AKKUYU NPP POWER GENERATION JOINT STOCK COMPANY

NUCLEAR POWER PLANT AKKUYU

Basic report for «Akkuyu» NPP site

Units 1, 2, 3, 4

AKU.C.010.&.&&&&&.&&&&.002.HC.0004

Revision 1

Moscow,

May 2013

AKKUYU NPP POWER GENERATION JOINT STOCK COMPANY

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Volume 3

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PLANNING AND DESIGN BRANCH JSC "CONCERN ROSENERGOATOM"

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ABBREVIATIONS ACCEPTED

aI	iodine aerosol form
BDBA	Beyond-design basis accident
CAA	Controlled access area
CEP	Collecting evacuation point
DBEE	Design Basis External Events
DEBK	Maximum possible accident
DERINSU	DERINSU Underwater Engineering & Consulting Company
DL	Design Limit
E	East /Easting
EIA	Environmental Impact Assessment
EMF	Electromagnetic fields
ENVY	ENVY Energy and Environmental Investments Inc
ESO	Earthquake Source Origin
FP	Fission products
HVDC	High-voltage direct current
IAEA	International Atomic Energy Agency
ICRP	International committee for radiation protection
IEP	Intermediate evacuation point
IPM	Individual protection means
ISO	International Organization for Standardization
IT	Information Technologies
IUCN	International Union for Conservation of Nature
JSC	Joint Stock Company
Akkuyu NPP JSC	Joint Stock Company for power generation of the Akkuyu NPP – the NPP Owner
km	Kilometer
LNG	Liquefied natural gas
LOCA	Loss of coolant accident
LPG	Liquefied petroleum gas
m	Meter
mI	iodine molecular form
METU	Middle East Technical University
N	North / Northing

NPP	Nuclear Power Plant
OBE	Operating Basis Earthquake
oI	Iodine organic form
OJSC	Open Joint-Stock Company
PAPZ	Protection actions planning zone
PAZ	Precautionary actions zone
PPM	Planned preventive maintenance
PSAR	Preliminary Safety Analysis Report
QAP	Quality Assurance Program
QMS	Quality Management System
REP	Receiving evacuation point
RP	Reactor Plant
S	South
SG	Steam Generator
SOL	Safe operation limit
SPEAM	Sheltered point for emergency activities management
TAEK	Turkish Atomic Energy Committee (Agency)
TNT	Trinitrotoluene
UPZ	Urgent protective action planning zone
USNRC	United States National Research Council
VVER	Water-to-water Power Reactor
W	West

7. ECOLOGICAL EFFECTS

Numerous and varied effects of technical objects on the environment, in particular hydro ecosystems, are a common knowledge. However, the technical objects, specifically their water supply systems, are not isolated from activity of hydrobionts, which might have significant effects on their operation. Thus, hydrobiont communities, inhabiting the water reservoir-coolers of power plants, are influencing the formation of water quality; they are causes of various biological hindrances to operation of equipment. Hydraulic works and various linings are solid substrata propitious for fouling organisms.

Fouling of service water supply systems should be understood as a particular case of litoreophil bioconenoses, consisting, except for algae, as usual of all faunal representatives, fouling a given water body.

Fouling consists of very different sea organisms capable to adhere tightly to hard surfaces. They are for example sea mussels and ostraceans among animals and barnacles among crustaceans are the most harmful. One can find bryozoans, sponges, sea squirts, hydroids and others in a fouling. Annelides dwelling in calcareous tubes or coreaceous tubes play less important role. The majority of sessile microbiota belong to the attaching benthos dwellers. At least 2000 species of plants and animals take part in fouling. However, not so many dwellers participate in abundant fouling; they are usually widespread eurybiontic organisms.

Experiment was conducted for formation of fouling on the man-made substrata in Akkuyu Bight[7/1]. After six months, nine species were found in fouling (Table 7/1). Among them *Pinctata radiata* and *Chama gryphoides* can potentially reach detrimental size. Apart from *Pinctata radiata*, other species are counted 61 % of the total number, but their biomass is 15 times greater than *Pinctata radiata*.

Table 7/1 – Number of Organisms on Experimental Plates for Fouling

Fouling organism	Population (per m^2)	%
MOLLUSCA		
Pinctata radiata (Pteridae)	276.0	39.0
Anomia ephippium (Anomidae)	27.6	4.0
Chama gryphoides (Chamidae)	193.2	30.0
POLYCHAETA		
Spirorbis sp. (Serpulidae)	41.4	5.0
BRYOZOA		
Schizobrachiella sp. (Escharellidae)	27.6	4.0

Fouling organism	Population (per m^2)	%
HYDROZOA		
Campanularia sp. (Campanulinidae)	55.2	7.0
Obelia sp. (Campanulinidae)	55.2	7.0
CHORDATA		
Ciona intestinalis (Cionidae)	13.8	2.0
Botryllus schlosseri (Styelidae)	13.8	2.0
Totally	703.8	100.0

Investigations of benthos on rock substrata in the vicinity of NPP site detected availability in the benthos of 16 species of Porifera, 5 of Cnidaria, 4 of Polychaeta, 25 of Mollusca, 4 of Decapoda, 4 of Cirripedia, 8 of Echinodermata, 4 of Tunicata, 14 species of algae, 1 lichen, 2 species of flowering plants [7/2]. All these species can influence the water intake facilities of the nuclear power plant.

