REPUBLIC OF TURKEY

EUROPEAN "STRESS TESTS" FOR NUCLEAR POWER PLANTS

NATIONAL REPORT OF TURKEY

May 2012

TURKISH ATOMIC ENERGY AUTHORITY

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ABBREVIATIONS

ACNS : Advisory Committee on Nuclear Safety

AEC : Atomic Energy Commission

APC : Akkuyu Project Company (Akkuyu NPP Electricity Production Co.)

BDBA : Beyond Design Basis Accident

DBA : Design Basis Accident

DBE : Design Basis Earthquake

DCH : Direct Containment Heating

DG : Diesel Generator

EPSS : Emergency Power Supply System

EUR : European Utility Requirements

IAEA : International Atomic Energy Agency

JSC : Joint Stock Company

MENR : Ministry of Energy and Natural Sources of Turkey

NPP : Nuclear Power Plant

NPT : Non-Proliferation Treaty

PAR : Passive Autocatalytic Recombiners

PHRS : Passive Heat Removal System

PMF : Probable Maximum Flood

PMP : Probable Maximum Precipitation

PMT : Probable Maximum Tsunami

PSAR : Preliminary Safety Analysis Report

SAMG : Severe Accident Management Guideline

SFP : Spent Fuel Pool

SG : Steam Generator

SSE : Safe Shutdown Earthquake

TAEK : Turkish Atomic Energy Authority

TEK : Turkish Electricity Authority

VVER : Russian design Pressurized Water Reactor

INTRODUCTION

This report is prepared in accordance with the European Nuclear Safety Regulators Group (ENSREG) requirements for performing comprehensive risk and safety assessment in the light of the Fukushima accident.

Turkey has currently no nuclear power plants in operation, under construction or decommissioned. However, negotiations to build a NPP at a site named Akkuyu in Turkey started with the Russian Federation in February 2010 and concluded with an Intergovernmental Agreement based on a Build-Own-Operate model. The Agreement was signed on May 12, 2010. Relying on the agreement, "Akkuyu Nuclear Power Plant Electricity Generation Joint-Stock Company (Akkuyu Project Company, APC)," responsible for the construction and operation of 4 units Water-Water Energetic Reactor, VVER, of each to produce 1200 MW power, was established. The nuclear regulatory body of Turkey, Turkish Atomic Energy Authority (TAEK), recognized APC as the owner (hereafter referred to as Applicant) on February 7, 2011.

The Akkuyu Site on the Mediterranean coast was granted a site license for building a Nuclear Power Plant (NPP) in 1976. In 2011, this site was allocated to Applicant as specified in the Agreement. Applicant started site investigations in Akkuyu for updating the site characteristics and parameters according to the national procedures laid out in the Decree on Licensing of Nuclear Installations. Upon completion of updating the information on the characteristics and parameters of the site and their approval by TAEK, Applicant may apply to TAEK for a construction license.

The report contains mainly seven topical areas in conformity with the ENSREG Guidance for the content and format of National Reports, and additionally an introductory chapter on Turkey's legislative and regulatory framework . The first chapter includes general information about the site and the plant design. In Chapters 2, 3 and 4, site and design features related to external events including earthquakes, floods and extreme weather conditions in the Akkuyu site are presented respectively. The information on the scenarios involving loss of electrical power and loss of ultimate heat sink are submitted in Chapter 5. Chapter 6 focuses on evaluation of actions considered in preliminary design documents and reference plant design to prevent severe fuel damage in the reactor core and spent fuel pool and also the plant response and the effectiveness of the preventive measures to be implemented in severe accident management strategies. It should be noted that the information in Chapters 2 through 6 presented by Applicant has not yet been approved by TAEK; the information will be reviewed and assessed in the course of licensing.

0. LEGISLATIVE AND REGULATORY FRAMEWORK IN TURKEY

0.1. Legislative framework

Turkish regulatory structure is composed of laws, decrees, regulations, guides and standards. The hierarchical pyramid of Turkish regulatory structure is given in Figure 1.

Within this structure, the current legislative and regulatory framework of Turkey is consistent with international conventions and treaties, and also satisfy IAEA requirements regarding nuclear safety and security.

Turkey's legislative and regulatory framework ensures that nuclear materials and facilities are utilized and nuclear activities are performed with proper consideration for health, safety, security and protection of people and the environment. In this respect, Turkey signed and/or approved international agreements and conventions, a list of which is given in Annex I.

Turkey is party to the Convention on Nuclear Safety.

As a non-nuclear weapon state party to the NPT, Turkey has established a system of accounting for and control of nuclear materials based on a Safeguards Agreement and an Additional Protocol with the IAEA. Turkey has received an ISSAS mission of IAEA in June 2010, who reviewed this system with respect to the requirements of the Safeguards Agreement and the Additional Protocol.

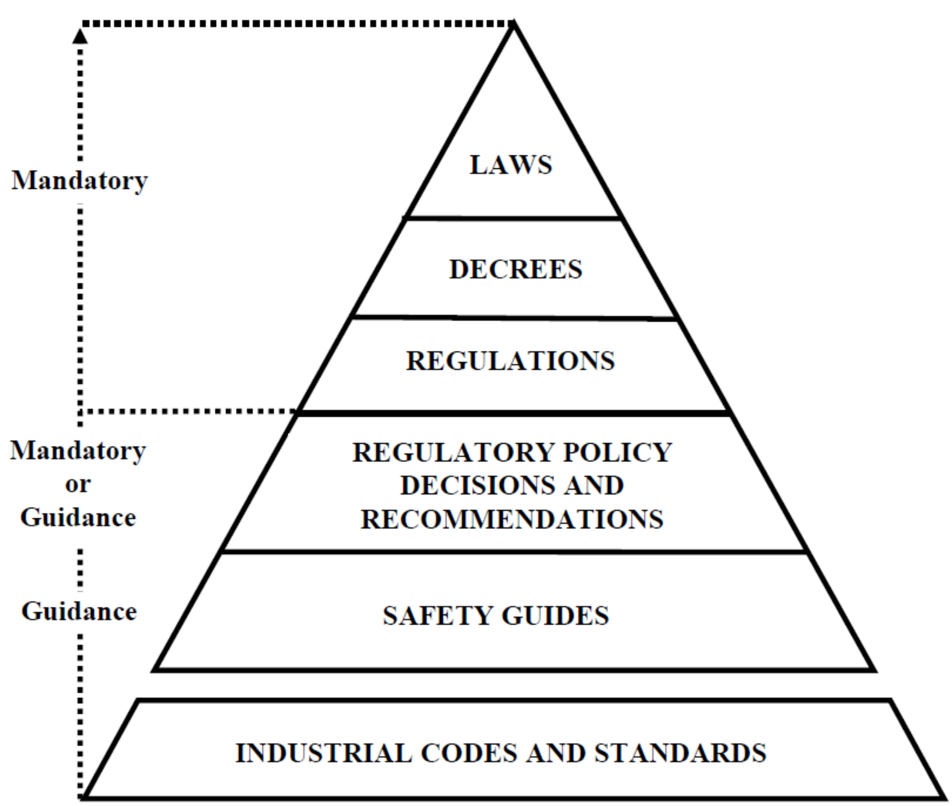

Figure 1 Regulatory Pyramid in Turkey

Turkey is also party to the Convention on Physical Protection of Nuclear Material and implemented its requirements in national regulations. Current regulations are under revision to introduce latest changes to these systems.

The main Turkish legislative framework regulating nuclear installations consists of the "Law on Turkish Atomic Energy Authority" regarding nuclear safety, security and radiation protection; the "Environmental Law" regarding environmental impact of these facilities; the "Penal Law", which also defines nuclear and radiological crimes and penalties; and the "Law on Electricity Market" regarding electricity production licenses. There are several other government bodies such as Ministry of Health, Ministry of Transport, Maritime Affairs and Communications, etc., which indirectly regulate an NPP as an industrial facility.

Regarding nuclear safety and radiation protection, there is the "Decree on Licensing of Nuclear Installations", which lays out the rules and procedures for licensing of nuclear installations.

Further details on safety principles are addressed in regulations. There are currently 14 regulations directly or indirectly addressing safety of nuclear power plants. The list of the laws, decrees, regulations and guides that are relevant to the nuclear power plants is given in Annex II.

Another important regulatory document is the "Directive on Principles of Licensing of Nuclear Power Plants", which lays out the rules for establishing a licensing basis for NPPs. These rules state that the issues insufficiently addressed by existing Turkish regulations on nuclear safety shall be covered by requiring compliance with the regulations of the vendor or designer country and the IAEA safety documents, particularly, safety fundamentals and safety requirements. For remaining issues, third party country laws, regulations and standards are referenced. The directive also requires the Applicant to submit the regulatory body a reference plant of the proposed design for facilitating the licensing process.

Rules and procedures related to the licensing of nuclear installations are laid out in the "Decree on Licensing of Nuclear Installations", entered into force in 1983. The decree defines permits and licenses to be obtained, requirements for applications to these permits and licenses, including lists of documents to be submitted, review and assessment procedures, the responsible entities within TAEK for each authorization, approval mechanisms for modifications during construction and operation; and authorizes TAEK for inspecting the installations throughout their lifetime and enforcing penalties such as limiting, suspending and revoking the licenses.

Rules and procedures for accounting for and control of nuclear materials are described in the "Regulation on Accounting for and Control of Nuclear Materials", which satisfy the requirements of the Safeguards Agreement with the IAEA. This regulation is under revision for ensuring compliance with the additional protocol. The national aspects of Convention on Physical Protection of Nuclear Material have been implemented in the "Regulation on Physical Protection Measures of Special Nuclear Materials". This regulation is under revision for ensuring compliance with INFCIRC 225/Rev. 4.

There are several regulations associated with nuclear safety. Suitability of NPP sites is addressed in the "Regulation on Nuclear Power Plant Sites". Basic requirements on design of an NPP are laid out in the "Regulation on Design Principles for Safety of Nuclear Power Plants" and on construction, commissioning, operation and decommissioning of an NPP in the "Regulation on Specific Principles for Safety of Nuclear Power Plants".

Nuclear and radiological emergencies are covered in the "National Regulation on Nuclear and Radiological Emergencies". This regulation only covers the roles and responsibilities of governmental authorities in case of a radiation emergency. Requirements on emergency preparedness and response are addressed by IAEA Safety Requirement GS R-2.

There are draft regulations that cover radiation protection, operating personnel qualification and licensing, clearance and release of sites from regulatory control and radioactive waste management in nuclear installations.

