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PRE-OPERATIONAL SAFETY OF NUCLEAR INSTALLATIONS
CZECH POWER WORKS
TEMELIN NUCLEAR POWER PLANT

23 April - 11 May 1990

REPORT TO THE GOVERNMENT OF THE
CZECH AND SLOVAK FEDERAL REPUBLIC

PREAMBLE

This report presents the results of the review carried out by an IAEA Pre-Operational Safety Review Team (Pre-OSART) of the Temelin construction site in South Bohemia, Czech and Slovak Federal Republic (CSFR). The results presented herein reflect the views of the participating international experts and are provided for consideration by the responsible Czechoslovak authorities. They are based on review of the documentation made available, on oral discussions with plant personnel, and on observations of relevant activities on site and at premises of the supplier.

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FOREWORD

by the
Director General

The IAEA Pre-Operational Safety Review Team (Pre-OSART) programme assists Member States to enhance the construction quality and the preparation for operation of nuclear power plants. Good design and thorough manufacture, construction and preparation for operation are prerequisites for the safe operation of a nuclear power plant, which also depends on the ability of the operating personnel and their conscientiousness in discharging their responsibilities. Pre-OSART missions focus on these aspects in assessing work processes on the site and at premises of the supplier. Comparisons with successful practices in other countries are made and ideas for improving safety are exchanged at the working level.

A Pre-OSART mission is made only at the request of a Member State. It is not a regulatory inspection to determine compliance with national requirements. The evaluation can complement national efforts by providing an independent, international assessment of work processes that may identify areas for improvement. Through the Pre-OSART programme, the IAEA facilitates the exchange of knowledge and experience between international experts and plant personnel. Such advice and assistance enhance nuclear safety worldwide. A Pre-OSART mission is also a good training ground for observers from plants under construction in developing countries who follow the evaluation process. This approach, based on voluntary co-operation, contributes to the attainment of an international standard of excellence in construction quality and preparation for operation, beyond the meeting of regulatory requirements.

Essential features of the work of the experts and their plant counterparts are the comparison of construction/manufacturing processes and preparations for operation with best international practices and the joint

search for areas where these processes can be enhanced further. The implementation of any recommendations or suggestions, after consideration by the constructing/operating organization and adaptation to particular conditions, is completely voluntary.

The IAEA Safety Series publications, including the Nuclear Safety Standards (NUSS) for nuclear power plants and the Basic Safety Standards for Radiation Protection, and the expertise of the OSART members themselves, form the basis for the evaluation. The review is not limited to the examination of documents and interviews but also covers performance. It is recognized that different approaches are available to a constructing/operating organization for reaching its safety objectives. Proposals for further enhancement of work processes may reflect good practices observed at other nuclear power plants.

A Pre-OSART review is tailored to the needs of a plant, as established for the current construction phase. A full scope review would cover ten areas: project management; quality assurance; civil construction; mechanical equipment; electrical and I&C equipment; preparation for startup; preparation for operation; training and qualification; radiation protection; and emergency response planning. Depending on individual needs, the Pre-OSART review can be extended to cover additional topics or can be concentrated on a few areas of special interest.

The Pre-OSART presents its conclusions, including proposals for enhanced work processes and good practices, to the constructing/operating organizations for consideration. A Pre-OSART review does not provide an overall safety assessment; it is, however, a comprehensive review of the manufacturing/constructing processes and of the preparations for operation of a nuclear power plant.

In formulating its views, the Pre-OSART discusses its findings with the constructing/operating organization and considers additional comments by team members. The Pre-OSART Report, which follows, summarizes the more significant matters and is submitted to the Member State.

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INTRODUCTION

At the request of the Government of the Czech and Slovak Federal Republic (CSFR), an IAEA team of international experts visited the Temelin nuclear power plant construction site in the South of Bohemia from 23 April to 11 May 1990. The purpose of the mission was to review the construction activities and the preparations for future plant operation, and to give advice on how work quality and safety practices might be further enhanced.

The team (see Annex I) was composed of experts from Canada, Finland, the Federal Republic of Germany, Hungary, Italy, the United Kingdom and the United States of America, in addition to IAEA staff members and observers from Bulgaria and Romania. Before visiting the Temelin nuclear power plant, the team studied relevant information that had been made available to them for familiarization with the plant's main features, the status of the construction work, important programmes and procedures for construction and operation, and the regulatory framework. At Temelin, the team of experts, using techniques derived from their over 300 years of collective nuclear experience, reviewed documents, observed construction and assembly work, observed the manufacture of equipment at premises of the suppliers, and interviewed power plant and contractor personnel to gain familiarity with relevant technical aspects of each review area. The scope of the review included: project management; quality assurance; civil construction; mechanical and electrical equipment; preparations for startup and plant operation; training and qualification; radiation protection; radwaste management and disposal; and emergency response planning. A thorough technical exchange of experience, opinions and ideas was achieved throughout the period of the review between the site and plant contractor personnel and equipment suppliers and manufacturers at various facilities in Czechoslovakia and the international experts.

The main conclusions of the Pre-OSART mission are highlighted in this report.

General comment

This Pre-operational Safety Review was the 40th Pre-OSART/OSART since the programme began in 1982 and the second to a nuclear power plant site in the Czech and Slovak Federal Republic following an OSART mission in 1989 to the Dukovany nuclear power station. The purpose of the Pre-OSART mission to Temelin was different from that of the mission to Dukovany since Temelin is still at an early stage of construction. Nevertheless, an international safety review at the current stage of construction is useful for the achievement of quality in construction and safety in operation. The team's conclusions from its reviews as outlined in this report contribute to further improvements in work processes and preparations for operation, based on the experiences of a variety of countries, utilities and nuclear power plants.

Since the accidents that occurred at Three Mile Island in the USA and at Chernobyl in the USSR, both international co-operation and competition among nuclear power plants in their striving for excellence have been recognized as prerequisites for the future utilization of nuclear energy. Each of these accidents could have been prevented or mitigated if more advanced instrumentation, more automatic response features and additional containment features had been available, if modern accident management techniques had been used, and if human factor implications had been taken into account; in short, if a true safety culture had existed.

It is in this context, that the Czech Power Works have embarked on a re-evaluation of the Temelin nuclear power plant project, which comprises a review of the site related design bases, the Pre-OSART review and an appraisal of the plant's major safety features. This ambitious programme should be completed in the summer of 1990. It may be supplemented by another Pre-OSART review in 1992/93, i.e. a year before the startup of Unit 1, and an OSART review after the commencement of commercial operation and the first refuelling. This would allow reviewers and their plant counterparts to verify that the international level of quality and safety has been met in all stages of the Temelin project.

Plant description

Temelin NPP was planned to be a four unit plant equipped with WWER-1000 pressurized water reactors. The latest government decision was to complete the first two units based on this Soviet design. Work on the other two units has been suspended to allow for additional evaluations to be made before any further decision is taken. The plant is situated in the northern part of the Ceske Budejovice district, 20 km from the town of the same name (100,000 inhabitants) and 150 m higher than the Vltava river, which flows in approximately 4 km distance. Two cooling towers for each unit will be used for cooling the turbine condensate.

Site clearing work began in 1981 and the preparatory work for the construction of the building for the first reactor unit commenced in 1986. The first unit was scheduled for startup at the end of 1992 and the second unit for start-up in 1994. The construction was delayed, however, and the startup of the first unit is now scheduled for 1994. While the primary side is built to Soviet design, most of the equipment and materials for it are of Czechoslovak origin. It is now under consideration whether some specific materials and parts for the I&C system should be imported from western countries. Energoprojekt, Praha, is the architect-engineer with Vodni stavby, Praha, the main civil contractor and VE Skoda, Plzen, the main equipment contractor.

The nuclear steam supply system (NSSS) of the four-loop WWER comprises the reactor pressure vessel, horizontal steam generators with submerged tube bundles and built in separation units, reactor coolant pumps, the pressurizer with relief and safety valves, the bubbler (quench) tanks and connecting piping. The WWER is comparable with pressurized water reactors in other nuclear power plants.

In the present design, the reactor core will contain 163 hexagonal fuel assemblies with 312 fuel rods per assembly arranged in a triangular grid. Sixty-one of these fuel assemblies have 18 movable control rods and 54 have fixed burnable poison rods. The enrichment of the fuel in uranium-235 is 4.4%. The neutron absorber material is boron carbide in an aluminium alloy

matrix. Negotiations with the Soviet designer are under way on a possible redesign of the reactor core, so these data may change.

To cope with design basis accidents, the design provides for safety features which, in addition to mechanical and chemical shutdown systems, include a redundant (3 x 100%) emergency core cooling system with high pressure and low pressure injection pumps, water storage tanks and accumulators, a containment isolation system and a large dry containment. This comprises the cylindrical containment vessel made of reinforced prestressed concrete, with a hemispheric dome and an inner lining of carbon steel. A containment spray system is provided as a protection against overpressure. Three diesel generators are installed for the emergency power supply of each unit.

Main conclusions

The conclusions reached were positive regarding the management and the workforce in the Temelin project on the basis of a thorough review of project management, quality assurance, civil construction, mechanical equipment, electrical (including I&C) equipment, preparations for startup, preparations for operation, training and qualification, preparations for radiation protection, for radwaste management and for disposal and emergency response planning. These conclusions are based on current accomplishments, work under way on-site and at the suppliers, and the plans for completing the plant.

Some good practices were identified which may be of interest in other nuclear construction projects. Among them are the turnover process of completed areas from civil to mechanical/electrical contractors; the development and updating of a detailed layout plan of the job site; the database for personnel recruitment; the systematic career development for personnel within the operating organization; and the grading of investigating levels with variations of background and effluent rates.

A fair number of proposals for improvements have also been made for consideration in the continuation of the Temelin project. Those which aim at correcting shortcomings or at making improvements in current working

conditions should be distinguished from those to be taken into account in the preparatory work for future operation.