In Turkey, nuclear installations are licensed by TAEK regarding nuclear safety, security and radiation protection issues. Licensing procedure is initiated by the application of the owner to be recognized as such. Licensing process for a NPP comprises three main stages in succession: Site License, Construction License and Operating License. There are several permits functioning as hold points during the licensing process, such as limited work permit, commissioning permit, permit to bring fuel to site, fuel loading and test operations permit for operating license, etc. For each authorization, documents required for review and assessment of TAEK are defined in the Decree. The Decree also requires the owner to apply for authorization of TAEK for every modification that may have an impact on the safety of nuclear installation.

It is explicitly declared in the Decree on Licensing of Nuclear Installations that nuclear installations cannot be operated without a valid license. The Penal Law defines operating a nuclear installation without a valid license as a felony, punishable by imprisonment.

In addition, NPPs should obtain an affirmative decision on environmental impact assessment according to the "Regulation on Environmental Impact Assessment" from the Ministry of Environment and Urban Planning as a prerequisite to the site license and an electricity production license from the Energy Market Regulatory Authority.

Regulatory inspection and enforcement activities cover all areas throughout the lifetime of a nuclear installation. Inspection of TAEK does not relieve the authorized person/organization of its responsibility for ensuring nuclear safety. The main philosophy for the regulatory inspection is "Trust and Verify". This is achieved by planning the overall approach in scope and content of the inspection to be conducted, not only limited to the authorized organization but also to include its contractor and supplier chains. TAEK conducts inspections to satisfy itself that the authorized organization is in compliance with the conditions set out in the authorization and applicable regulations, based on the "Regulation on Nuclear Safety Inspections and Enforcement". Enforcement actions may be taken, as deemed necessary, by TAEK in the event of deviations from, or non-compliance with, conditions and requirements.

Regulatory inspection includes a range of planned and reactive inspections over the lifetime of a nuclear installation and inspections of other relevant parts of the operator's organization and contractors/suppliers to ensure compliance with regulatory requirements. The methods of inspection include examination and evaluation of all records and documentation, and surveillance, monitoring, auditing and interviewing of personnel and management, as well as performing of actual tests and measurements in all phases of the installation. In addition to TAEK staff, outside local or foreign services may be procured for specific inspection tasks for the purpose of pre-evaluation and obtaining data where necessary.

The Decree on Licensing of Nuclear Installations authorizes TAEK to grant, decline, limit the scope, suspend and revoke the licenses. TAEK may put a formal request to the Prime Minister to close down a nuclear installation.

In case of regulation violations, TAEK takes into account importance, urgency and seriousness of the violations in regard to nuclear safety for the imposed enforcement. All decisions and actions by TAEK may be challenged by any interested party through the legal system of Turkey.

0.2. Regulatory body

Regulatory body of Turkey in nuclear and radiation area is Turkish Atomic Energy Authority (TAEK), which undertakes all regulatory activities concerning nuclear and radiation safety together with coordination and support of research and development activities in nuclear field.

TAEK was established by the Law on Turkish Atomic Energy Authority as a government body reporting to the Prime Minister. TAEK has been affiliated with the Ministry of Energy and Natural Resources (MENR) since 2002.

TAEK is responsible for defining safety measures for all nuclear activities and for drafting regulations concerning radiation protection and the licensing and safety of nuclear installations.

More specifically, TAEK is responsible for the following:

- Formulating the general policy and relevant programmes on peaceful use of nuclear energy and submitting to the Prime Minister for approval,
- Carrying out and/or coordinating research on nuclear energy applications to support scientific, technical and economic development of Turkey,
- Issuing licenses to private and state enterprises conducting various activities involving radioactive materials, supervising such enterprises from the radiological safety standpoint, and ensuring that licensing conditions are complied with,
- Issuing approvals, permits and licenses for siting, construction, operation and decommissioning of nuclear power and research reactors and nuclear fuel cycle facilities,
- Performing review, assessment and inspection,
- Granting, declining, limiting the scope, suspending and revoking licenses and putting a formal request to the Prime Minister to close down a nuclear installation,
- Drafting rules and regulations related to nuclear and radiation safety,
- Ensuring the safe transport, processing, storage and disposal of radioactive waste produced by nuclear installations and radioisotope laboratories, and
- Training the personnel for the nuclear sector.

TAEK is headed by a president, assisted by three vice presidents, who are appointed by the President of the Republic of Turkey. The administrative organs of TAEK include the Atomic Energy Commission, the Advisory Council, specialized technical and administrative departments and research centers.

The Atomic Energy Commission (AEC), under the chairmanship of the President of the Turkish Atomic Energy Authority, consists of the Vice Presidents, one member from each of the Ministries of National Defense, Foreign Affairs, Energy and Natural Resources and of four faculty members in the field of nuclear energy. Duties of AEC are:

- To set the working principles and programs of TAEK, to approve the draft budget for submittal to the Prime Minister,
- To draft and submit to the Prime Minister laws, decrees and regulations related to nuclear field, and

- To observe and evaluate the studies of TAEK, to submit the annual work program and annual work report to the Prime Minister.

AEC also acts as a decision making body for licenses and some of the permits for nuclear installations.

The Advisory Council consists of faculty members working in the nuclear field and experts from other related institutions and bodies, and meets upon invitation. The members of the Advisory Council are appointed with the nomination of the AEC and approval of the Prime Minister. The Council is invited to meet at least once a year by the President of the TAEK who presides the meeting. The Advisory Council comments on the subjects addressed by the AEC.

TAEK's main organization consists of four technical and one administrative department:

- Nuclear Safety Department (regulatory activities in nuclear safety and security),
- Radiological Health and Safety Department (regulatory activities in radiation, transport and waste safety),
- Technology Department (technological development in nuclear field),
- Research, Development and Coordination Department (coordination of all kind of activities in nuclear field), and
- Administrative and Financial Affairs Department (administrative and financial activities of TAEK).

Main responsibilities of Nuclear Safety Department are the licensing of nuclear installations (review and assessment of documentation related to nuclear safety), preparation and amendment of regulations and inspection of nuclear installations. In case of need, assistance from a technical support organization may be sought during licensing of a NPP.

Nuclear installation licensing responsibilities are shared among Nuclear Safety Department and the Advisory Committee on Nuclear Safety (ACNS). ACNS is established and its main responsibilities are defined in the "Decree on Licensing of Nuclear Installations". The members of ACNS are faculty members and experts working in relevant fields. ACNS performs an independent review of the documents submitted with license applications.

Nuclear Safety Department of TAEK has maintained its human and financial resources at a level based on adequacy for regulatory supervision over existing nuclear installations. Currently, Nuclear Safety Department has 50 technical staff.

1. GENERAL DATA ABOUT THE SITE AND NUCLEAR POWER PLANT

1.1. Brief description of the site characteristics

Akkuyu NPP site is located on the Mediterranean Sea coast in the Province of Mersin. The Site is situated approximately 47 km south-southwest of the town of Silifke and approximately 140 km west-southwest of the city of Mersin. Figure 2 presents the Akkuyu NPP site location.

The surrounding area is surrounded by hills of height up to 200 m, which are a natural boundary of the NPP accommodation area. Ground elevation varies from 0 to 50 m above the sea level. The topography of the Akkuyu NPP site is flat coastal plain. The valley in the middle of the hills is open to the sea in the west-southwest direction. The ground is covered with a forest of dense and small trees. The topography of the site plays an important role in determining the climate of the region.

There are no swamplands at the Akkuyu NPP site accommodation area. There are no water storage basins or reservoirs that may affect the Akkuyu NPP site.

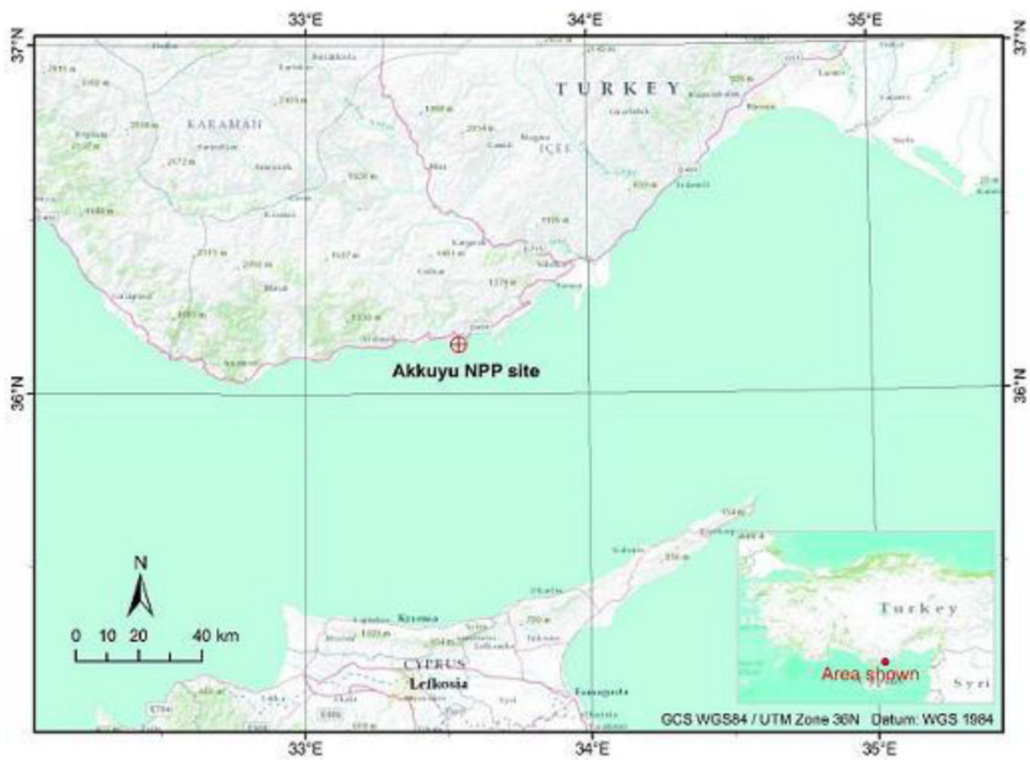

Figure 2 Akkuyu NPP site location

1.1.1. Main characteristics of the units

The Akkuyu NPP is a VVER-1200 design with a rated electrical power of 1200 MWe, and a thermal power output of 3200 MWt per unit. The power generating unit includes a pressurized water-cooled nuclear reactor and a steam turbine unit. This design is based on VVER-1000 type reactors with increased rated power and upgraded system design.

1.1.2. Description of the systems for conduction of main safety functions

In order to protect the reactor from accidents, the systems related to safety such as protection systems, localizing systems, support systems and control systems are provided in the NPP design, in compliance with the defence-in-depth concept.