In the first category are measures to revise the distribution of authority between the Federal Ministry of Fuel and Energy, Czech Power Works and the Temelin Plant such that oversight and budget allocation are clearly separated from project implementation and adaptation to changing technical requirements. Further, some reorganization at Czech Power Works headquarters is proposed so as to concentrate nuclear activities in a unit which would be charged with safety oversight, technical assistance including quality assurance, and overall direction of nuclear power plant construction and operation.

Recommendations in the second category are mainly provided to support and supplement the operating organization's efforts in personnel training, development of procedures for coping with normal and emergency conditions, radiation protection of the workforce and the general public, advanced radioactive effluent control, introduction of radwaste management methods for reduction of volumes to be disposed of and development of an emergency response capability to cope effectively with the consequences of emergencies, however unlikely they may be.

Three issues were noted that require particular efforts: (1) the power plant organization should be streamlined by separating operational, maintenance and technical support functions into dedicated sections. (2) Quality assurance should be developed into a comprehensive programme incorporating currently established quality control and quality assurance but extending beyond the present regulatory requirements. (3) The Czech Power Works should also be given the necessary tools to lead concerted efforts by contractors and also subcontractors to improve industrial safety and housekeeping practices on-site.

In conclusion, the Pre-OSART review found at Temelin dedicated, qualified and experienced managers and workforces for building this nuclear power plant. All are aware of their responsibilities for the safety of plant, personnel and the public. Work carried out on-site and at the suppliers is of

good quality. Advanced features beyond the original design are being incorporated in order to meet international standards. This may cause some delays and will require additional investments. However, high quality work and adequate resources are essential elements to ensure that the a safety culture required for the completion and future operation of the Temelin nuclear power plant is maintained.

1. PROJECT MANAGEMENT

The Temelin nuclear power project is managed in accordance with the investment management system developed in Czechoslovakia. The system is based on a well advanced planning process prior to construction start. It is a rather rigid system that cannot easily be adapted. Also, the main contractors and subcontractors were appointed in the early phase of the Temelin NPP project and could not be changed, since there were no competing companies and foreign companies are barred from consideration owing to lack of hard currency.

Investor, designers and contractors

The utility, which is presently the investor and later will be the operator, is the Czech Power Works (Ceske energeticke zavody, CEZ). During the design period CEZ formed a separate organizational branch for the Temelin project, Power Plant Temelin (Elektrarna Temelin, ETE).

The main designers are a Soviet design organization responsible for the 'Soviet design zone' and Energoprojekt (EGP), Praha, responsible for the rest of the plant and for the co-ordination between the two design zones. The Soviet design zone includes the reactor building, the auxiliary building and the diesel buildings, including the main safety features of the plant.

The main contractors are Vodni stavby, Praha, the general contractor for civil construction and Vystavba elektraren Skoda (VE Skoda). Plzen, the general contractor for mechanical and electrical equipment. Both contracts include manufacturing, construction, erection, installation and startup of the supplied equipment. These two contractors formed separate organizational units for fulfilling their site obligations.

Project development

Before beginning with the construction work, a comprehensive set of mandatory documents with rather detailed contents was developed. These are

the project tasks, the site permit, the introductory project and the construction permit. The project tasks, completed in 1984, contain items that were approved by the Federal Ministry of Fuels and Energy (FMPE). Any changes to these items need the approval of the FMPE.

The well defined preparation and design system is a firm basis for the implementation of the Temelin project. At the end of 1986, the introductory project was accepted by CEZ, the construction permit was obtained and the two main contracts were negotiated.

For the Temelin project, CEZ-ETE set up a Section for Investment, led by a deputy director and reporting to the site director. Correspondingly, both main contractors established special Temelin branches. The fourth main partner, EGP, had already designated a design chief engineer for the whole project period.

Authority and responsibilities within CEZ

CEZ headquarters does not have an organization with the necessary resources whose main function would be to provide the oversight and technical assistance to its nuclear power plants. These functions, which are typical functions of electrical utilities operating nuclear stations, are currently distributed among several committees and ministries. In view of the expected turnover of most of these functions to CEZ, headquarters resources should be concentrated and strengthened under a deputy director general charged with the oversight of nuclear safety and the provision of direction and assistance for safe operation and quality construction.

The distribution of the decision making authority in respect of the Temelin project among CEZ-ETE, CEZ headquarters, FMPE and the Council of Ministers is such that changing the originally approved implementation is complicated and time consuming. This constitutes an impediment to introduction of upgradings necessary to meet international standards of safety, to compensate for delays, to streamline the organization and to meet industrial safety standards.

It is therefore recommended that CEZ headquarters and CEZ-ETE be given the authority within an approved budget and work programme to take the decisions necessary for efficient project implementation. In addition, extrabudgetary requirements should be processed more swiftly than in the past. Furthermore, CEZ-ETE should be assigned more authority for exercising direct control over all design, manufacture and construction for the Temelin project. The available staff have the knowledge and experience necessary to carry out such duties.

Co-ordination and decision making

EGP's design chief engineer had a total of approximately 600 specialists working on the introductory project, co-ordinated through a five member support team and eleven design centres. The Soviet design zone, however, was excluded, but it may be worth considering an extension of EGP's responsibility to cover the entire design in the future. Continuing consultations were held with CEZ and the main contractors, which were obliged to submit binding technical data.

The co-ordination and the decision making process between CEZ, EGP, VJET and VE Skoda has been organized through a well structured hierarchy of meetings. The meeting levels are working group meetings, project manager meetings, director meetings and the management meetings with representatives of the Ministry. Unresolved issues will be passed on to the next higher level until the matter in question is resolved. The principle is that the decisions between these four organizations must be unanimous.

Planning and scheduling

The planning of the construction of the Temelin NPP is based on the usual system for construction investments in Czechoslovakia. The project has been subdivided into well defined phases. The end of each phase forms a control point.

The implementation of the project is based on a critical path approach with network schedules. According to legislation valid up to 1 April 1990,

establishment of a special 'construction regime' at the beginning of construction work is required, based on the network schedule and covering the activities of the next two years. Timely execution of the construction regime is followed up by monthly control meetings, which also serve to reach consensus on any modifications necessary.

At CEZ-ETE, the Planning Department of the Investment Section maintains the network schedule and submits items to the control meetings for review. The two years construction regime contains 800-2000, and the entire network schedule 10,000, different activities. The schedule and planning processes form a good basis for the implementation and control of the Temelin NPP project.

Commencement of commercial operation of Unit 1 was scheduled for November 1992. Unit 2 should be ready 18 months later. In the meantime, however, work has been delayed and a new schedule is under preparation. Commercial operation of Unit 1 is now expected to begin in the first half of 1994.

Approvals, permits and licences

The nuclear regulatory body in the Czech and Slovak Federal Republic is the Czechoslovak Atomic Energy Commission (CSKAE). The licensing process provides for site approval, construction permit and operating licence.

A special feature of the licensing process for industrial installations, including nuclear power plants, is that a regional authority, i.e. the Regional People's Committee, co-ordinates all licensing activities. The applicant submits applications to the authorities having responsibilities in such areas as nuclear safety, radiation protection, industrial safety, fire protection etc. These send their approvals with possible conditions attached to the Regional People's Committee, which issues the corresponding permits. This concentrated licensing system simplifies liaison between the utility and the regulatory body.

2. QUALITY ASSURANCE

The observed manufacturing and construction quality meets international standards. The quality assurance (QA) programmes of the contractors and subcontractors are generally well implemented and contribute to the overall quality of work. However, they are limited in scope and mostly address quality control (QC) activities. Comprehensive QA programmes, in particular the auditing functions, have still to be developed by CEZ-ETE and the main contractors, VJET and VE Skoda.

The existing QA programmes meet current regulatory requirements, and many elements of an effective QA programme are in place, addressing such topics as installation instructions, drawing controls, design verification, welding procedures, inspections and tests, equipment storage, shipment and records. However, international QA practice extends beyond the existing programmes, and efforts should be made to meet that standard by combining the existing elements and adding the missing features to implement a comprehensive QA programme.

Quality assurance programmes

QA programmes have been written to meet CSKAE requirements. The QA programmes were written specifically for products or services and are referred to as Individual Quality Assurance Plans (IQAPs). Companies that offer multiple types of products or services also have QA programmes that basically identify the products and the applicable IQAPs together with some additional quality assurance information. The quality assurance programmes have limited scopes, primarily addressing QC inspections, non-destructive testing, shop inspections and storage and shipping activities. These programmes would be more appropriately described as QC programmes rather than QA programmes.

Several recommendations were offered in the area of the QA programmes: the investor, CEZ-ETE, should develop an overall QA programme to match international practices, as outlined in IAEA NUSS Code of Practice 50-C-QA (Rev. 1), 1988, and associated Safety Guides.

This is important since CEZ-ETE has overall control of the Temelin project. The two major contractors, VJET and VE Skoda, also need to expand their QA programmes to intermediate level QA programmes, which meet the requirements of IAEA NUSS Code 50-C-QA (Rev. 1). Similar recommendations were made for the design organization EGP and for suppliers to expand their QA programmes accordingly.

There was a good practice identified, in that QA programmes are reviewed and approved by CEZ-ETE and CSKAE as well as by the procuring organization suppliers and subcontractors. This has succeeded in providing sufficient controls to ensure a quality product. This is very appropriate when suppliers are not competitively selected based on quality and pricing.

QA organization

All the organizations performing work in Safety Classes 1, 2 and 3 have independent quality assurance organizations. The QA personnel were found to be knowledgeable in quality control and non-destructive testing. There were recommendations offered in some cases where the reporting relationships of the site QA supervisors did not provide for sufficient independence.

The significant recommendation in this area is that QA auditing functions be developed with CEZ-ETE, main contractors and subcontractors and that QA auditing programmes be initiated. Regular auditing is needed to identify programmatic weaknesses. It would have assisted in correcting some problems observed, such as in connection with weld rod control, material control, shop inspection and storage conditions.

Quality control inspections

CEZ-ETE, the main contractors and subcontractors for Class 1, 2 and 3 items, have well planned and executed inspection programmes with appropriate documentation. They included first level QC inspections as well as second level monitoring. In addition, CEZ-ETE performed selected third level inspections and monitoring. However, no QC checklists were used during these evaluations, although they were available at the work locations.