A double channel design for active safety systems and a four channel design for passive systems are incorporated into the plant. The active double channel safety system design provides the ability to respond to any Design Basis Accident (DBA) scenario and maintains a safe status of the reactor plant, in the event of any associated channel failure, any non-associated active component failure or in the case of operator error in any other channel. This design allows a single safety channel to be out of service for maintenance or any other reasons for a limited period of time during unit operation.

In case of loss of off-site power supply, the safety-related equipments are powered from two independent emergency DGs – one per safety system channel. Each of the DGs is capable to bear all the loads of the given safety channel and is intended for on-load operation with no maintenance for 240 hours. The DGs are located in special rooms designed to withstand category I seismic loads and shock waves and are electrically independent from each other. The DGs are equipped with main autonomous systems for fuel, oil and cooling water, air systems for suction of air and release of gasses, as well as electric systems. The DGs are always in the standby mode.

The systems and the safety functions which they fulfill are shown in Table 1.

Table 1 Plant systems and safety functions

Safety functions	**Safety systems**	
	Active systems	**Passive systems**
1. Reactivity control		
- prevention of unacceptable changes in reactivity; - keeping the reactor in a safe, subcritical state - shut down of the reactor in order to prevent anticipated operational occurrences, leading to design based accidents and in order to limit the consequences of design based accidents	Reactor Control and Protection System (Reactor Trip System), Emergency boron injection system	Reactor Trip System (in case of loss of off-site power)
2. Heat removal from the core		
- Keeping a sufficient quantity of coolant for cooling the core during and after design basis accidents, when the boundaries of the coolant circuit are intact; - Residual heat removal in certain operational states and accidents when the coolant circuit boundaries are intact;	Steam Generator Emergency Cooldown System Emergency Boron Injection System Emergency and Planned Primary Circuit cool-down and Spent Fuel Pool cooling system	System for Passive Heat Removal ECCS Hydro- accumulators of first and second stages
- Keeping a sufficient quantity of coolant for cooling the core during and after all postulated initial events; - Heat removal from the core after a rupture in the coolant circuit	Emergency and Planned Primary Circuit cool-down and Spent Fuel Pool cooling system Emergency Gas Removal System	System for Passive Heat Removal – ECCS Hydro-accumulators of first and second stages

Safety functions	Safety systems	
	Active systems	**Passive systems**
boundary so that the damage of the fuel rods can be limited		
- Residual heat removal from the spent fuel, storage outside the core;	Emergency and Planned Primary Circuit cool-down and Spent Fuel Pool cooling system (as backup) Spent Fuel Pool Cooling System	Additional reserve of water in the spent fuel pool
- Maintaining a subcritical state when the fuel is stored outside the core, SFP	Structure of Spent Fuel Pool, racks made of boron steel	
- Sustaining the design tightness of the claddings of the fuel rods in the core	All the above mentioned system ensuring cooling of the core	
- Sustaining of the integrity of the reactor coolant system (RCS) boundary - Sustaining the integrity of the secondary circuit	Primary Circuit Overpressure Protection System (PRZ PORV actuated by control signals) Secondary Circuit Overpressure Protection System (SG PORV actuated by control signals)	PORV are actuated mechanically when a certain pressure is reached without any control signal
3. Confining of radioactive substances		
- Ensuring the integrity of the last physical barrier against spread of radioactive products	Containment Spray System	System for Passive Heat Removal Large volume of the containment which excludes a rapid change of the parameters Core catcher (in case of severe accidents) Passive hydrogen removal system (recombiners)
- Retention of radioactive substances within the volume of the hermetic structure in all types of postulated accidents	Systems of isolation valves at the boundary of the containment	Hermetic structures with double containment A system of airtight premises in the primary containment A system of airtight penetrations A filter-ventilation system of the annular space between the primary and secondary containments

Detailed description of all systems relevant to safety will be assessed by TAEK during licensing. Only generic data about the VVER-1200 design is available at the moment.

2. EARTHQUAKES

Turkey is situated in seismically active area and this fact imposes significant importance of the seismic investigations of the site. Turkish regulatory requirements address this fact and include additional specific requirements for seismicity of the site and the plant.

The Applicant has been conducting earthquake surveys in compliance with Turkish regulations, IAEA requirements and Fundamentals, and Russian Federation Regulations.

According to the Russian requirements for newly designed NPPs regardless of the site seismicity the seismic accelerations corresponding to SSE shall be taken as at least 0.10 g. The seismic accelerations corresponding to the OBE shall be taken as at least 0.05 g [1]. According to the Turkish requirements S1 is defined as a half of the minimum level of S2. The acceptable minimum level of S2 should be 0.15 g. This particular case demonstrates the high level of rigor of the Turkish national seismic requirements.

2.1. Design basis

Turkish Regulation on Nuclear Power Plant Sites, issued in 21.03.2009 gives a definition of the design levels S1 and S2 [1]:

"S1: Maximum earthquake ground motion level that can reasonably be expected to be experienced at the site area at least once within the operating life of the plant, during which normal operation can continue,

S2: Earthquake ground motion level that corresponds directly to safety limits and maximum earthquake potential that can affect the site,

Levels S1 and S2 are determined based on seismotectonic considerations, seismicity and geological characteristics of the site area and soil materials.

2.1.1. Earthquake against which the plants are designed

In the seismic zoning map of Turkey (1997), zones are defined by a probabilistic method based on peak ground accelerations (Figure 3). It is assumed that the zone of seismic hazard level V (the lowest in Turkey) is characterized by a peak acceleration of less than 0.1 g with a probability of exceedance of 10% within 50 years. The Akkuyu site belongs to the zone V of seismic hazard on this map.

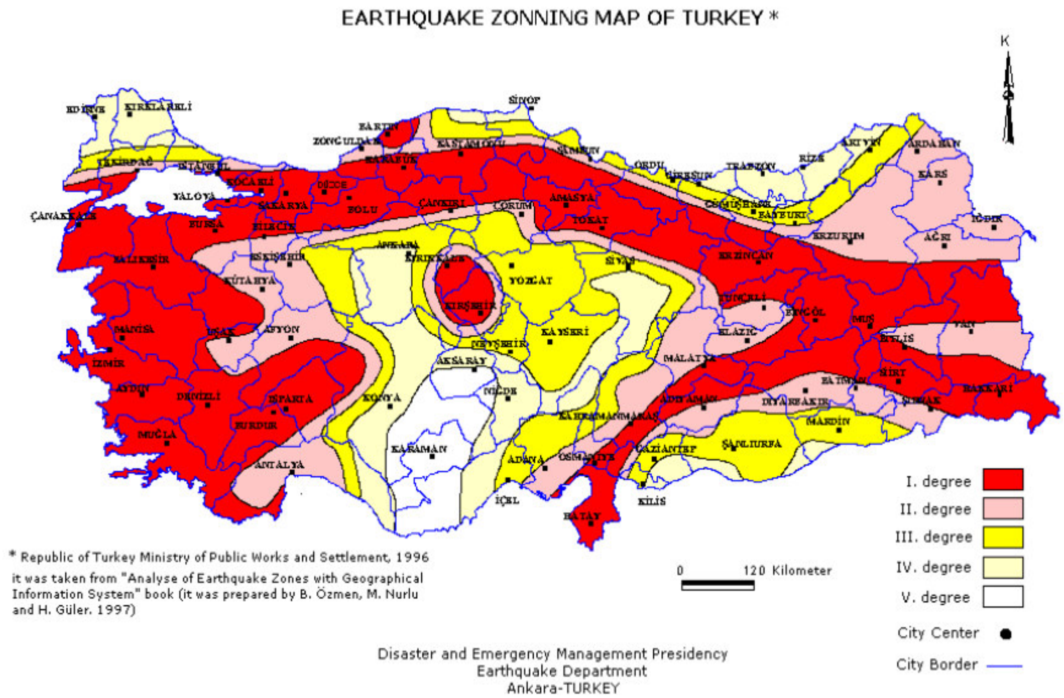

Figure 3 Earthquake zoning map of Turkey

In accordance with the requirements, a series of seismic investigations were done in the region around the site. The investigations are summarized below.

Early seismic studies were performed under the auspices of Turkish Electricity Authority (TEK). Seismological studies were performed by the Geology Department of Mining Research and Exploration Institute (MTA), Engineering Seismological Research Institute (EERI) of Middle East Technical University (METU), Geophysics Department of Istanbul Technical University (İTÜ), and also by a specially organized Engineering-Consulting Consortium ENG (Emch-Berger, Basler und Hoffman) [2],[3],[4],[5],[6].

Summarized results of these studies (including seismotectonic and seismological studies) for the Akkuyu NPP were presented in a series of TEK reports in 1983 [7]. The seismotectonic zoning issues were considered and summarized in the METU report in 1989 [8]. In 1990 the TEK/İTÜ summary report of seismicity and system of design parameters of seismic vibrations for the Akkuyu NPP was published. Akkuyu NPP site seismotectonic and seismological conditions were also evaluated by IAEA experts in 1986 [9].

In 2011 seismological study of the Akkuyu site was renewed. A system of instrumental observations in the near region (up to 40-50 km) has been established by Kandilli Observatory And Earthquake Research Institute under the auspices of the Applicant in July 2011. This local seismic network consists of seven strong motion and six weak motion seismic stations.

Preliminary calculations are being performed for determining the design basis earthquake for the Akkuyu NPP. The calculations show that the safe shutdown earthquake (SSE; level S2) will be in the range of 0.32-0.38 g. Further investigations are in progress for determination of the exact values of DBE and SSE (levels S1 and S2, respectively).

2.1.2. Provisions to protect the plants against the design basis earthquake

The preliminary design features show that the plant has sufficient robustness to withstand the design basis earthquake (actually, the SSE) and to remain in a safe condition. This shall be verified through analyses and assessment as the design progresses. All structures, systems and components required for shutdown and maintaining a safe condition will also be identified in this process.

2.1.3. Compliance of the plants with its current licensing basis

The plant's compliance with the licensing basis will be assessed after an application is made for construction license.

2.2. Evaluation of safety margins

Akkuyu NPP design will be developed in compliance with up-to-date requirements of IAEA and EUR. Approaches and calculated values shall be provided after the detailed design is completed, during which safety margins can be evaluated.

3. FLOODING

The Applicant has been conducting flooding studies in compliance with Turkish regulations, IAEA requirements and Fundamentals, and Russian Federation Regulations.

According to the Turkish Regulation on Nuclear Power Plant Sites [1], Section 6, Hydrological External Natural Events, the following flood effects have to be considered in NPP design:

"Article 18 - (1) Flood causing events and their potential effects in the region shall be taken into account individually for sites on river banks and on sea coasts, including coasts of enclosed and semi-enclosed water bodies, gulfs and lakes.

(2) In order to determine floods within the scope of design basis external event, probabilistic or deterministic methods shall be used. If those methods are not applicable, a stochastic method can be used. Uncertainties should be considered in analysis.

(3) Oceanographic, hydrological, meteorological and topographical information including seismic data shall be collected for coastal sites. Collected data shall be compared through scale maps, tables and graphics, and by using aerial photographs and satellite images probable areas that are subject to flood hazards shall be identified.

(4) Hydrological and meteorological data for rivers shall be compiled to cover a minimum of 50 years.

(5) In addition to hydrological and meteorological events, individual regional events such as failure of water retaining structures that may cause flooding separately, and floods that may occur through combination of events shall be analysed.

(6) Parameters of tsunamis or seiches that can affect the plant, are determined via deterministic and probabilistic methods and, whenever possible, these results shall be verified with reviewing historical records. Conservative approach shall be used in case of inconsistency.

(7) The nature and breaking mechanism of the waves and for the entire range of water elevations that are expected shall be identified, and the hydrostatic and hydrodynamic loading on structures important to safety shall be evaluated".

3.1. Design basis

The Akkuyu NPP location, regional topography, bathymetry, and other major features of the area are shown in Figure 4. The Akkuyu NPP Project site is located adjacent to Akkuyu Bay, a small semi-enclosed body of water connected to the Mediterranean Sea.

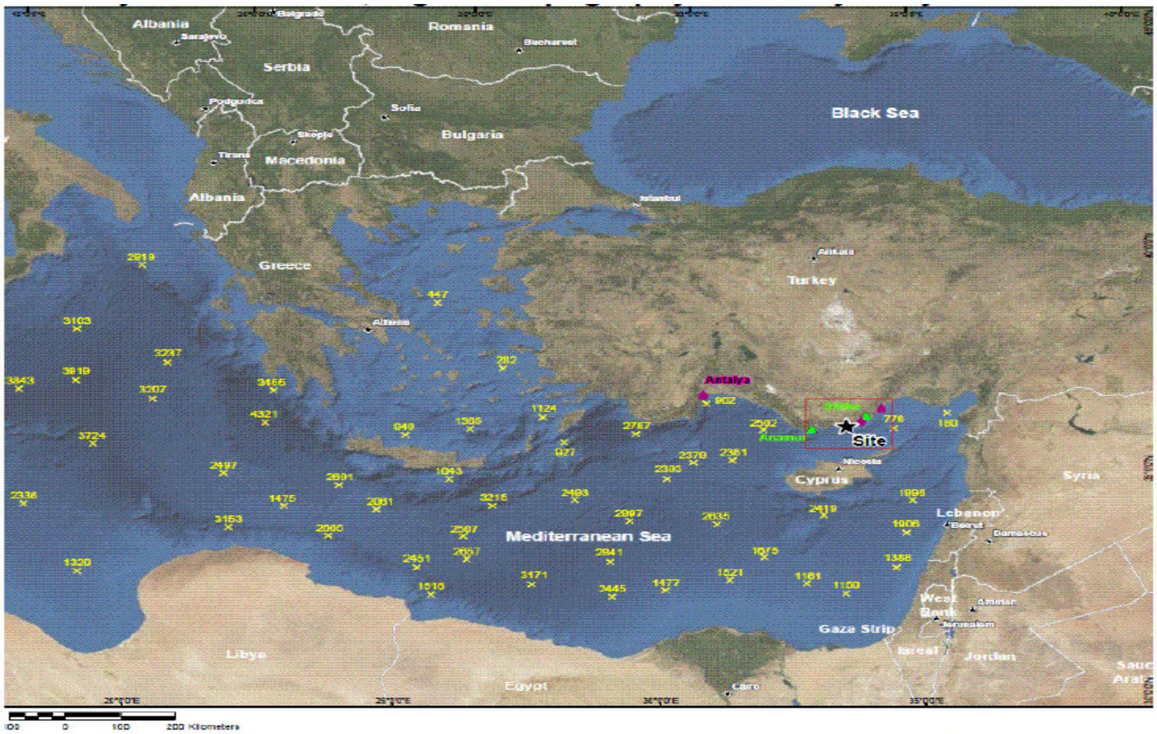

Figure 4 Akkuyu NPP location, regional topography and bathymetry

3.1.1. Flooding against which the plants are designed

The design basis flood elevation for the NPP will be determined by considering a number of different flooding scenario combinations. The flooding scenarios to be investigated include:

- Probable Maximum Precipitation (PMP)
- Probable Maximum Flood (PMF) on streams and rivers
- Potential dam failures
- Probable maximum surge and seiche flooding
- Probable Maximum Tsunami (PMT)
- Ice effect flooding
- Channel diversion flooding

Each of these flooding scenarios will be investigated in conjunction with other flooding and meteorological events, such as wind generated waves, as required in accordance with the guidelines presented in ANSI/ANS 2.8-1992 [10] document.

Because the Akkuyu NPP Site is located on the Mediterranean Sea coastline, PMF water levels are potentially influenced by tide levels, storm surges, and wind-generated waves. Storm surges and precipitation runoff events are interdependent and, thus, could occur at the same time [10]. Therefore, for the determination of the PMF water level, influences of the tide, storm surge, and coincident wind-generated waves will be considered at the downstream boundary of the hydraulic stream model.

The calculated value of the 24 hour maximum precipitation once per 10 000 years is 314.22 mm [11]. As it is shown in the report [11] the Probable Maximum Precipitation (PMP) is 2 times more than the calculated 24 hour maximum precipitations. It is obvious that the PMP value 688.5 mm is considered as conservative, and it can be used while calculation of the parameters intended for Akkuyu NPP design basis.

The coastal areas of East-Mediterranean part of Turkey might be impacted by a tsunami with a wave height of 4 – 6 m according to earlier and more recent studies. This value will be finalized upon completion of the site investigations.

3.1.2. Provisions to protect the plants against the design basis flood

The preliminary design features show that the plant has sufficient robustness to withstand the design basis flood and to remain in a safe condition. This shall be verified through analyses and assessment as the design progresses. All structures, systems and components required for shutdown and maintaining a safe condition will also be identified in this process.

3.1.3. Plants compliance with its current licensing basis

The plant's compliance with the licensing basis will be assessed after an application is made for construction license.

3.2. Evaluation of safety margins

Akkuyu NPP design will be developed in compliance with up-to-date requirements of IAEA. Approaches and calculated values shall be provided after the detailed design is completed, during which safety margins can be evaluated.

4. EXTREME WEATHER CONDITIONS

The Applicant has been conducting meteorological surveys on extreme weather conditions in accordance with Regulation on Nuclear Power Plant Sites. In this regard, the Applicant has been working on deriving extreme values of meteorological parameters, i.e. winds, rainfall, snow cover, air temperature, snow loads as well as design parameters for rare meteorological phenomena, e.g. tornado.

4.1. Design basis

Design basis weather conditions will be determined by considering the following events:

- Heavy rainfall
- Heavy winds (tornado, cyclone, storm)
- Air tempreature

Preliminary results of the calculations and measurements are as folows:

The maximum precipitation recorded at Anamur station in November during the last 30 years is 150,8 mm, at Silifke station the maximum monthly precipitation 139.5 mm is recorded in January. The calculated maximum 24 hour precipitation with a frequency once per 10 000 years under the Anamur and Silifke meteorological stations are equal to 314.2 and 266.8 mm respectively.

Maximum wind velocity of 56.5 m/s in 10 min was observed at the sea side of Akkuyu NPP site. It is within the probabilistic evaluation of maximum wind velocity of up to 66 m/s.

Severe hurricanes or cyclones have not been observed within 150 km of the NPP location. The preliminary calculations for tornado characteristics are being performed by the Applicant.

In 1975-2009 Anamur meteorological station recorded air temperature absolute extremums as -0.8 and 42 °C, while Silifke meteorological station values are -3.2 and 42.4 °C. The calculated air temperature absolute extremums with reliability of 0.01% are -10.0 and 48.8 °C at Anamur station, and -13.4 and 51.3 °C at Silifke station.

Historical information and eyewitness reports on catastrophic hydrometerological phenomena near NPP site is not available. There is no recorded event of ice and snow accumulation.

The calculations are preliminary. The site specific parameters and design basis will be determined upon completion of the site investigations.

4.2. Evaluation of safety margins

Akkuyu NPP design will be developed in compliance with up-to-date requirements of IAEA and EUR. Approaches and calculated values shall be provided after the detailed design is completed, during which safety margins can be evaluated.

5. LOSS OF ELECTRICAL POWER AND LOSS OF ULTIMATE HEAT SINK

The safety principles related to the residual heat removal and station blackout are established in the Turkish Regulation on Design Principles for Safety of Nuclear Power Plants as follows [12].

Emergency heat removal

"Article 16 – (1) In case normal heat removal fails or the integrity of the primary cooling system boundary is lost, alternative methods or systems are designed to restore and maintain fuel cooling under accident conditions."

Station blackout

"Article 22 – (1) Plant is designed so that the simultaneous loss of on-site and off-site AC electrical power (a station blackout) will not lead to fuel damage during a specified time period. In case of a station blackout reactor core, related coolant, control and safety systems and on-site DC sources and other support systems can provide core cooling and protection of containment integrity during this period. The time period is determined by taking into account the redundancy and reliability of on-site AC sources, and the frequency of loss of and the duration to restore off-site AC power."

On-site fuel storage

"Article 24 – (1) Plant design provides for transport, handling and storage of fresh and spent fuel in such a way as to ensure protection of workers and to prevent the release of radioactive material.

(2) On-site storage units keep the fresh and spent fuel in a safe and subcritical array under all anticipated storage conditions. The design of the units and fuel racks takes into account external loads and forces. Since the spent fuel contains a significant inventory of fission products, shielding from radiation and a safe means of loading the assemblies into shipping casks are provided. The integrity of spent fuel cladding is preserved by redundant and reliable means of removing decay heat. Means are provided for inspecting fresh and spent fuel, testing, handling and storing defective fuel, and for retrieving fuel for remedial action, e.g. for shipping it off-site for post-irradiation examination".

The Applicant has provided the preliminary data related to loss of off-site power and loss of ultimate heat sink. For each analysis, the Applicant has also submitted the capabilities of the systems as designed. Information presented here is as obtained from the Applicant, which has not been approved by TAEK at the time of writing of this report.

Heat removal paths for plant states are summarized in Table 2.