It is recommended that the QC checklists should be simplified and made easier to use. Cable pulling should also be subjected to QC inspection to ensure proper installation and system separation. In general, CEZ-ETE QC personnel carry out final inspections of facilities and systems prior to turnover. This programme is well prepared and executed.

Non-conformance control

CEZ-ETE does not have a non-conformance control report (NCR) procedure and should develop one to ensure the recording of problems identified and traceability of the problem resolution. The main contractors, subcontractors and suppliers have such programmes, but the prevention of recurrence of problems is often not addressed adequately. This particular item concerns VJET and should also be checked at the civil subcontractors.

Deviations from requirements were observed to be recorded as NCRs. There were, however, no tags hung on equipment or in the warehouses. It is recommended to develop a non-conformance tagging system to physically identify non-conforming items that could not be segregated. The use of a standardized red tag by all parties (CEZ-ETE, contractors and subcontractors) is also suggested. Further, the Sigma warehouse should establish a holding area for non-acceptance and non-conforming items, and the other subcontractors should be reviewed to verify that they have such holding areas.

Quality records system

The quality records systems of CEZ-ETE, VJET and VE Skoda are well advanced and meet international standards. CEZ-ETE and VJET have computerized databases and the records are complete, traceable and retrievable. This latter applies to the record systems of the suppliers as well.

Current storage facilities for the documents both at the subcontractors and at CEZ-ETE do not meet international standards, however, in so far as the fire protection provisions are either inadequate or non-existing and the destruction of important documents by fire cannot be ruled out. Subcontractor offices should be provided with fire proof vaults for the storage of their

QC/QA documents until turnover and CEZ-ETE should build an adequate fire proof document vault on-site for the permanent storage of documents. Document control, including access to documents, should also be strengthened to prevent their unauthorized use.

Material control

Adequate storage and handling facilities are available. The material was generally found to be adequately stored and handled.

However, outside storage should be improved by neatly stacking material and placing lumber under the material to raise it off the ground. Inside warehouse storage should also be improved by establishing a clean room for electronic material and reducing dust by coating the floor and by frequent use of vacuum cleaners. Furthermore, a control system should be developed for weld filler material, including storage, distribution and return of unused material.

All contractors, subcontractors and fabricators of safety related piping assemblies should transfer heat numbers before a length of pipe is cut off, i.e. the heat number should appear on both sides of the cut. This should be verified by QC before the material is cut.

Quality work controls

Work was found to be well planned and was progressing in an orderly fashion. Drawings were in use and the drawing details appeared to be constructible. Many installation activities were observed and work was performed in accordance with the drawings and instructions.

Several recommendations were offered for specific work activities. Guidance should be developed for structured cold springing, controls should be developed for approving and documenting the cutting of permanent structured steel and leak test results should be fully documented, in particular failures.

3. CIVIL CONSTRUCTION

Civil construction at Temelin is managed by an experienced and qualified staff. Up-to-date equipment and construction methods are applied. Extensive use of prefabricated elements is a design feature, though consideration should be given to increased use of shoring to permit concrete pouring to a larger extent.

Due attention is paid to quality control, and adequate testing methods are applied and appropriate testing methods used. An excellent turnover procedure has been established. The computer-aided design (CAD) output is also used to maintain the detailed site/plant layout up-to-date.

The industrial safety issues discussed in this section concern the entire site and are not restricted to civil construction work only. Concerted efforts are required to organize and implement an effective industrial safety programme.

Civil organization

Civil construction at Temelin is assigned to the site branch (Vystavba jaderne Elektrarny Temelin, VJET), of Vodni stavby, Praha. VJET, which is managed by an experienced and qualified staff, constructs the main safety related buildings, subcontracting steel structures, auxiliary structures and finishing work. Its technical office adapts the Soviet design to meet Czechoslovak regulations, examines the construction drawings and prepares lists of material for purchasing.

An excellent turnover from VJET to CEZ-ETE has been established with ample use of standardized measuring points and computer aided design (CAD) drawings. All actual geometrical measures are loaded in the CAD database and are available for the electrical and mechanical contractors. The CAD output is also used to maintain the detailed site plan layout up-to-date. This function remains under the responsibility of Energoprojekt and includes all provisional works facilitating eventual modifications.

Auxiliary construction facilities

All on-site construction facilities are of high quality with sufficient capacity for peak load service. A 190 m³/h computer controlled Stetter batching plant was installed with over 50 batching mixes preregistered for immediate use. Daily feedback of batching information is sent to the main VJET planning division for schedule updating.

Warehouses are operated to high standards and are well equipped with computer aided identification for inventory control. Greater attention should be paid to housekeeping, however, to reduce dust and mud on the site.

Quality materials and QC/QA

Quality and QC/QA of materials are defined in state regulations, design drawings and QC plans. Material specifications are contained in detailed design drawings with the exception of cold squeezed rebar splices that are approved directly by the Soviet designers. The VJET Quality Control Department (QCD) is functionally independent from construction with skilled and trained personnel.

The on-site material testing laboratory is housed in adequate facilities with excellent modern equipment. Qualified personnel carry out testing and inspection according to Czechoslovak regulations that correspond with international standards in both type and frequency.

Excavation, backfilling and waterproofing

A supplementary geological survey was conducted jointly by VJET and the Czechoslovak and Soviet designers to establish all parameters necessary for rock blasting. Blasting of subareas of seven by ten metres was monitored to compare the resulting seismic wave with the limits established by the designers. Favourable results of the elastic modulus of the rock foundation would lead to lean concrete covering within 24 hours of excavation, in line with best engineering practices.

Backfilling is done according to good engineering practices using material originating from the excavation. Water proofing was done according to standards applicable in the nuclear industry using white polyvinyl chloride sheets, heat joined and mechanically protected by geotextiles and lean reinforced concrete.

Concrete and steel construction

Prefabrication is extensively used in both concrete and steel construction. The prefabricated elements are constructed mainly in factories off-site and transported by rail or by road to the power plant. Wall elements of the reactor building are principally formed by 8 cm precast concrete slabs and/or steel liners, completed with internal prefabricated rebar cages and concrete poured in five layers to avoid excessive loading of the 8 cm slabs. Consideration should be given to a greater use of shoring to permit full height concrete pouring with a resulting gain in quality and saving in time.

Pre-erection and on-site erection of the steel structures are undertaken by the Hutni Montaze subcontractor according to standard practices in the nuclear industry. Consideration should be given to applying primer to steel bolts as soon as torque verification is concluded to prevent formation of rust if painting is delayed.

Industrial safety

The industrial safety issues discussed in this section are not restricted to civil engineering works. High accident risks were seen in many places on the site. The fatality index is well above the average for nuclear construction sites. Accident statistics and subsequent analyses for the whole site are not readily available. Safety plans specifying work methods and the provisions necessary to meet safety requirements should be implemented. An overall industrial safety co-ordination group, formed by the safety officers of all firms on-site, should be established and chaired by the CEZ-ETE safety officer. It should review the individual safety plans, prepare site accident statistics and analyses, and carry out site inspections zone by zone with the objective of identifying and analysing shortcomings that could impair safety.

This co-ordination group should provide recommendations to CEZ-ETE for improving industrial safety. CEZ-ETE should be given authority in industrial safety matters over all personnel and contractors working on-site.

Individual workers should be held responsible for keeping their work places clean and removing trash and tools on completion of work. Each main contractor (VJET and VE Skoda) should ensure that the site is kept clean.

Site access control should be extended to all entrances to bar entry to unauthorized persons who are unaware of the applicable industrial safety measures and potential hazards.

4. MECHANICAL EQUIPMENT

Concerning mechanical equipment, technical, personnel and administrative aspects of the Temelin site are satisfactory for the current phase of construction. In general, construction and manufacturing quality is adequate and management and staff are well qualified. A major rescheduling of the construction and installation work is presently under way. There is every reason to believe that mechanical work will be done to a high standard.

Mechanical installation work is carried out by several subcontractors under the control of the Co-ordination Department of VE Skoda, Plzen. VE Skoda also acts as the supplier/installer of the turbine generator. Each subcontractor supplies all the equipment within the framework of its contract. CEZ-ETE accepts the completed work from VE Skoda.

Organizational charts clearly depict the foregoing relationship. The organizational chart of a typical subcontractor (Kralovopolska strojirna Brno, KSB) showed the normal setup with the QC section reporting separately from production. CEZ-ETE inspectors witness tests, carry out inspections of safety related work and sign the test reports. CEZ-ETE's decision to introduce titanium for the condenser tubing was noted and is supported in an overall drive to eliminate copper from the secondary circuit. This should allow a water chemistry providing optimum protection of the steam generator tubing.

Document storage

Document storage at subcontractors, as reported earlier, is not satisfactory. A fire could easily destroy important documents, including radiographic films and other test records, thereby creating a very serious problem.

Similarly, the CEZ-ETE QA/QC record storage room has a fire detector on the ceiling but no fire-fighting system to protect the records, which are placed on open shelving. The door to the room is not of fireproof material. There is little control over access to the room.

Receipt, storage and handling

All warehouses visited lacked a segregated or quarantined area for non-conforming items. It is recommended that all warehouses storing safety related areas hold non-conforming items received. A system of conditional acceptance with proper records and controls should be set up so that in cases in which delays would result, non-conforming items can be installed.

The KSB Brno warehouse was found to be neat and clean, and all warehousing operations were efficiently carried out. Since the project is still in an early stage, there was a relatively small amount of equipment and material stored. Provisions are made for cold, covered storage and for temperature controlled storage as well as for outside, uncovered storage. KSB is responsible for supplying and installing piping for the nuclear steam supply system.

Skoda's welding electrode storage building contained a mixture of nuclear grade and non-nuclear-grade electrodes. Some boxes of nuclear grade stainless steel welding electrodes were stored on shelves, together with other electrodes. These stainless steel electrodes were being held pending receipt of certificates of compliance. They were neither tagged as non-conforming nor were they put in a segregated area. It is recommended that, in all weld electrode storage rooms, nuclear grade electrodes be separated from non-nuclear-grade electrodes so that the possibility of confusing the two is reduced.