Table 2 Heat removal paths in different plant states

No.	Plant State	Heat removal path (scheme)	Ultimate Heat Sink	Power supply
1	Normal operation – hot condition	Reactor – Steam generators – Turbine bypass (BRU-K) – Turbine condensers – Main cooling water system	Sea water	Normal operation power supply

2	Normal operation – cooling down	Cooling down starts under scheme No.1, and when the primary circuit temperature decreases below 150 ºC normal residual heat removal by scheme No.3 is started	Sea water	Normal operation power supply
3	Residual heat removal (cold condition, reactor maintenance, refueling)	Reactor – Emergency and planned primary circuit cool-down system – Component cooling system – Cooling water system for essential equipment	Sea water	Normal operation power supply
4	Reactor cooling down through the secondary circuit in case of malfunction in scheme No.1	Reactor – Steam generators – Steam dump valve to atmosphere by BRU-A (short-term control of the process dynamics, for which an additional water reserve is provided in the SG), Reactor – Steam generators – Emergency Steam Generator Cooldown System (continuous) – Component Cooling System – Cooling water system for essential equipment	Atmospheric air (until SG pressure is reduced to the set-point of BRU-A closure) Sea water	Power supply from the emergency diesel generators of the safety systems
5	Reactor cooling down through the secondary circuit in case of malfunction in schemes No.1 and No.4 without reactor coolant loss	Reactor – Steam generators – Passive heat removal system	Atmospheric air	Power supply for forced cooling is not required. The accumulator battery is used for monitoring parameters
6	Reactor cooling down through the secondary circuit in case of malfunction in schemes No.1 and No.4 and loss of primary coolant (LOCA)	First and second stage hydro accumulators (ECCS passive part) – Reactor – Steam generators – Passive heat removal system	Atmospheric air (until borated water is available in the hydro accumulators)	The accumulator batteries are used for transferring PHRS to cooldown mode and for monitoring parameters
7	Reactor cooling down as BDBA accident management strategy (primary feed & bleed)	Reactor – PRZ safety valves – Containment sump – Emergency and planned primary circuit cool-down system (low pressure safety injection with containment recirculation and heat removal in heat exchangers) – Component cooling system – Cooling water system for essential equipment	Sea water	Power supply from the emergency diesel generators of the safety systems

5.1. Loss of electrical power

5.1.1. Loss of off-site power

The power grid is the external source of power supply. Power from the grid is supplied to the systems through the main or standby transformers. The turbine generator, diesel generators (DG) and the accumulator batteries are inner auxiliary power supply sources. The off-site power supply of Akkuyu NPP shall be implemented through 380 kV Gas Insulated Switchgear and 154 kV switchyard [13, 14].

In case of loss of off-site power supply the safety-related equipment are powered from two 6.3 MW independent emergency DGs – one per safety system channel. The DGs are located in special rooms designed to category I seismic load and shock wave and are electrically independent from each other and from the respective equipment they provide. The DGs are equipped with main autonomous systems for fuel, oil, cooling water, starting air, systems for suction of air and release of gasses as well as electric systems. The DGs are always ready to start up and get load within not more than 15 s once the command is given to start the DG before it is ready to be loaded. Each of the DGs is capable to bear all the loads of the given safety channel and is intended for on-load operation with no maintenance for 240 hours. If the DGs fail to start automatically they can be started manually from the main control room or locally.

The operation of the systems for primary coolant circuit residual heat removal supplied with electrical power by the DG provides stabilization of the parameters and ensures residual heat removal until the normal power supply is restored. The reactor core cooling is performed through the secondary circuit by the operation of the emergency steam generator cool down system. If any of the emergency steam generator cool down system safety trains is not actuated, this function will be performed by the respective safety train of the passive heat removal system. As a result the Unit is maintained in hot shutdown state for sufficient time without violation of the safety limits.

The service fuel tank (day tank) of the DG is sufficient to run it for eight hours. The service tank is automatically replenished from an intermediate underground reservoir with a capacity of 100 m^3 by means of two pumps (one is operating and the other is on standby) installed in the pump house of the intermediate diesel fuel storage. The diesel fuel inventory in the intermediate reservoir is sufficient for supplying the diesel-generators for 72 hours. The intermediate reservoir is also replenished automatically via a pipeline from the central NPP diesel fuel store by means of pumps installed in the central fuel store pump house or by tank trucks.

In case of loss of off-site power, the residual heat from the spent fuel pool (SFP) shall be removed by the SFP cooling system, the pumps of which are supplied with electrical power by the emergency DG. Heat is transferred to the component cooling system, and eventually to the ultimate heat sink. In case of SFP cooling system failure residual heat removal may be provided by the main or emergency primary circuit cool-down systems. If cooling water to heat exchangers is not available SFP heat removal is removed by evaporating water in the pools and water supply from the spray system, hydro accumulators or SFP purification system tanks. Reliable power supply to the SFP purification pumps may be provided from the stand-by DG station [13, 14].

5.1.2. Loss of off-site power and loss of the ordinary back-up AC power source

In case the emergency diesel generators fail to operate, emergency back-up power supply can be provided by an independent standby diesel generator station (located on the site) or from "Ermenek" hydropower plant (about 60 km from the site).

The standby diesel generator station is available for startup and load acceptance within 15 s of the time of startup command. The standby diesel generator station has two independent physically separated channels. Each channel provides autonomous systems of fuel, oil, cooling water, starting air, air intake for burning and exhaust. The DG start up can be provided manually or automatically when power is lost at the switchgear to which the DG is connected.

The standby diesel generator station is classified as class I of radiation and nuclear safety and category I of seismic safety.

The number of sections in each train is selected to ensure the possibility of connection of inter-redundant mechanisms or systems to different sections.

5.1.3. Loss of off-site power and loss of the ordinary back-up AC power sources, and loss of permanently installed diverse back-up AC power sources

When the AC power supply is lost the batteries take up the load automatically and within 15 s of the start-up command.

The batteries (DC 220 V) supply power to the safety systems through autonomous inverters. The accumulator batteries are rechargeable through two rectifier devices.

DC circuit includes two sets (by number of safety trains) of batteries. One battery is designed for 2 hours discharge time, the other one for 24 hours.

The battery discharge time is designed as follows:

- Two hours without recharging for design basis accidents when normal power supply or power supply from EPSS is not available. In that case the batteries are used for supplying power to localizing valves and automated process control system.
- At least 24 hours without recharging for beyond design basis accidents when there exists no power supply for automated process control system.

In addition separate 110 V batteries for the Core Protection System are provided. Also, one of the batteries of each train provides power supply to the passive heat removal system's I&C for at least 24 hours.

The reactor is maintained at the hot shutdown state for at least 72 hours by the passive heat removal system (scheme 5 of Table 2). If necessary, the passive heat removal system can be brought by the operator to a mode of reactor installation cooling by opening of the regulating device, which is supplied by the emergency power supply system. In this case the power supply is ensured by the DC batteries, which are intended for beyond design basis and severe accidents and are available for 24 hours.

In case of loss of coolant accidents the operation of the passive systems – first and second stage hydro accumulators – provide sufficient coolant inventory in the primary circuit and the passive heat removal system assures effective removal of the residual heat.

5.1.4. Conclusion on the adequacy of protection against loss of electrical power

Conclusion on the adequacy of the design against loss of electrical power will be assessed during evaluation of the PSAR.

5.2. Loss of the decay heat removal capability/ultimate heat sink

The Mediterranean Sea water is the primary ultimate heat sink for Akkuyu NPP. Cooling seawater from the Mediterranean Sea is provided through water-intake structures which is common for all systems. The seawater is delivered into a common transverse water intake canal of the pump station.

In any case of loss of ultimate heat sink, the power unit shall stop operation (automatic reactor scram) and enter into cooling mode until reaching safe cold state [13, 14].

The residual heat in the spent fuel pools is removed by the SFP cooling system, transferred to the component cooling system and further to the Mediterranean Sea through the essential component cooling water system.

The availability of the essential component cooling water system relies on the availability of the active safety systems (availability of emergency power supply by DG) and on the availability of the ultimate heat sink.

The loss of ultimate heat sink leads to loss of auxiliary safety systems ensuring cooling, including for DGs, and therefore to consequent loss of power supply. For this reason the loss of ultimate heat sink can be considered identical with the loss of all AC power supply sources.

In case of the fact that residual heat can not be removed through the primary ultimate heat sink (the Mediterranean Sea water) the turbine's condenser or the essential component cooling water system, it can be removed continuously to the atmosphere by the PHRS. The reactor can be brought into a controlled state – in that case power supply for forced cooling is not required and for monitoring the parameters an accumulator battery is used. The operation of the PHRS does not have time constraints, does not require any special accident management actions and shall be sufficient for removing the residual heat from the reactor core.

In case of loss of coolant accidents the operation of the passive systems – first and second stage hydroaccumulators – provides sufficient coolant inventory in primary circuit and the PHRS assures effective removal of the residual heat in reactor cool down mode.

The residual heat in the SFPs can be removed by evaporating water in the pools and water supplied from the containment spray system, hydro accumulators or SFP purification system tanks (operation of active systems requires power that can be provided by mobile equipment). The additional water reserve in the spent fuel pools provides additional provision for heat removal [13,14].

Conclusion on the adequacy of the design against loss of decay heat removal capability and ultimate heat sink will be assessed during evaluation of the PSAR. Also assessment will be performed for multi units.

5.3. Loss of the primary ultimate heat sink, combined with station black out

The passive systems will be actuated with the loss of primary ultimate heat sink combined with station blackout. The passive systems are designed for providing cooling of the core and

SFP. This information will be confirmed during the detailed design stage of the NPP. Also this issue will be evaluated in the assessment of the PSAR.

6. SEVERE ACCIDENT MANAGEMENT

There is no approved Emergency Plan of the Applicant at the time of writing of this report. The plans and procedures to be developed is expected to reflect IAEA recommendations and world experience after the Fukushima accident. Requirements and expectations on the quality of the emergency plans and emergency preparedness activities of the Applicant are summarized below [13, 14].

6.1. Organization and arrangements of the licensee to manage accidents

6.1.1. Organisation of the licensee to manage the accident

The NPP operation shall be conducted by a sufficient number of qualified personnel who know and understand the design basis, the safety analyses, the plant design and operational documentation for all operational states and accident conditions. The shift operation personnel shall ensure reliable operation and power unit safety, and manage accident situations. All operation personnel will be assigned to seven shifts. Five shifts are involved with operation on a permanent basis, one shift is on standby, and one shift undergoes skill maintenance training. Shift rotation is specified by the NPP management so that all the employees would undergo training courses including emergency exercises and drills within a year. The competency of the personnel shall be analyzed and verified systematically and documented. The operating organization will develop long term staffing plans for implementation of the activities associated with ensuring and supervising safety.

Any changes in the number of personnel, which may be safety significant, shall be justified in advance, planned and evaluated after implementation.

The overall objective of emergency response planning is to provide a framework for the administration and implementation of dose reducing and possibly immediate life saving actions and remedies in the event of a range of accidents that could produce off-site radiological doses in excess of established protective action criteria. The range of possible planning measures is potentially quite large, ranging from no action, when radiological consequences of an accident are unlikely to occur, to planning for the worst possible accident regardless of how low the potential likelihood of occurrence may be.