The Sigma Modrany warehouse contained piping flanges which were stored with the machined face resting on the concrete floor without any protection. Some material was stored on open ground beside this warehouse without the use of bolsters. There was an accumulation of dust and dirt on the plastic covering of some Soviet supplied equipment, which could be spread throughout the warehouse. These shortcomings should be eliminated.

Prefabrication work

Prefabrication of tanks and piping for nuclear systems was reviewed at KSB Brno shops. The shops are well run, stainless steel material is well protected, and a review of a sample of quality records showed that all is in order.

A tour of the Vitkovice Plant in Ostrava was made. The work in progress for CEZ-ETE (steam generators, pressurizers, primary circuit piping) appeared to be of high quality. A check of the QC inspection records of one particular piece of primary circuit piping showed that all was in order. A tour of the Welder Training Centre, which is located in a different part of the plant, revealed that buildings are old and dirty, opened boxes of welding electrodes were left lying on open shelving, and automatic welding machines were old and dirty. Vitkovice should upgrade the welder training facility to meet the standards expected from a major supplier of nuclear equipment. Welder training records did, however, appear to be good, and were on a computerized system.

Installation work

Rooms in the reactor building below the containment floor contain major safety related pieces of equipment, including large pump motor sets, air compressors and ventilation fans. The equipment, placed in its final position but not bolted down, has been covered with blankets. However, inside the blankets, plastic wrappings or covers have been torn away or ripped. This allows atmospheric humidity to affect the equipment, including the motors.

The atmosphere in these rooms is highly humid as concrete is being poured in the upper areas. Dust and dirt are present in large amounts in some areas. Damage is likely to occur to this equipment, as the anticipated storage time in these conditions is long, i.e. until the mechanical installation phase of the project commences.

The condition of the safety related mechanical equipment in the reactor building should be re-evaluated and steps taken to prevent damage occurring owing to ongoing civil work, high humidity, dust and dirt. The equipment should be cleaned, sealed with plastic wrappers and enclosed in a protective cover to prevent damage. Open ends of piping and ducting should be capped to prevent the ingress of foreign material. Missing documents referenced in the storage specification for Soviet supplied pump sets should also be obtained.

5. ELECTRICAL EQUIPMENT

Since the main installation activities for electrical and instrumentation and control (I&C) equipment at Temelin will begin only at the end of 1991, the emphasis of the reviewing activities was placed on planning and preparatory work, in addition to visits to a number of factories that manufacture electrical components. These factories are producing quality equipment and have effective quality control programmes.

Electrical power supply

A 400 kV network and a 100 kV standby network will ensure sufficient off-site power supply. The on-site emergency distribution supplied by three diesel units and batteries (three independent 100% systems) has been designed to provide a highly reliable supply. This reliability, however, depends on the quality of the installed electrical equipment. For the non-safety-related power distribution system, rectifiers and inverters will be delivered by western suppliers.

Experience of poor quality of these components in other Czechoslovak nuclear power plants was the reason that the supplier for Temelin was changed. However, the contract with the previous supplier still provides for the delivery of the equipment for the safety related power supply. In order to ensure also a highly reliable power supply for safety related systems, only rectifiers and inverters that meet the highest requirements of quality and reliability should be used.

Instrumentation and control equipment

Instrumentation and control (I&C) equipment for the auxiliaries in the secondary system and for the turbine falls under the responsibility of the Czech designer, while the other I&C parts, including the process computer system, are designed in the USSR. Because of expected problems at the interfaces between the different designs, but also expected problems with the compatibility of the Czech and Soviet hardware, consideration is being given to having a new supplier for the entire I&C equipment.

Since cables to be installed in the containment have to be resistant to radiation, temperature, corrosion and humidity, it was decided to upgrade the original design and to have a Czechoslovak supplier develop such cables in accordance with international standards.

Fire detection in electrical and electronic rooms will be by optical, ionization and heat sensors which are connected with sub-centres in different buildings and with the data processing unit in the fire control room. The location of a fire can be identified on an alarm panel and a printout is provided with instructions for fire-fighting. Fire-fighting in electronic rooms will be with automatic carbon dioxide extinguisher systems, while cable rooms are equipped with sprinkler systems.

Electrical and I&C Departments

The Electrical Department is a branch of the Production Section and is subdivided into the Operations (shift), Technical Automation, Electrical Protection and Telecommunication Groups, headed by experienced electrical engineers. Approximately half the staff have already been hired and are undergoing on the job training (OJT) at other Czech power plants, switchyards and manufacturers.

The I&C Department is also a branch of the Operations Section, charged with: the operation of I&C equipment on shift; maintenance of technological measuring devices in the primary, secondary and auxiliary systems; operation of computer systems; and the reactor control and protection systems. Approximately one third of the staff have been hired and sent to the Dukovany nuclear power plant for OJT or to the Brno and Trnava Training Centres.

When electrical and I&C installation and commissioning starts, both Electrical and I&C Departments should be fully staffed in order to make use of the opportunity of acquiring familiarity with the equipment through participation in its completion. The transfer of knowledge from the commissioning specialists to the operations and maintenance personnel is essential for successful future operation.

Equipment manufacture

A number of factories that are manufacturing electrical components for Temelin were visited, among them ZPA (Zavody prumyslove automatizace), Cakovice; Elektromont, Teplice; Skoda, Plzen; EJF (Elektrozavody Julia Fucika), Brno; and Metra Blansko.

ZPA manufactures electronic modules for the CEZ-ETE computers to be used for the control of safety and non-safety-related equipment. The fabrication does not meet international standards of automation, since all assembly work is still manual, but the essential quality requirements are fulfilled. In addition to precautions already taken, personnel should wear bracelets for permanent earthing of static loads which could cause damage to sensitive components.

Elektromont supplies low voltage switchgear including the safety related switch gear for CEZ-ETE. It has a specific design, identified by the order number on the nameplate. In the different manufacturing steps, QC checks are performed. On completion, comprehensive functional tests are carried out, and CEZ-ETE and CSKAE are invited to witness the tests. With the exception of the feeder cabinets, busbars are mounted in the back of the electrical cabinets, in accordance with Czechoslovak industrial safety standards, but this is still dangerous for the operating personnel. The busbars should be separated from the operating and maintenance areas and would be better installed at the back of the switchgear.

Skoda, Plzen, manufactures the main generator and its exciter, in addition to the heavy mechanical components. The hydrogen cooled generator is the first of its size to be built by Skoda. A new assembly plant with 500 t crane, a test area for generator auxiliaries and an overspeed balancing pit are still under construction.

EJF, Brno and Metra Blansko are suppliers of high voltage switchgear and automation systems, respectively. Both were found to manufacture equipment in accordance with international quality standards and to apply comprehensive QA/QC measures.

Equipment installation/commissioning

Installation of electrical and I&C equipment will be performed by Elektromont, CKD and Skoda ZES. Work will be carried out in accordance with the installation drawings provided by the subcontractors, after validation by EGP and according to the construction schedule established by VE Skoda. Work quality will be checked by subcontractor, main contractor and CEZ-ETE's Quality Control Department. The protocol on satisfactory results serves as the permit to begin with the commissioning work.

The commissioning programmes to be developed for I&C equipment will describe the parts to be tested, the test process and the required results. Selected parts of the programme will be verified by CSKAE. Presently, only a list of the planned commissioning tests exists.

Storage of electrical and I&C equipment falls under the responsibility of the subcontractors. In accordance with the manufacturer's specifications, heated and unheated storehouses and open space are available. If receipt control discovers discrepancies, the supplier has to correct them at the storage area or take the equipment back. Warehouses/stores should be equipped with fire detection systems.

6. PREPARATIONS FOR STARTUP

In discussing the startup plans for Temelin, management and staff were found to be conscientious, knowledgeable and experienced. There is considerable experience available in the construction and operation of nuclear power plants from the startup of eight earlier WWER-440 reactors in Czechoslovakia. They were put into operation with an organizational set-up that corresponds to international practices. The startup plans for Temelin NPP have been enhanced on the basis of the experience of the previous startups and only small changes are foreseen.

Temelin is still in an early stage of construction and there was little opportunity to review actual startup practices. The review of the area is therefore based on the plans and programmes of the organizations involved. The startup will be carried out in two phases. The first phase will be carried out by the contractors with CEZ-ETE staff well integrated in the startup organization. The second phase will be executed under the responsibility of the operating organization. While startup activities are not yet being performed, the plans and programmes reviewed made a good impression. Progress to date is satisfactory, although some issues were identified on which improvements should be made.

Startup organization

CEZ-ETE has a contract with VE Skoda for commissioning the plant. The Startup Control Group (Ridici skupina spousteni, RSS) was established in 1988 for preparing all necessary documents and for starting up the plant. The first phase, which ends with the regulatory approval for fuel loading, is managed by VE Skoda. The second phase, under the responsibility of CEZ-ETE, finishes when the 144 hour full power trial run begins, which is VE Skoda's responsibility.

After six months of trial operation, VE Skoda gives a one year guarantee. It is during this period that the licence for commercial operation is expected to be issued. A detailed programme for the preparation and

execution of all startup activities has been established. CSKAE has identified those steps that need its approval.

RSS controls working groups for: the primary circuit; secondary circuit and external objects; electrical facilities; I&C equipment; special systems; radiation monitoring and dosimetry; heating, ventilation and air conditioning; and technological processes. Support to the startup activities is also provided by the Nuclear Power Plant Research Institute (Vyzkumny ustav jadrovych elektrarni, VUJE), Trnava.

It is recommended, that in addition and in accordance with international practice, a safety committee be established already during the pre-operational and startup phases. Its members should be qualified individuals representing different disciplines, without being involved in the day-to-day operations, and should advise the Temelin management on important pre-operational activities, special test procedures, test results, procedure changes and plant modifications.

Staffing for startup

The eight startup working groups are currently composed of 35 VE Skoda and 25 CEZ-ETE staff. Staff of subcontractors are also enlisted as required. The organization is flexible and staffing levels are considered sufficient to cope with present and future (larger) work loads. Almost all staff members have experience in startup activities at other nuclear power plants.