The Applicant shall have responsibility to organize training programmes for all personnel on emergency plans and to conduct special training sessions for the employees who will implement those plans (emergency response teams).

To maintain the emergency preparedness, the Applicant shall ensure that the members of the emergency response teams:

- Possess the necessary qualification, experience and skills to implement the emergency plans;
- Have adequate training on implementation of the emergency plans, relevant procedures and operational instructions;
- Have different types of training periodically for maintaining and enhancing their qualification, experience and skills.

In the event of an accident, plant operation and monitoring teams shall determine the nature of the accident and the significance of the consequences that may develop due to possible releases. Ongoing monitoring of meteorology and plant radiological parameters will determine the degree of protective measures that will be required. If a decision is made to advise sheltering or evacuation along the plume exposure pathway within the emergency planning zone, appropriate authorities shall be notified to implement actions necessary to ensure public safety.

6.1.2. Possibility to use existing equipment

The equipment foreseen in Akkuyu NPP design for severe accident management includes:

- Containment – the reactor containment is a double containment design,
- Passive system for filtering the space between the two containments designated for filtering possible radioactive leakages before release to the environment,
- Power supply to specific engineered safety features, safety I&C and post-accident monitoring equipment for severe accident management,
- PARs to reduce the hydrogen concentration in primary containment,
- Core catcher for fuel melt retention and cooling after reactor pressure failure,
- System of pipelines and valves for water supply to the core catcher

Use of mobile devices under emergency conditions shall be planned in advance. The time required to put the mobile equipment in operation shall be analyzed and fixed in appropriate emergency procedures. There shall be provisions for sufficient fuel supply for stationary and mobile DGs during operation of the plant.

The intermediate diesel fuel storage house will accommodate fuel storage tanks with capacity of 100 m^3, which will provide fuel reserve for 72 hours. Fuel supply systems will be autonomous for every diesel generator.

Management of radioactive releases, provisions to limit them

In case of accidents with containment pressure increase, the following procedure will be applied:

- Recirculation systems for the containment rooms will be tripped,
- Shutoff valves on air ducts will be closed at crossing the containment, and the containment input and exhaust systems will be tripped,
- Other systems will operate in normal operation mode and emergency overpressure system for the reactor building annulus will be in operation.
- Exhaust repair-emergency systems will be actuated to ensure recirculation air cleaning in these rooms from iodine and aerosols (in two stages).
    - At the first stage, one system fan operates to ensure recirculation air cleaning from iodine and aerosols through the filtering plant. Air for cleaning will be taken from the box and discharged to the reactor hall.
    - At the second stage, when air is cleaned to the required level, air-tight valves on air ducts will open and the system will switch to “input-exhaust” operation mode, with subsequent discharges to vent-stack.

In case of radioactivity releases after severe accident (fuel-clad damage) in the containment rooms, the measures to limit radioactive releases, including operational provision, are recommended in SAMGs.

Communication and information systems

It is stated that the NPP communication and alarm systems were intended for efficient, reliable and stable operative control during normal operation and emergency situations. The systems receive the centralized annunciation signals and convey them to the NPP personnel (for timely information about emergency situation), the on-site forces and services of plant civil defense, as well as the managers and personnel of other facilities and the general public situated in the coverage zone of the local annunciation system.

Personnel's access to external communication networks, local anouncement system and emergency conditions management means will be ensured in the plant design by the use of internal communication complex.

The communication systems shall consist of two sets: for external and for internal (on-site) communication channels. The external communication facilities include main and stand by (including direct ones) channels of all necessary kinds of communication: telephone, data transmission and others.

Independent communication lines (wired including fiber-optic, radio relay, radio and satallite) are stated to be included to ensure the reliability of the system. The external set includes channels for linking NPP users with the public telephone communication system, SW and USB radio communication, trunk radio communication, and personnel radio search systems will be used.

For organizing communication in emergency situations, three spatially separate systems are stated to be organized in sheltered emergency control centers at NPP site, in the NPP town ship and in the NPP evacuation region.

It is stated that the communication and signaling systems within the nuclear power plant buildings shall be of the highest safety and seismic stability class and shall be available for emergency and communication in the time of design basis and beyond design basis accidents (design extension accidents).

Detailed classification of communication and signaling components with regard to safety, seismic stability and reliability of power supply are stated to be elaborated at the detailed design stage, taking into account the results of safety analyses.

6.1.3. Evaluation of factors that may impede accident management and respective contingencies

To ensure life support for the personnel at the Main Control Room (MCR) or Stand-by Emergency Control Room (SCR) when the atmospheric air in the zone of air intake devices is contaminated with radionuclides with concentration higher than 0.3 of the permissible concentration, the air conditioning systems are switched to 100% recirculation mode, with the system for cleaning outdoor air using aerosol and iodine filters is switched on. During operation in this mode, the characteristics of the filters allow the personnel to stay in the control rooms for at least 12 hours. After that or if toxic gases appear in the atmospheric air that cannot be removed with the filters the life support system is switched into operation, which contains storage of air sufficient for the personnel to work for at least 4 hours. If the outdoor air in the zone of air intake devices is contaminated with smoke, the air conditioning systems are switched for 100% recirculation.

SCR shall have independent air conditioning systems and decontamination facilities in order to ensure sheltering and safe management of the accident.

Accessibility in case of severe accidents shall be according to the corresponding emergency procedures.

It is remarked that alternative evacuation routes and shelter areas will be assessed for external events (e.g. beyond design basis earthquake, flooding).

6.1.4. Conclusion on the adequacy of organisational issues for accident management

Adequacy of the organization of the plant to manage accidents will be assessed after evaluation of the PSAR, emergency plan and SAMGs and a period of practice including exercises, drills and training.

6.1.5. Measures which can be envisaged to enhance accident management capabilities

It is stated in the Applicant's report that Akkuyu NPP design would be developed in compliance with up-to-date safety requirements to emergency preparedness and accident management capabilities that are established by IAEA and EUR.

6.2. Accident management measures in place at the various stages of a scenario of loss of the core cooling function

6.2.1. Before occurrence of fuel damage in the reactor pressure vessel/a number of pressure tubes (including last resorts to prevent fuel damage)

Procedures will be developed to ensure cooling of the core (fuel) in the reactor.

Safety justification of the reactor plant will be conducted based on the following criteria:

- Pressure in the primary circuit and steam lines of SG shall not exceed 115% of the design value,
- Fuel pellets shall not melt even locally (their temperature shall not exceed 2540°C for burned fuel and 2840°C for fresh fuel),
- Criteria for emergency core cooling:
    1. Maximum temperature of fuel cladding in accident conditions shall not exceed 1200°C.
    2. Local oxidation depth of fuel cladding shall not exceed 18% of the initial cladding thickness.
    3. Hydrogen amount generated during reaction of fuel cladding with coolant shall not exceed 1% of the maximum possible amount that could be generated if the whole section of fuel cladding enveloping the fuel pellets reacts completely with water and transforms to ZrO_2 ($Zr+2H_2O=ZrO_2+2H_2$). For the analysis of the actual amount of hydrogen generated it is necessary to take into account all reactions resulting in hydrogen generation.
    4. Channels for coolant flow inside the fuel assemblies shall not be blocked to the extent that deteriorates cooling ability because of inflatement or damage of fuel

cladding, as well as deformations of other fuel assembly details and reactor internals.

5. Melting of control rods is not allowed.
6. Movement of control rods into the reactor shall not be impeded by possible deformations of the fuel assemblies, control rods and reactor internals.
7. Interaction between different components of fuel assemblies shall not cause their melting.
8. Safe state of the core shall be attained in such a way that conditions shall be established to keep the reactor in a subcritical state, maintain cooldown and reach a shutdown state after the accident.

The main task in case of this kind of BDBA is to protect the integrity of fuel pellets and fuel cladding as protective barriers. It is achieved by stopping the chain reaction and emergency cooling of the reactor core.

During an accident involving leaks from the primary circuit (LOCA) the coolant inventory shall be maintained and heat from the core shall be removed. This function will be carried out by redundant active systems of emergency core cooling and by the complex of passive systems consisting of hydroaccumulators and the PHRS, operating on the cool-down mode. With operation of the active system of emergency core cooling heat removal to the ultimate heat sink is achieved by the following path: Reactor – ECCS heat exchanger – component cooling system for essential equipment –cooling water system for essential equipment – sea water.

The passive heat removal system will provide heat removal from the reactor core by following path: Reactor – SG – PHRS – atmospheric air.

6.2.2. After occurrence of fuel damage in the reactor pressure vessel

Safety justification of the reactor plant will be conducted based on the following criteria:

1. Concentration of gas mixture generated into the reactor vessel after core melting shall not reach a value that can cause explosion hazard.
2. Pressure in the primary and secondary circuits shall not exceed the corresponding design strength values.
3. The pressure in the primary system shall not exceed 1 MPa at the time of vessel failure.
4. Admissible impact of pressure impulse on the elements of concrete shaft will be 150 kPa/s.
5. Maximum admissible pressure in the concrete shaft is 2.0 MPa.
6. Subcriticality of core debris and melt shall be assured.

6.2.3. After failure of the reactor pressure vessel

In case of reactor vessel melt, the corium enters into a specially designed system for the purpose of retention and cooling of the corium (Corium retention and cooling device, the so called “corium catcher”). Thus, direct containment heating and release of fission products to the containment is prevented.

In case of severe accidents water from the containment sump tank, which collects water from primary circuit leakage and ECCS hydroaccumulators is used for cooling the heat exchanger of the corium catcher. Water reserve from the spent fuel pool may also be used. The total volume of water in the sump tank on the floor of the containment, together with the water volume in the spent fuel pool above the heat-generating part of the assemblies, is about 1500 m^3.

In case of total loss of power supply, the corium transferred to the catcher is cooled through water supply from above, of the water located in the inspection shafts of the reactor internals during the first 24 hours. After 24 hours, corium cooling is provided from an external source (fire fighting vehicles). Water is provided by connecting fire fighting vehicles through a fire-fighting connecting joint to the pipeline for water supply to the corium catcher.

6.3. Maintaining the containment integrity after occurrence of significant fuel damage (up to core meltdown) in the reactor core

After failure of the reactor pressure vessel all equipment designed to keep the pressure in the containment within the prescribed range should be operational and capable to function over the prescribed time period.

6.3.1. Elimination of fuel damage / meltdown in high pressure

During BDBA or severe accidents pressure in the primary circuit can be decreased by actuation of safety systems or through the means of accident management.

The plant design provides different technical means for decreasing pressure in the primary circuit during an accident. If AC power supply is available, steam generator emergency cooling system performs this function. In case of a BDBA with total loss of AC power supply, the passive heat removal system decreases the primary circuit pressure down to 1 MPa within the specified time period.

In case residual heat cannot be removed through the secondary circuit, pressure in the primary circuit can be decreased via the pressurizer relief valves.

Moreover, the corium retention and cooling device prevents direct containment heating (DCH) if the core melts through the pressure vessel.

The operator actions shall be documented in severe accident management guidelines (SAMGs). The criteria for transition to SAMGs shall be defined and included in the procedures.

6.3.2. Management of hydrogen risks inside the containment

The design of the NPP includes provisions for eliminating the hydrogen risk. Passive systems are most convenient to reduce the hydrogen concentration in the containment. Some operational activities are also possible in reducing the risk of explosion.

Hydrogen explosion safety is provided by implementation of the following criteria:

- under normal operation conditions the system of emergency hydrogen removal is regularly inspected and tested according to the process schedule,
- in case of design basis accidents the emergency hydrogen removal system prevents formation of explosive concentration of hydrogen above the design limits defining deflagration burning,
- in case of BDBA the emergency hydrogen removal system prevents the formation of explosive concentration of hydrogen above the design limits defining detonation.

The limit for BDBA is defined by one of the following three requirements:

- not more than 5 vol. % of hydrogen in the dry containment,
- within the interval of 5 - 10 vol. % of hydrogen in an atmosphere with:
  - more than 60 vol. % of steam or
  - less than 20 vol. % of air (oxygen less than 5 vol. %),
- more than 10 vol. % of hydrogen in an atmosphere with more than 5 vol. % of steam and less than 20 vol. % of air (oxygen less than 5 vol. %).

The plant design foresees a system for control of the concentration and emergency removal of the hydrogen in the containment. The system includes passive autocatalytic recombiners (PARs), which eliminate the possibility of detonation of the hydrogen mixtures in the containment in all considered BDBA accidents by maintaining the hydrogen volume concentration in the mixture below the limits.The PARs will be situated at locations with most probable accumulation of hydrogen.

The operator's actions will be described in the severe accident management guidelines (SAMGs).

6.3.3. Prevention of overpressure of the containment

Preliminary provisions for prevention of overpressure in the containment are as follows:

- The actuation of the PHRS provides sufficient heat removal from the reactor core so that failure of the reactor vessel under high pressure does not occur.
- The corium localization device is designed to prevent accumulation of water where corium is localized before the beginning of the corium transition to the corium catcher. Steam explosion is avoided by the design.
- The passive systems (hydroaccumulators, PHRS, the corium catcher and PARs) are designed to keep the containment pressure below its designed value.
- The active ventilation system maintains the decreased pressure in the annulus between inner and outer containment strucutures during normal operation and air filtering in case of accidents. The passive annulus filtering system also maintains the decreased pressure and air filtering under accident conditions.

6.3.4. Prevention of re-criticality

The subcriticality of corium is assured by presence of boron in the structural materials of the control and protection system and the boric acid in the coolant as well as the hydroaccumulators. Also the corium catcher design ensures subcriticality of the corium in the concrete vault.

Available concentration and volume of boric acid solution and functional pump systems are essential for effective prevention.Therefore, analyses considering both in-vessel and ex-vessel corium shall be performed to assess the efficiency of the procedures for prevention of re-criticality. Also the emergency action procedures will ensure subcriticality of the reactor.

6.3.5. Prevention of basemat melt through

To mitigate the consequences of a severe accident involving core melt, the design incorporates a corium catcher for confining the melt after reactor vessel rupture.

The corium catcher performs the following main functions:

- handling the liquid and solid components of melt, core fragments, and reactor structural materials,
- heat transfer between melt and cooling water,
- preventing the melt from escaping the design boundaries of its confinement,
- ensuring subcriticality of the melt in the concrete vault,
- supplying cooling water and removing steam,
- ensuring minimal release of radioactive substances into the containment space,
- minimizing the release of hydrogen,
- keeping the maximal stresses in the constructions lying in the concrete vault space under the reactor vessel within permissible limits,
- minimizing the need for control actions by the operators during its function.

Molten corium is confined and cooled for an unlimited time. After an accident with station blackout, the melt is confined and cooled by the water from the containment sump during the first 24 h. After 24 hours, corium cooling is provided from an external source (fire fighting vehicles). Water is provided by connecting fire fighting vehicles through a fire-fighting connecting joint to the pipeline for water supply to the corium catcher.

The system for passively filtering the medium and maintaining rarefaction in the annulus, the system for emergency discharge and purification of medium, and the system for passively removing hydrogen from the containment space operate jointly with the corium catcher.

6.3.6. Need for and supply of electrical AC and DC power and compressed air to equipment used for protecting containment integrity

The design means for containment integrity protection are passive i.e. there is no need for a power supply for their actuation during the accident.

The means for severe accident management are supplied by separate batteries with capacity for at least 24 hours.

6.3.7. Measuring and control instrumentation needed for protecting containment integrity

The main equipment for severe accident management includes sensors, communication means and equipment for measurement and indication of the following conditions:

- neutron flux,
- temperature (at core outlet, in primary and secondary circuit, in the containment),
- pressure (in primary and secondary circuit, in the containment),

- radioactivity (in secondary circuit, in the containment),
- state of the corium (temperature, location, criticality),
- temperature in the reactor vessel,
- temperature in the concrete reactor shaft,
- state of the atmosphere in the containment (e.g. hydrogen concentration),
- coolant level in the RPV.

6.3.8. Capability for severe accident management in case of simultaneous core melt/fuel damage accidents at different units on the same site

In case of severe accidents in several facilities, in addition to the already described technical and organizational measures and severe accident management guidelines, measures devised to cope with multi-unit accidents shall be implemented to prevent and mitigate the consequences of severe accidents throughout the NPP and to avoid unacceptable impact on the personnel, public and the environment. Adequacy of such measures shall be analyzed in the appropriate chapters of the PSAR.

6.3.9. Conclusion on the adequacy of severe accident management systems for protection of containment integrity

Conclusion on the adequacy of severe accident management systems for protection of containment integrity is stated to be drawn after evaluation of the PSAR, emergency plan and SAMGs.

6.3.10. Measures which can be envisaged to enhance capability to maintain containment integrity after occurrence of severe fuel damage

Akkuyu NPP design will be developed in compliance with up-to-date safety requirements established by IAEA and EUR to the systems maintaining the containment integrity in case of accidents with severe fuel damage/melt in the reactor core.

6.4. Accident management measures to restrict the radioactive releases

6.4.1. Radioactive releases after loss of containment integrity

Analyses of the radiological consequences of severe accident scenarios will be provided in Akkuyu NPP PSAR.

The preliminary data provided by the Applicant [13] is that the design shall include provisions for fulfillment of criteria for limited impact (EUR), as follows:

- No emergency protection action beyond 800 m from the reactor - in case of releases outside the containment, there is no need for serious urgent protection measures (evacuation) at a distance of 800 m and more from the reactor early in the accident
- No delayed action beyond 3 km from the reactor - there is no need for postponed temporary evacuation at a distance of 3 km or more from the reactor,

- No long term action beyond 800 m from the reactor - there is no need of any measures for resettlement of population for a long period of time at a distance more than 800 m from the reactor.
- Limited economic impact - level of radioactive contamination of soils and water do not impose restrictions on large scale land and water use.

6.4.2. Accident management after uncovering of the top of fuel in the fuel pool

The spent fuel pool is located in the containment, which impedes the spread of the radioactive products in case of accident at the reactor. Water level above the fuel assemblies in the spent fuel pool provides radiation shielding.

The operator shall provide cooling of spent fuel pool for at least 24 hours by using the emergency and primary circuit cool-down system through the following path: spent fuel pool – ECCS heat-exchanger – low pressure safety injection pump – spent fuel pool, or by supply of boric acid solution from the RPV inspection shaft or tanks of SFP purification system.

It is stated that releases after severe damage of spent fuel in the fuel storage pools would be limited by the inner containment with leakage rate less than 0.03% per day and outer containment with leakage rate less than 10% per day in case of additional loss of capability to maintain the subatmospheric pressure in the annulus volume.

Measurement channels are foreseen in the design are:

- spent fuel pool water level,
- activity above SFP,
- SFP temperature,
- Radiation dose rate above SFP.

6.4.3. Conclusion on the adequacy of measures to restrict the radioactive releases

Conclusion on the adequacy of measures to restrict the radioactive releases will be drawn after evaluation of the PSAR.

7. GENERAL CONCLUSION

Due to the fact that the Fukushima accident has increased awareness and sensitivity on the potential dangers of earthquakes and tsunamis, the studies related to external events in the region of Akkuyu site, at which 4 units of VVER-1200 will be constructed, have become more important. Although many studies about the earthquake and tsunami potential for this site have been carried out before the Fukushima accident, TAEK has requested from the Applicant to update these studies. Within this context, for instance paleotsunami studies not previously performed will also be included in these activities. On the other hand, existing regulations related to earthquakes and tsunamis, calculation methods and steps of hazard analysis are being reviewed.

Taking into account the preliminary design documents submitted to TAEK by Applicant, an evaluation for the design issues such as loss of power, containment integrity, etc. were briefly presented in this report. In these evaluations, the Applicant states that safety criteria and design limits of Akkuyu NPP are established in accordance with the applicable Russian and international regulations such as IAEA safety standards and European Utility Requirements. Since the Akkuyu NPP project is at the very early stages, there is no information about the plant response and the effectiveness of the preventive measures to be implemented in severe accident management strategies, as provided by the Applicant. In addition, there is no approved Emergency Plan of the Applicant at the time of writing of this report. The plans and procedures to be developed are expected to reflect IAEA recommendations and world experience after the Fukushima accident. As far as the information provided by the Applicant indicates, the Akkuyu NPP design is expected to comply with the improved nuclear safety requirements based on the lessons learned from the Fukushima accident. Also, it should be noted that the information presented by Applicant has not yet been approved by TAEK; the information will be reviewed and assessed in the course of licensing.

7.1. Key provisions enhancing robustness

Key provisions enhancing robustness of the design are listed as follows:

- Akkuyu NPP design includes safety systems that could maintain or recover the critical safety functions under conditions far beyond of DBAs.
- In case of failure of a critical safety function, independent and diverse systems are designed for reactor scram and maintaining the reactor subcritical for an unlimited time period. Actuation of control rods for scram is based on gravitational forces and the core power has self-limitation properties due to negative coefficients of reactivity.
- In case of failure of core cooling, if the active systems for emergency cooling fail water is provided to the primary circuit by passive hydro-accumulators.
- Under the conditions of DBA and BDBA, the primary circuit heat removal is provided by the steam generator emergency cooling system based on active principles. In case this system fails, heat is removed through passive heat removal systems.
- Protection against common cause failures due to internal and external hazards is ensured by means of spatial and physical separation, and diversification of the safety systems included in the design.