The involvement of the operating personnel in the startup testing is well planned. They are integrated in all departments and groups of the startup organization, including also system engineers. Consideration, however, should be given to assigning, in addition, startup engineers to all important system groups (primary circuit, secondary circuit, special systems, I&C). Their task would be to witness installation, testing and maintenance of the equipment for ensuring systematic feedback of relevant information to CEZ-ETE's maintenance and technical support departments. There is also a programme for the maintenance personnel comprising OJT and familiarization with responsibilities and tasks during startup.

A surveillance test programme for safety related equipment is included in the schedule for all testing phases and will be executed by the operating organization. This should serve to detect any deterioration of equipment after installation and before turnover to the startup groups.

The maintenance section is scheduled to be fully staffed prior to core load. Preventive maintenance will be carried out by the CEZ-ETE. Corrective maintenance is the responsibility of VE Skoda. After core load all preventive and corrective maintenance will be the responsibility of the operating organization.

Development of the startup programme

VE Skoda is responsible for the production of the startup programmes, operating documentation and all other instructions needed for commissioning and operation of the plant. Comments of CEZ-ETE and CSKAE are to be included. While the startup documentation will be approved by CSKAE, CEZ-ETE, VE Skoda, VUJE and the Soviet design organization, the operating procedures will only be approved by the operating organization.

Furthermore, to enable the development of startup programmes, procedures and documents in accordance with a uniform format, development of a comprehensive administrative procedure is recommended to ensure a uniform format and consistency of contents for user friendliness.

Programmes for developing the labelling, tagging, locking and work authorization systems have already been produced by VE Skoda and commented on by CEZ-ETE. The list of the procedures, instructions and other documents to be produced is comprehensive. It was suggested to include in the work programme some long term projects such as symptom based emergency operating procedures and probabilistic safety assessment studies.

Safety parameter display system

It is noteworthy that the installation of a comprehensive computerized system with adequate hardware is under consideration to provide the control

room operators with information on plant parameters and system status (expert system). These plans, including a safety parameter display system, are endorsed. The details of the system should be worked out as soon as possible to enable installation and commissioning early enough to support startup testing.

Interface construction: startup

The installation of all systems and components in Temelin is carried out by VE Skoda and its subcontractors. Co-ordination between the parties involved in the startup is accomplished through meetings at the working group level. RSS will hold meetings when several groups are involved or when moving from one to another phase of the startup programme. Major changes requiring additional funds will be resolved at the management level of the organizations concerned.

Before functional testing of the components and systems begins, all civil and installation work will be completed and a protocol will be signed by the contractors and CEZ-ETE. The protocols will include lists of reworks, repairs, modifications and other work (punch lists). Such work has to be completed by the contractors regardless of financial consequences.

Nuclear and acceptance testing

Plant startup after fuel loading (startup Phase 2) falls under CEZ-ETE's responsibility. The planning of the programme for this phase is based on experience gained from the startup of other reactors in the country. These were put into operation with organizational setups that corresponded to international practices. CEZ-ETE, VE Skoda and VUJE have the necessary experience as well as the personnel. The time required from fuel loading to trial run at full power is planned to be approximately ten months, which is in line with international practices.

The programmes for static, dynamic and power testing have already been prepared. A detailed list of tests and equipment required exists. VUJE will carry out approximately 50% of the tests after fuel load. In addition to

utilizing the experience gained in starting up 440 MW units, special attention will be paid to new equipment and anticipated problems with 1000 MW units.

Interface CEZ-ETE: CSKAE

CSKAE will monitor all startup activities in accordance with the applicable regulatory requirements. It is responsible for approval of the startup programme and the Technical Specifications. Special approvals are required for fuel loading, physical tests, power ascension tests and full power trial operation. More than one regulatory inspector will be stationed on site during the startup activities.

A good professional relationship exists between plant management and the regulatory authority. This will facilitate the achievement of high safety levels during startup in accordance with international practices.

7. PREPARATIONS FOR OPERATION

At the present stage of the project, activity in this area is mostly confined to preparing and refining plans and methods of working.

The state of preparedness was found appropriate to the proposed commercial operation date for Unit 1 of 1994, and the staff were found to be professional and highly motivated in their approach. The principal concern throughout the review was the over-complex organization, which will hamper communication, particularly at a site employing so many people. Many of the recommendations relate to this.

Reorganization principles

Detailed plans have been made for the staff structure in the operating phase. However, these are based on the original planning for four units, and construction of Units 3 and 4 is temporarily suspended. They are now under review by CEZ-ETE management who believe that significant improvements can be made. The current proposal provides for five sections (Nuclear Safety, Operations, Maintenance, Economics and Personnel) reporting to the site director, each headed by a deputy director. In addition to these sections, there are seven departments/divisions which are also directly under the site director, giving a total of 12 individuals reporting to the site director, more than is desirable for effective control.

The planned staff of 3092 (for four units) appears high by international standards but this is partly explained by a comparative lack of remote control and display equipment. However, the fragmentation of maintenance and technical support functions makes a clear contribution. This will inevitably make co-ordination and communication more difficult, not only reducing efficiency but also posing a potential threat to quality.

It is recommended that the current redesign of the plant staff structure be pursued, with particular attention to the need to bring similar functions into the same section and to reduce the number of individuals reporting to the site director.

Concentration of similar functions

The first part of the reorganization principles gives rise to two more detailed recommendations. Accordingly, all maintenance activities should be brought into the Maintenance Section, with shift maintenance being provided by multidisciplinary teams reporting to maintenance line management. Furthermore, a Technical Support Section should be created to provide a strong centre for technical advice and surveillance, outside the immediate control of the Operations and Maintenance Section. This new section would be formed by combining the current Nuclear Safety Section with the technical support functions currently in the Operations Section.

Another organizational recommendation is made in order to establish clear lines of authority and responsibility for those who actually operate the plant. The Operations Section should be reorganized to make the field operators directly responsible to the shift line management. Consideration should also be given to adopting a common shift pattern for all shift operations staff in order to allow effective teams to develop.

Operational quality assurance

The review found a number of well planned arrangements for control of quality in the operating phase, including proposals for internal audit of activities controlled by statutory regulations. Thus, although most of the elements of a quality assurance system are present, they are not drawn together for application in a coherent way. This leads to a recommendation that, beyond current regulatory requirements, an operational quality assurance programme should be prepared, embracing all the activities of the operating organization. Preferably, this should be based on the IAEA NUSS Code 50-C-QA (Rev. 1) of 1988 and associated Safety Guides.

Recruitment of operating staff

The recruitment programme was found to be very well organized, although temporarily suspended owing to the construction delay. The software, developed by CEZ staff, for a database used to plan and monitor the recruitment process was identified as a good practice.

All staff encountered during the review were well motivated, which may be partly due to the company policy of support for continuing education of staff to enable them to gain further qualifications, enhancing their career prospects. Plant staff, however, have not been able to participate fully in the international exchange of experience on nuclear power plant experience through attendance at conferences, visits to other power plants, temporary staff secondments, etc. A change in this policy would be of benefit to both CEZ--ETE and the nuclear industry in general.

Procedure development

The programme for production of operating procedures is well organized, apart from two aspects which led to recommendations. First, an improved specification for the content and format of procedures should be prepared and issued to all engaged in the preparation of procedures as soon as practicable. Second, symptom based procedures, which have better potential for recovery from faults beyond the design basis than event based procedures, should be included in the suite of emergency operating procedures. This places additional emphasis on issues previously raised.

Maintenance Section

The proposed Maintenance Section comprises six active departments covering the mechanical and heavy electrical areas, which are controlled by the deputy director heading this section aided by a team of co-ordinators. These departments are supported by three service departments, for planning, work study and vendor relations, stores and material procurement, and transport. In addition, maintenance workers in the light electrical and I&C areas are found on shift in the Operations Section. It had been proposed to transfer these staff to the Maintenance Section as soon as all units are commissioned. Maintenance out of day hours would be performed by shift maintenance teams of mixed craftsmen under a multidisciplinary foreman per shift. There appears to be no reason for implementing this proposal now.

The preparations being made for maintenance were most impressive in scale. The number of personnel and the range of workshops and equipment

proposed should be more than adequate for the work load, even on this large project. Concepts in line with the latest international thinking were under consideration for condition monitoring and predictive maintenance. It is recommended that these concepts be worked up into a clear predictive/preventive maintenance strategy, leading to the development of a programme over the next two years.

Technical support

The currently proposed organizational setup divides technical support functions between the Nuclear Safety and Operations Sections, with the result that the Operations Section contains a mixture of executive and support functions. The technical support functions are needed for both Operations and Maintenance, however. All technical support functions should be placed outside both the Operations and the Maintenance Sections. Such new Technical Support Section would comprise the present Nuclear Safety Section plus the Reactor Physics and Operational Regimes; the Technical; and the Computer Departments. In addition, the Professional Chemists and Laboratory Analysts and the Engineers responsible for specific plant areas should also be transferred.

Clear operational policies are being developed in the core physics and chemistry areas. The provision of system engineers, each responsible for the technical well-being of a particular plant area, correspond with international practice. Active participation in the commissioning process will equip them well for their future role and ensure that the plant is taken over from the contractors in optimum condition.

Advanced proposals for computing systems to support the operational phase were found to be in keeping with the modern approach. The systems proposed in this area will be a major asset to effective management of this large plant.

The plans reviewed for industrial safety, physical security and fire protection were found to be in keeping with international practice.

8. TRAINING AND QUALIFICATION

Nuclear training activities are effectively organized. The national education system and close co-operation between Temelin and local specialized secondary schools and the Technical University in Praha provide for a good foundation on which to build. Psychological selection tests are used in identifying personnel suitable for operational positions. Specific nuclear training is well defined and carried out in accordance with detailed regulations.

The means of effective implementation are in place, such as the two specialized nuclear training centres in Trnava and Brno, as well as the Dukovany nuclear power plant for OJT. These measures ensure that Temelin will have effectively trained personnel. This basic education policy is considered good.

Organization and administration

The two training centres in Trnava and Brno provide classroom training in nuclear matters and at Trnava a full scope WWER-440 simulator is available. The training centres have qualified staff. For OJT at Dukovany, administrative procedures together with governmental regulations define on-the-job training activities and responsibilities.

The organization of the initial training programmes is considered thorough and balanced. For the different personnel groups A, B, C, D, E, F and G (management staff, control room operators, professionals, shift foremen, foremen, shift workers and other workers, respectively), there are separate training programmes under development which take into account the results of job and task analyses. Training results are checked by means of tests and an examination has to be passed.

For direct operating positions, qualification for the WWER-440 is needed because of the OJT at Dukovany. After operators have worked there for certain periods, qualification training for the WWER-1000 follows. This training

includes classroom training at Trnava or Brno and, for reactor operators and unit and shift supervisors, OJT at WWER-1000 plants in other countries. When the WWER-1000 training package will be available, this will be used for initial qualification training of all other personnel groups.

Simulator training

The initial simulator training on the WWER-440 simulator lasts five weeks, of which three weeks cover normal operation and two weeks cover failures and emergencies. Simulator training is given only to potential control room operators. The main problem in simulator training because of the difference between WWER-440s and WWER-1000s is the lack of a Temelin-type WWER-1000 simulator for qualification training.

A WWER-1000 full-scope simulator is under development at Orgrez, Brno. A delaying factor in the project is the uncertainty concerning the possible changes in the control and protection systems which will affect simulator layout. The current schedule provides for completion of the simulator by mid-1993, when the start of pre-operational testing of Unit 1 is expected. Concerning the siting of simulators, modern developments are leading many nuclear power plants to install a simulator on-site, where it can be used for other purposes in addition to operator training, such as the development and checking of operating procedures.

It is therefore recommended to give a high priority to finalizing the WWER-1000 simulator to enable qualification training of the control room operators to be carried out on a representative full-scope simulator. In the interim, arrangements should be made to allow extensive participation of the operators in pre-operational and startup activities and to familiarize them with WWER-1000 operations. The same applies to the maintenance personnel.

Training centres

The two training centres in Brno and Trnava have well equipped classrooms. At Temelin there are presently no specific training facilities nor are there plans to install any. However, suitable training facilities

(such as classrooms, library, etc.) with necessary teaching aids should be provided. This will be necessary for the conduct of the introductory training (industrial safety, radiation protection, fire protection, etc.) and for the continuing training (training days) of the plant staff.

The Brno training centre has, as a special feature, facilities for psychological testing. In addition, there are two outstanding features, one being the production of video films and computer graphics and the other the development of partial simulation programmes. In Trnava there are similar projects in progress. In both training centres, small scale mock-ups of main primary system components and miniature plant models of the WWER-440 plant are available. In Trnava a full-scope simulator of a WWER-440 (model 213) is in use.

Training material

Student reading material for the WWER-1000 is being prepared and is scheduled for completion in September 1990. However, because of the delays in the Temelin project, the last delivery of some of the final system descriptions will also be affected and this will result in delays for training activities.

Simplified and unified student reading material on the WWER-1000 plant should be finalized before the qualification training of WWER-1000 operators begins. During the subsequent continuing training, possible plant modifications should be handled before the commencement of the pre-operational testing.

Operations personnel

The recruitment programmes for the shift/unit supervisors and control room operators are proceeding well. Of the 50 operators needed for Units 1 and 2, 42 have already been recruited. Most of them come directly from universities, some have reactor operator licenses or turbine operator licences. The remaining three years before the start of physical testing in mid-1993 is enough time for their qualification for shift and unit supervisors

at the Dukovany NPP and for their participation in the early phases of the pre-operational activities and testing at Temelin.

Maintenance personnel

Recruitment of maintenance personnel has started and the chiefs of the different departments have been recruited mainly at the beginning of 1990. Qualification training for the WWER-1000 depends on the employee's background. In the case of personnel who already have WWER-440 training, qualification training for WWER-1000 consists of three to five weeks theoretical training, an examination and practical training. In the case of new employees initial training comprises more theoretical training, additional OJT, an examination and practical training. Dukovany is used for the OJT.

For job related practical training, staff have been divided into several subgroups according to equipment. For each subgroup, agreements have been concluded with the equipment suppliers that Temelin personnel can participate in assembling and testing the equipment in the supplier's factory. Also foreseen is the participation in outages at Dukovany, and in maintenance, equipment verification and development of procedures during construction and in pre-operational testing at Temelin.

Construction personnel

Czechoslovak regulations define in a very detailed manner qualification requirements for all the personnel groups who have safety related duties in the construction phase. These ensure that all requirements are met and that respective training and qualification activities are arranged.

The Welding Research Institute in Bratislava guides the development of welding techniques at the welding schools and supervises the examination boards for the qualification of welders. For nuclear grade welders, special training is provided as well as tests and certificates. Certificates have to be renewed every two years. For welding work in the Soviet design zone it is required that Soviet welding qualification requirements be met. These personnel are tested by the Welding Research Institute or the State Materials Research Institute in Bechovice.

The State Materials Research Institute in Bechovice, provides for the training and examination of personnel involved in non-destructive testing. For each non-destructive testing method (ultrasonic testing, X-ray testing, etc.) there are three qualification levels with associated training and examination requirements. Certificates are issued and must be renewed every five years, while training should be given once a year.

It is recommended that professionals and technicians working in quality assurance and quality control receive training on plant and system knowledge and their design basis to improve their understanding of the safety significance of the equipment they are checking. Furthermore, the two training centres in Trnava and Brno should have special training programmes for personnel working in quality assurance and quality control during the construction and operation of the plant. These programmes should be offered not only for the operating organization but also for contractors.

Start-up personnel

VE Skoda will have 70-80 startup staff for Temelin. Presently, there are 40 persons in this group. About 80% of the staff have undergone training either in Trnava, Brno or the USSR and have experience from earlier projects. These personnel include as a minimum five shift supervisors and five turbine operators whose training was the same as that of the CEZ-ETE operators. The only difference is that the VE Skoda staff are not permanently working in the control room.

Industrial safety

Consideration should be given to improving industrial safety training, especially for the construction personnel, such that more professional industrial safety training is given in addition to the training given by the supervisors. Creation of the right attitude should begin at the vocational schools and these attitudes should be strengthened by the supervisors. For further guidance, see IAEA-TECDOC-535, 'Reviewing Industrial Safety in Nuclear Power Plants'.

9. RADIATION PROTECTION

The proposed radiation protection facilities and equipment are generally good to excellent, and where the staff have observed deficiencies, they have initiated improvements. The staffing and organizational arrangements are appropriate for both normal and abnormal circumstances, and the Radiation Safety Department is independent of the Operations Section. The current staff of 29, out of a planned complement of 125, are competent, thorough, self-reliant and dedicated in their efforts to develop an excellent radiation protection programme for the Temelin nuclear power plant.

Protection in the workplace

Radiation work permits require a radiation inspector to survey the workplace and recommend protective measures as well as the monitoring to be done while the work is in progress. In addition, every worker is required by station regulations to take such measures that doses to himself and others are as low as possible. All exposures greater than 13 mSv must be reported to the Regional Hygiene Centre (Krajska hygienicka stanica, KHS) which is the regulatory authority for radiation protection. Protection is to be optimized using judgement and experience. Consideration should be given to supplementing this approach with one or more of the objective approaches recommended by the International Commission on Radiological Protection (ICRP).

Respiratory protection is to be provided mainly by single-use respirators with a simple dust filter, and by military type respirators if exposure to radioiodines is likely. For greater protection, air supplied protective suits will be available. It is recommended that a programme for regular inspection, testing and maintenance of respiratory protective devices be developed, including air supplied protective suits; and provision should be made for fit testing of respirators and for informing workers in the initial and continuing training programmes about the risks of wearing a leaky respirator in an emergency.

A central radiation control room is to be provided, with a total of 500 inputs from the first two units and the auxiliary building (the Russian designed CIMSRL system). Inputs will include dose rates and concentrations of noble gases, aerosols and radioiodines in working areas, as well as measurements of delayed neutrons, noble gases and radioiodines in the primary circuit. Gamma dose rates will also be measured on the primary circuit, with an alarm on high dose rate, and it is intended to add equipment for gamma spectrometric measurements.

Provisions for some emergency measurements are being designed, including dose rate measuring devices on the reactor dome. The CIMSRL system requires considerable adjustment and maintenance and is being reviewed, with the possibility of using a different system for Units 3 and 4.

Personnel dosimetry

The facilities for internal dosimetry include whole body and thyroid counters, as well as provisions for the analysis of excreta using gamma and alpha spectrometry, liquid scintillation counting and radiochemistry. In an emergency two additional detectors can be installed in separate shielded cubicles within the whole body counter. It is recommended that the procedures for analysis of excreta be reviewed for circumstances when skin contamination prevents whole body counting, with the objective of developing more flexible procedures for identifying persons with high level internal contamination.

External dosimetry is to be done primarily with film badges, with all workers in controlled areas to be monitored. Films are to be changed monthly or on request. Several thousand extra dosimeters can be obtained for emergency use. Thermoluminescence dosimeters (TLD) are also to be worn, in a separate holder attached to the film badge. The shift radiation inspector will be able to process TLDs immediately if required. The replacement of film dosimeters with TLDs as the primary dosimeter is being considered.

It is intended to obtain 100 to 300 modern electronic personnel dosimeters for certain high risk work. Self-reading electroscopic dosimeters and neutron dosimeters will also be available. A calibration facility is

planned which would provide for automatic calibration of several instruments at a time with caesium-137 with dose rates of up to 10 Gy/h.

Personal dose records for each worker provide for recording deep and shallow dose equivalents, intakes of iodine and other radionuclides, and effective dose equivalents. The records for each worker must be kept at the plant for at least 30 years after the worker leaves the NPP. Copies of the records are to be transmitted to the KHS.

Effluent monitoring

The proposed monitoring programmes are comprehensive and capable of providing appropriate information under both normal and accident conditions.