- Emergency power supply system is reliable and is redundant. It consists of two emergency DG for each of the safety trains and there are additional DG stations for normal operation systems important for safety.
- In case of loss of all the power sources, including in-house sources, external sources and DGs, all critical safety functions can be performed by the passive systems for a long period of time. The residual heat removal is assured through the passive heat removal system.
- Each Akkuyu NPP unit has two independent ways of heat removal from the reactor core to the ultimate heat sink:
    - through essential service water system to the sea, and
    - through passive heat removal system to the atmosphere.
- The total loss of primary ultimate heat sink is an initiating event with consequences similar to the total loss of AC power supply, described above. Safety of the plant is assured in this case as well.
- As a result of the passive safety systems operation during a severe accident, the pressure in the containment is maintained below the design value.
- The minimum volume of water is maintained in the spent fuel pool to guarantee a long time period before fuel uncovery.
- The passive hydrogen recombiners, with their capacity and location in the containment, prevent the possibility of hydrogen accumulation and hydrogen explosion hazard in both design basis and beyond design basis conditions.
- The severe accident management principles foreseen in the design correspond to the requirements for nuclear installations of latest generation and the design provides necessary technical measures for implementation of the required severe accident management strategies.

Further safety analyses will be performed during the project implementation. The emergency plan and severe accident management guidelines will also be developed.

7.2. Safety issues

Akkuyu NPP design will be developed in compliance with up-to-date safety requirements that are established by IAEA and EUR. Safety systems and engineered safety features for beyond-design-basis accident management to be implemented in the design shall provide adequate core cooling, spent fuel pool cooling and ultimate heat sink.

7.3. Potential safety improvements and further work forecasted

In the progress of the design, severe accident management guidelines and emergency plans will be developed taking into account the lessons learned after the Fukushima accident in Japan. These requirements and measures will be considered for further investigations and implemented in Akkuyu NPP.

During development of the design, attention will be paid to the NPP safety improvements for the following aspects:

- increase in autonomy of emergency power supply system,
- protection against hydrogen explosion,
- increase in seismic resistance of the plant,
- conditions of the hydrotechnical structures,
- increase in capabilities of emergency core cooling and spent fuel pool cooling systems,
- enhancement of NPP emergency preparedness, accident management and firefighting capabilities.

ANNEX I

Multilateral Conventions, Treaties and Bilateral Agreements of Turkey

1. Convention on Nuclear Safety, 1994
2. Paris Convention on Third Party Liability in the Field of Nuclear Energy (29 July 1960), 1961
    a. Protocol to Amend the Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960 (28 January 1964), 1967
    b. Protocol to Amend the Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as Amended by the Additional Protocol of 28 January 1964 (16 November 1982), 1986
3. Treaty on the Non Proliferation of Nuclear Weapons (NPT), 1979
4. Agreement Between the Government of the Republic of Turkey and the IAEA for the Application of Safeguards in Connection with NPT, 1981
    a. Protocol Additional to the Agreement Between the Government of the Republic of Turkey and the IAEA for the Application of Safeguards in Connection with NPT, 2001
5. Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, 1990
6. Convention on Early Notification of a Nuclear Accident, 1990
7. Convention on the Physical Protection of Nuclear Material, 1986
8. Comprehensive Nuclear-Test-Ban Treaty, 1999
9. Agreement Between the Government of Canada and the Goverment of the Republic of Turkey for Co-operation in the Peaceful Uses of Nuclear Energy, 1986
10. Agreement Between the Goverment of the Republic of Turkey and the Government of Argentine Republic for Co-operation in the Peaceful Uses of Nuclear Energy, 1992
11. Agreement Between the Goverment of Korea and the Goverment of the Republic of Turkey for Co-operation in the Peaceful Uses of Nuclear Energy, 1999
12. Agreement Between the Government of French Republic and the Goverment of the Republic of Turkey for Co-operation in the Peaceful Uses of Nuclear Energy, 2011
13. Agreement for Cooperation Between the Republic of Turkey and the United States of America Concerning Peaceful Uses of Nuclear Energy, 2006

14. Memorandum of Understanding for Technical Cooperation and Exchange of Information in Nuclear Regulatory Matters Between Turkish Atomic Energy Authority and the State Nuclear Regulatory Committee of Ukraine, 2008
15. Agreement Between the Government of the Republic of Turkey and the Cabinet of Ministers of Ukraine on Early Notification of a Nuclear Accident and Exchange of Information on Nuclear Facilities, 2001
16. Agreement Between the Government of the Republic of Turkey and the Government of the Republic of Bulgaria on Early Notification of a Nuclear Accident and on Exchange of Information on Nuclear Facilities, 1997
17. Agreement Between the Government of the Republic of Turkey and the Government of Romania on Early Notification of a Nuclear Accident, 2008
18. Agreement Between the Government of the Republic of Turkey and the Government of the Russian Federation for Cooperation in the Use of Nuclear Energy for Peaceful Purposes, 2011
19. Agreement Between the Government of the Republic of Turkey and the Government of the Russian Federation on Early Notification of a Nuclear Accident and Exchange of Information on Nuclear Facilities, 2011

ANNEX II

Laws, Decrees, Regulations and Guides Concerning the Safety of Nuclear Power Plants

Laws

1. Law on Turkish Atomic Energy Authority, 1982

Decrees

1. Decree on Licensing of Nuclear Installations, 1983

Regulations

1. Regulation on Physical Protection of Nuclear Materials and Nuclear Facilities, 2012
2. Regulation on Working Procedures of Atomic Energy Commission, 1983
3. Regulation on the Establishment and Working Procedures of Advisory Committee on Nuclear Safety, 1997
4. Regulation on Safe Transport of Radioactive Materials, 1997
5. Regulation on Accounting for and Control of Nuclear Materials, 1997, (Under Revision)
6. Regulation on Radiation Safety, 2000
7. Regulation on National Practices during Nuclear and Radiological Emergencies, 2000
8. Regulation on Nuclear Safety Inspections and Enforcement, 2007 (Rev'd 2008)
9. Regulation on Basic Requirements on Quality Management for the Safety of Nuclear Installations, 2007 (Rev'd 2009)
10. Regulation on Design Principles for Safety of Nuclear Power Plants, 2008
11. Regulation on Specific Principles for Safety of Nuclear Power Plants, 2008
12. Regulation on Environmental Impact Assessment, 2008
13. Regulation on Nuclear Power Plant Sites, 2009
14. Regulation on Protection of Outside Workers in Controlled Areas from the Risks of Ionizing Radiation, 2011

Documents and Guides

1. A Guide on Fire Protection in Nuclear Power Plants
2. A Guide on Documentation Examples, Work Instructions and Procedures for the QA Program for Survey, Assessment and Approval of Nuclear Power Plant Sites
3. A Guide on External Man-Induced Events in Relation to Nuclear Power Plant Design
4. A Guide on Seismic Design and Qualification of Nuclear Installations
5. A Guide on the Earthquake Related Subject Requested in the Issuance of Limited Work Permit and Site License, 1989
6. A Guide on Establishing and Implementing a Quality Assurance Programme for Safety in Nuclear Installations, 2009
7. A Guide on Management of Non-Conformance Control and Corrective Actions for Safety in Nuclear Installations, 2009
8. A Guide on Management of Document Control and Records for Safety in Nuclear Installations, 2009

9. A Guide on Inspection and Testing for Acceptance for Safety in Nuclear Installations, 2009
10. A Guide on Assessment of the Implementation of the Quality Assurance Programme for Safety in Nuclear Installations, 2010
11. A Guide on Quality Assurance in Procurement of Items and Services for Safety in Nuclear Installations, 2010
12. A Guide on Establishing and Implementing a Quality Assurance Programme in Siting for Safety in Nuclear Installations, 2010
13. A Guide on Format and Content of Site Report for Nuclear Power Plants, 2009
14. Directive on Principles of Licensing of Nuclear Power Plants, 2010
15. A Guide on Quality Assurance in Manufacturing for Safety in Nuclear Installations, 2011
16. A Guide on Quality Assurance in Research and Development for Safety in Nuclear Installations, 2011
17. A Guide on Quality Assurance in Design for Safety in Nuclear Installations, 2011
18. A Guide on Quality Assurance in Construction for Safety in Nuclear Installations, 2011
19. A Guide on Quality Assurance in Commissioning for Safety in Nuclear Installations, 2011
20. A Guide on Quality Assurance in Operation for Safety in Nuclear Installations, 2011
21. A Guide on Quality Assurance in Decommissioning for Safety in Nuclear Installations, 2011

REFERENCES

[1] Regulation on Nuclear Power Plant Sites. No.27176 dated 21.03.2009. TAEK.

[2] Akkuyu Nuclear Power Plant. Geotechnical Investigations. Vol 1-4, S. Tezcan at all, 1979.

[3] Second microearthquake study in Akkuyu region (field recording in spring 1978) Project No TEK-77-01.2, Final report ITU, July, 1978.

[4] Seismicity of Akkuyu nuclear power plant site and its vicinity. Project № TEK-77-02, Final report, ITU. October, 1978.

[5] Akkuyu nuclear power plant. Seismotectonics. Parts 1, 2. Turkish Electricity Authority, September, 1980.

[6] Earthquake resistant design parameters for the Akkuyu nuclear plant site. Part 1. Report № 79-4. METU/EERI. Ankara. July, 1979.

[7] Akkuyu nuclear power plant. Detailed site investigation report, Parts I-III, Turkish Electricity Authority, NSD-I-29. June, 1983.

[8] Seismotectonic evaluation of the Akkuyu nuclear power plant site. METU. Ankara. August, 1989.

[9] Review of geological and seismological aspects of Akkuyu site. Report to the Government of Turkey. IAEA-TA-2366. 23 May, 1986.

[10] ANSI/ANS 2.8-1992, Determining Design Basis Flooding at Power Reactor Sites.

[11] Meteorological/Aerological works. With the implementation of stage II comments. Stage III, ENVY, 2011

[12] Regulation on Design Principles for Safety of Nuclear Power Plants, No.NG-GR02-E dated 28.02.2011. TAEK.

[13] Akkuyu NPP Stress Tests Report, WorleyParsons Nuclear Services JSC, InterRAO-WorleyParsons LLC, 2012.

[14] Supporting Information to the Turkish National Report on Convention on Nuclear Safety, Akkuyu NPP Electricity Generation Joint-Stock Company, 2012.