For liquid effluent monitoring, a continuous sample from the liquid waste channel is to be pumped past a monitor, with a sample to be automatically valved into a plastic bottle once every five minutes. The bottle will be changed daily. If an intervention level is exceeded, an emergency sample will be automatically valved into a separate bottle. Analysis for transuranium nuclides will be done whenever an investigation level is exceeded. Investigation levels may be changed annually, depending on the average discharge rate and discharge fluctuations during the preceding year.

For monitoring airborne effluents, each stack will be provided with a variety of samplers and instruments. Actual effluent concentrations are expected to be much lower than the minimum detection level of the presently planned monitors, and it is therefore planned to add a semiconductor gamma spectrometer, which is more selective. High volume samplers will also be used for collecting aerosols, with weekly counting of the filters. Silica gel samplers will be used for tritium, and a cartridge is being designed for sampling iodine. Dose rate measurements are to be made in the stacks, with a range of up to 50 Gy/h. Aerosol filters are to be analysed monthly for strontium and transuranics. Once per day or in the event of high effluent activity, air samples would be compressed into 0.3 L steel bottles and analysed in the laboratory.

A good practice noted with respect to effluent control is that the investigation levels may be varied, depending on the average release rate and release fluctuations during the previous year. This practice was introduced in order to compensate for the decreasing background levels of caesium-137 due to the Chernobyl accident, but it is also a good practice for normal operation because it focusses on changes from normal rather than on some arbitrary and constant investigation level.

Environmental monitoring

The environmental monitoring programme is to be integrated with a national monitoring system being planned by the Institute of Hygiene and Epidemiology (Institut hygieny a epidemiologie, IHE) in Praha. The plant will provide eight comprehensive monitoring stations and 25 TLD stations within 30 km of the the plant, with monitoring by TLD within and beyond the 30 km radius to be done by other organizations. The comprehensive stations will be equipped with high-volume air samplers, whose filters will be changed weekly. Continuous fallout samples will also be provided, with monthly sample collection, and charcoal-silver nitrate cartridges will be provided for sampling iodine compounds.

In addition, a system is being developed for continuous dose rate measurements at 48 locations from 700 to 1500 m from the site, as well as for iodine monitors at 16 stations that would start automatically at a dose rate above some predetermined level. The monitoring information will be transmitted by telemetry to the plant's laboratory in Ceske Budejovice.

The laboratory is to be equipped with two vans to be used during both normal and emergency circumstances for collecting samples and making gamma dose rate and spectrometric measurements in the field. The pressurized ionization chambers and semiconductor spectrometers used for these measurements will also be used for determining surface and soil contamination levels. Samples to be analysed in the fixed or mobile laboratories will include drinking water as well as water from rivers, ponds and lakes and from bore holes around the plant and near waste sites. Fish, sediments, soils and agricultural products are also to be sampled, with the emphasis on milk, which is to be collected from large farms as well as from dairies.

Regulatory authorities

The regulatory authority for radiation protection is the KHS, which obtains expert advice from the IHE. The limits for liquid and gaseous effluents are included in the licences for the nuclear power plant issued by the National Regional Administration. Problems are anticipated owing to the extremely low limits that are expected to be imposed for liquid effluents. For example, continuous discharge of a mixture of corrosion and fission products at the expected concentration limit of 10 Bq/m^3 would result in a yearly dose to the highest exposed members of the public of only about 10^{-5} times the dose limit recommended by ICRP and IAEA. Such a low limit cannot be supported by radiological health protection considerations. Limits, as well as any enforcement of the limits, should have a radiological basis.

Effluent limits should be set according to the recommendations of the ICRP and IAEA. This would require first deriving the amounts of each important radionuclide which, if released during the course of a year to the various environmental pathways, would result in a dose equal to the annual dose limit for the public. Then, an authorized limit should be specified for the total dose from all radioactive effluents, which would be some fraction of the dose limit for the public. Each amount derived in the first step would be multiplied by this fraction in order to obtain the authorized annual release limit for each radionuclide and pathway. Finally, a formula should be specified for limiting the release of mixtures of radionuclides from all effluent streams such that the total dose from all radioactive effluents does not exceed the authorized dose limit for releases.

It is also recommended to determine compliance with any effluent concentration limit on the basis of the concentration of the relevant radionuclide: averaged over a period of a few weeks.

10. RADWASTE MANAGEMENT AND DISPOSAL

In the operation of a nuclear power plant, solid, liquid and gaseous wastes are produced which must be safely processed and disposed of. Liquid and gaseous wastes are collected and decontaminated before discharge into the environment. Concentrates and slurries are solidified and, together with the solid waste, prepared for disposal at the Dukovany repository. Spent fuel is temporarily stored in the power plant for later shipment to the USSR.

The methods selected for the Temelin nuclear power plant to be used for radwaste management are in accordance with international practices. Recommendations are aimed at further improvements in effective radioactivity retention, volume reduction of radwaste and advanced environmental protection.

Radwaste production

The expected waste volumes and activities for liquid and solid wastes are comparable with those of other nuclear power plants, except for the volumes of concentrates from evaporators and spent resins from ion exchangers. Volumes of these waste types are eight to ten times higher than for other plants. It is recommended that the reasons for this should be explored.

Gaseous waste management

The system for off-gas treatment will correspond to international standards concerning principal approach, the processes used and the retention times for noble gases. It will be composed of a gas drying subsystem, a particulate filter and charcoal trains for noble gas retention. Retention times will be 700 hours for xenon and 45 hours for krypton at a maximum flow rate of $60 \text{ m}^3/\text{h}$.

Installation of a filtered venting system for the containment in order to maintain containment integrity in the event of a severe accident is already under consideration by CEZ-ETE. Such a hypothetical event, which presumes major core damage due to long-term loss of residual heat removal, would be

coped with by a controlled pressure relief via filter systems. For the Temelin site, a common system could be developed which would serve all four units. These plans, which reflect the most recent approach in several European countries, are endorsed.

Waste water management

Design and process principles of the waste water treatment system correspond to international practice. It is composed of collector and discharge tanks and equipped with evaporators and ion exchange filters. Tank sizes and capacities of the process units are adequate for the waste volumes expected. For the treatment of laundry water, a precipitation process is foreseen.

To reduce the solid waste volumes from the laundry water treatment substantially, the precipitation process should be replaced by a centrifugation process. Investigations should also be initiated to minimize the waste water volumes coming from the steam generator blowdown ion exchangers. An option would be monitoring and segregating active from inactive waste and providing for external regeneration.

Concentrates, slurries and spent resins

For solidification of concentrates, slurries and spent resins, two processes have been developed. One is the calcination of the waste plus mixing of the calcinates with bitumen in a separate unit. The other one is the evaporation of the waste water and simultaneous mixing of the solids with bitumen using a rotor film evaporator.

The equipment is in an advanced stage of development. There is as yet no long term operating experience of the systems and equipment. It is still to be decided which of the methods will eventually be given priority. The possibility is even being considered of installing a combination of both technologies to provide more redundancy. Bituminization of the waste has been chosen owing to the need for very low leach rates and final storage in above ground pits. It is recommended that the development and pilot plant tests to

be accelerated in order to have the solidification equipment verified and available for operation at the time of startup of the first unit. Such thorough preparation is necessary to prevent potential trouble originating from modifications or repairs in high radiation areas once the plant has been put into operation. Studies should also be carried out of the behaviour of bituminized dried resins in case the product is exposed to water and to high level radiation.

Solid waste management

The different types of solid waste are sorted according to contaminated parts and conventional trash. Contaminated waste will be pressed into drums by a low pressure compactor. Non-compactible waste in smaller pieces will be put into drums. Larger metal pieces will be decontaminated. All the wastes will be temporarily stored in the power plant to await shipment to the repository at Dukovany. The system design and the measures taken for the management of the solid waste are in accordance with international practices. Until the incineration plant presently under development is operable, burnable and compactible wastes should be compressed by a super compactor (1500 tonnes) for further volume reduction.

For packaging of solid and solified waste, it is planned to use 200 L steel drums. Filling, drum capping and manipulation of the drums will be accomplished in a remotely controlled work station designed for use in Temelin. The waste drums are transported in cast iron containers. These shielded containers are placed in special racks for shipment in normal transport containers.

Spent fuel, in core lances and spent control rods are temporarily stored in the fuel pool. Smaller activated parts are placed in concrete vaults in the plant for lifetime storage. Compact storage of the spent fuel will be provided in the fuel pool of each unit to maximize the storage capacity. All these measures correspond to international practices. According to earlier agreements, spent fuel is expected to be sent later to the USSR.

Radwaste repository

For final engineered storage of low and medium level radioactive waste, above ground pits are foreseen at the Dukovany site. A three barrier approach has been taken to provide for immobilization and enclosure: bitumen as the binding agent for the waste, leaktight construction of the pits and favourable hydrogeological conditions (a low ground water velocity). The construction of the pits is based on a multiple wall design, with asphalt/concrete/polyethylene layers between the walls. The effectiveness of the three barrier concept against contamination of drinking water was demonstrated in the Preliminary Analysis Safety Report.

Extensive efforts have been made in research and development, safety evaluations and calculations, and design and construction to ensure the highest possible safety for the final waste storage. Burial with and without engineered storage is an internationally accepted method. It was recommended that during the operation of the repository a thorough control programme should be carried out for pit structures, the drainage system and the ground water. All results should be carefully recorded.

Furthermore, a documentation system should be set up to provide information on type, radioactivity and origin of the waste buried in each pit. Experience with similar storage facilities in operation in other countries (e.g. France and USA) should be followed up to obtain additional useful information for possible improvements. It is suggested that investigations also be carried out on waste storage in the deep underground, e.g. in abandoned or still operating mines, and to follow up on similar work in the Federal Republic of Germany, Sweden, Switzerland and the USA to learn whether these methods offer viable alternatives.

11. EMERGENCY PLANNING AND PREPAREDNESS

Since Temelin is under construction, emergency plans, procedures and facilities for the operational stage have not yet been prepared. However, there are already other nuclear power plants in operation in Czechoslovakia, so the regulatory and organizational framework for emergency planning exists and relevant experience is available.

In view of the date of the planned arrival of the fuel on the site (1993), timely completion of the emergency plans and development of emergency preparedness is expected.

Off-site emergency responsibilities

On the federal level, a Governmental Emergency Commission was established for the co-ordination of measures in the event of a nuclear accident. In 1989, a basic regulation was issued that defines the responsibilities of the various off-site organizations and the possible protective measures, the intervention levels and the emergency planning zones (EPZ). It sets up a system of emergency commissions on the levels of the regions, districts, towns and villages. For off-site emergency planning and preparedness the regional emergency commission is responsible. In the case of Temelin, this is the Regional Emergency Commission of South Bohemia, chaired by the chairman of the Regional Administration, with five deputies (including the chief of the regional civil defence staff and the director of the nuclear power plant).

Site emergency responsibilities

The Temelin site emergency organization and plan has to comply with the relevant regulations in force and will take into account the emergency organization and plan of the Dukovany nuclear power plant as modified after the OSART mission at that plant in 1989. It should be considered, however, that the shift supervisors have too many responsibilities in connection with the notification to off-site organizations under the present setup. These responsibilities should be delegated to other persons. The site director will

not be able to participate in the work of the Regional Emergency Commission; this responsibility should also be assigned to another knowledgeable staff member at the plant.

According to the governmental regulations on radiation monitoring, an Operative Monitoring Group will be set up in the event of an emergency. This group provides all the data for the assessment of the environmental situation, by means of the personnel and equipment of the nuclear power plant, the relevant regional services and other organizations. The Operative Monitoring Group reports to the monitoring centre at the Institute of Hygiene and Epidemiology (IHE), which assesses the situation and advises the Governmental Emergency Commission on actions to be taken. The Regional Emergency Commission decides on protective measures upon the recommendation of the Governmental Emergency Commission.

Emergency planning zones

The basic regulation for emergency planning zones (EPZs) and protective measures was issued after the Chernobyl accident and incorporates unnecessary conservatism, requiring upon notification that immediate protective measures be taken all around the nuclear power plant in a 30 km zone before any assessment of the situation.

It should be considered whether to rely more on the assessment of the situation beyond a 10 to 15 km radius around the plant. The procedure of assessment and decision making should be supported by defining derived intervention levels and by developing models for the dispersion of the release in the environment and for dose prediction.

Co-ordination, communication and notification

Since assessment and decision making in the planned emergency organization take place on different levels, the flow of information and communications should be well organized between the site, regional and federal levels, as well as between the organizations concerned. Close co-ordination should be established between the nuclear power plant and the responsible

public authorities during emergency planning. A dedicated group of two or three people should be organized in the nuclear power plant to develop the site Emergency Plan and to ensure co-ordination and integration into the off-site emergency plan.

The emergency plan for the region is now under development. The work is based on high level conventional civil defence practice and is directed by the regional civil defence staff. Within the framework of the civil defence organization, redundant channels and means are available for notification and communication as well as for warning the public.

The nuclear power plant will establish a public warning system (a so-called HDO system) for the 30 km zone around the plant. This system will ensure a very rapid warning, quicker than by the means of the civil defence organization.

For rapid and correct data and information exchange, facsimile machines (telefax) should be installed on-site and in off-site organizations, in particular for transmission of diagrams, tables, etc.

Facilities, equipment and resources

For on-site personnel protection, three shelters will be available. One will serve as an emergency control and technical support centre. This shelter should be provided with a data transmission and display system for the most important technical parameters of the plant.

The planned and partly already existing fire protection system will have adequate facilities, equipment and personnel for coping with fires. The well equipped meteorological station will be in full operation later this year.

Medical care is available on-site 24 hours a day during the construction of the plant. For the operational stage, a traumatological plan will be developed, ensuring communication with and the possibility of support from off-site medical facilities. There is an agreement of collaboration already in force between the nuclear power plant and the health care centre of the uranium mines in Příbram.

For the purposes of the off-site emergency response, the civil defence organization has appropriate shelters and headquarters and personal protective equipment.

Co-ordinated planning

All eight districts of the southern Bohemia region participate in off-site emergency planning and preparedness. If the system of regions is to be changed eventually, the co-ordinated planning and decision making should be maintained by appropriate means (e.g. a territorial emergency organization comprising all the districts concerned, supported by a similar civil defence organization).

It is expected that the development of the emergency plans will be completed by mid-1992, one year before the fuel arrives on the site. This provides an opportunity to organize a combined on-site and off-site staff exercise. This could reveal possible shortcomings, check connection lines and prove the capability of the system to cope with accidents.

Public information

Owing to increasing antinuclear activities, special emphasis has to be placed on supplying information about emergency response planning to the public in Czechoslovakia and to neighbouring countries.

The recently organized Public Information Centre and the Public Safety Committee are significant steps in this direction. Provisions should be made to provide the public with readily understandable information relating to emergency planning, drills and exercises, and protective measures.

Consideration should be given to making necessary arrangements with the authorities in Ceske Budejovice for a press centre to be used in the event of an emergency. Based on the agreement with Austria and the Federal Republic of Germany, regional level contacts with public authorities of the neighbouring regions should be established to enhance mutual understanding and acceptance as well as to prevent misinformation.

ACKNOWLEDGEMENTS

The Czechoslovak Federal Ministry for Fuel and Energy, the Czechoslovak Atomic Energy Commission, Czech Power Works (CEZ) and especially the Temelin nuclear power plant (ETE) provided valuable support for the IAEA Pre-OSART mission to the Temelin construction site. The traditional close co-operation of the Czech and Slovak Federal Republic with the IAEA in various nuclear safety activities, and the participation of a number of Czechoslovak experts and scientific visitors in previous OSART missions, had already established personal contacts and a common basis for continuing work. The advance information provided to team members was a valuable assistance to the Pre-OSART.

Throughout the whole mission, CEZ, ETE and contractor personnel were most co-operative, open-minded and helpful in locating sources of information and responding to queries. Their co-operation was instrumental in maintaining a professional and highly productive working atmosphere from the first day to the last.

The Pre-OSART wishes to thank all Czechoslovak organizations, including federal, regional and local authorities; the Dukovany nuclear power plant; construction companies, equipment manufacturers, and research institutes for their support and the excellent co-operation. The work of the liaison officers, plant counterparts, interpreters and secretaries was outstanding.

ANNEX I: COMPOSITION OF THE TEMELIN TEAM

Experts

ARO, Ilari - IAEA
Division of Nuclear Safety
Senior NPP Operational Safety Specialist
16 years of nuclear experience
Review area: Training and Qualification

BUSH, William - IAEA
Division of Nuclear Safety
NPP Operational Safety Specialist
33 years of nuclear experience
Review area: Radiation Protection

CANDLISH, J.R. Ralph - CANADA
Atomic Energy of Canada Limited
Engineer, Construction and Modularization
33 years of nuclear experience
Review area: Mechanical Equipment

CORCORAN, James - USA
Philadelphia Electric Company
Superintendent, Business Unit
20 years of nuclear experience
Review area: Quality Assurance

CZOCH, Ildiko - HUNGARY
National Atomic Energy Commission
Head, Nuclear Safety and Safeguards
19 years of nuclear experience
Review area: Emergency Planning and Preparedness

DOLFI, Pietro - ITALY
ENEL, Ente Nazionale per l'Energia Elettrica
Chief, Construction Section
6 years of nuclear experience
Review area: Civil Construction

DULAR, Janez - IAEA
Division of Nuclear Safety
Senior NPP Operational Safety Specialist
24 years of nuclear experience
Review area: Preparation for Start-up

ERWIN, Ashley - IAEA
Division of Nuclear Safety
Senior NPP Operational Safety Specialist
26 years of nuclear experience
Assistant Team Leader

ANNEX I: COMPOSITION OF THE TEMELIN TEAM (Continued)

FRANZEN, Ferdinand L. - IAEA
Division of Nuclear Safety
Head, NPP Operational Safety Services Section
35 years of nuclear experience
Team Leader

QUEISER, Horst - FEDERAL REPUBLIC OF GERMANY
Siemens-UB KWU 153
Deputy Director, Waste Management
28 years of nuclear experience
Review area: Radwaste Management and Disposal

RAUMOLIN, Heikki - FINLAND
Perusvoima Oy
Technical Director
20 years of nuclear experience
Review area: Project Management

ROESSLER, Wolfgang - FEDERAL REPUBLIC OF GERMANY
Siemens AG, KWU-R 122
Senior Commissioning Engineer
15 years of nuclear experience
Review area: Electrical Equipment

WRIGHT, Peter - UK
Nuclear Electric plc, Sizewell B Power Station
Operations Manager
18 years of nuclear experience
Review area: Preparation for Operation

Scientific Visitors

IVANOV, Ivan - BULGARIA
Energoprojekt - Sofia
Chief Design Engineer
17 years of nuclear experience
Training area: Project Management

MIHAILOVA, Vessela - BULGARIA
Energoprojekt - Sofia
Head, Department of Civil Construction
17 years of nuclear experience
Training area: Civil Construction

NICORESTIANU, Stefan - ROMANIA
National Commission for Nuclear Activities Control
Senior Inspector
20 years of nuclear experience
Training areas: Preparation for Start-up and
Emergency Response Planning

ANNEX II: SCHEDULE OF ACTIVITIES

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| 1. Invitation for the preparatory meeting | 23 January 1990 |
| 2. Preparatory meetings in Prague and at Temelin site | 29-31 January 1990 |
| 3. Request for Pre-operational Safety Review of Temelin nuclear construction site | 14 February 1990 |
| 4. Approval of the mission by IAEA Nuclear Safety Division and Technical Cooperation | 16 February 1990 |
| 5. Recruitment of team members | February/April 1990 |
| 6. Pre-Operational Safety Review of Temelin Nuclear Power Plant | 23 April-11 May 1990 |
| 7. Concluding meeting and press conference | 11 May 1990 |
| 8. Submission of report | July 1990 |