In the course of groundwater survey conducted in 2011 in Akkuyu Bight it was revealed that the studied region is characterized by rather rich variety of species [7/3].

179 species, belonging to 12 systemized groups (Chlorophyta, Anthozoa, Nemertini, Nematoda, Sipunculida, Plathelminthes, Oligochaeta, Polychaeta, Crustacea, Mollusca, Echinodermata, Cephalochordata), were found among zoobenthos specimens taken in ten stations (in depths of 10-100 m). Total population of zoobenthos varied from 450 specimens/m^2 to 3120 specimens/m^2.

82 species and forms, belonging to six classes: Bacillariophyceae (4 kinds and 4 species), Coscinodiscophyceae (6 kinds, 11 species), Dinophyceae (14 kinds, 48 species), Mediophyceae (6 kinds, 17 taxons), Euglenophyceae (1 kind, 1 species), Prymnesiophyceae (1 kind, 1 species), were found among phytoplankton specimens. Dinophyceae prevails by the number of species (59 % from total quantity of species). For specimens sampled in the surface layer the total quantity of phytoplankton varies from 12310 cells/l to 149184 cells/l, biomass from 223.1 microgram/l to 766.445 microgram/l. For specimens sampled in the bottom layer the number varies from 650 cells/l to 19880 cells/l, biomass from 15.981 microgram/l to 622.22 microgram/l. Concentration of chlorophyll «a» characterizes the studied part of the Mediterranean Sea as being oligotrophic.

23 species from order Copepoda, 3 species from order Cladocera were found in zooplankton. Except for these two groups (Copepoda and Cladocera), specimens of 6 groups of holoplankton (Appendicularia, Chaetognatha, Doliolida, Foraminifera, Pteropoda, Siphonophora) and 8 groups of meroplankton (larvae of Ascidiacea, Bivalvia, Cirripedia, Decapoda,

Echinodermata, Gastropoda, Polychaeta) were also found in zooplankton. Total quantity of zooplankton varied from 422.3 to 3764.1 specimens/m^3.

112 species of fish were identified in fish catches during 1999-2000 in Akkuyu Bight and Babadilimani; 13 of them are species of commercial fish [7/1]. The highest concentration of fish was observed at depths upto 50 meters. Fisheries cover the entire shelf that streches from the coast to the width of 4 miles. 24 species of fish sprawn in the region (10 of them belong to the species of commercial value). The following species: *Boops boops, Merluccius merluccius, Mullus barbatus, Mullus surmuletus, Pagellus erythrinus, Saurida undosquamis, Spicara maena, Spicara smaris, Synodus saurus, Trachurus mediterraneus, Trigla lucerna, Upeneus asymmetricus, Upeneus moluccensis* are the important commercial fish.

32 fish species were caught throughout the year of 2011 [7/3]. 24 species were caught during the first trawling, 22 – during the second trawling (Table 7/2). 13 species were of Indo-Pacific origin and penetrated into the East Mediterranean via the Suez Canal. Intruder species inhabit shallow waters, and they occupied the same eco-niches in the Mediterranean Sea. They form sizeable populations in the investigated seashore area in the East Mediterranean and are related to dominating species. But, as and when depth increase is observed, they do not dominate any longer, and domination is taken over by local species.

Table 7/2 – Catch Composition (Size and Weight)

Trawling	Species	Number of specimens	Length, cm			Weight, g
			min	max	average	
	Apogon fasciatus	38	6.5	10.5	9.71 ± 0.79	500
	Apogon smithi	14	12.0	13.5	12.60 ± 0.56	400
	Arnoglossus keslerii	1	8.9			6.0
	Callionymus filamentosus	1	14.9			10.6
	Chelidonichthys lucerna	-				0
	Cynoglossus sinusarabici	1	14.7			21.4
	Citharus linguatula	-				0
	Dasyatis pastinaca	2	37	48	42.5 ± 7.77	4700

Trawling	Species	Number of specimens	Length, cm			Weight, g
			min	max	average	
Trawling 1	*Epinephelus caninus*	1	12,5			40
	Equulites klunzingeri	1590	4.,5	10.5	7.30 ± 1.36	9160
	Gymnura altavela	8	58	83	73.37 ± 7,81	25200
	Lagocephalus sceleratus	1	64			2200
	Lagocephalus spadiceus	111	7	18	11.02 ± 1.82	2800
	Mullus barbatus	983	7.5	16	11.9 ± 2.34	22500
	Nemipterus randalli	27	7	21.5	13.91 ± 4.48	1050
	Pagellus erythrinus	1	9.6			12
	Raja clavata	-				0
Trawling 1	*Rhinobatos cemiculus*	1	84.5			1800
	Sauridaundos quamis	96	12	34	23.23 ± 5.70	9600
	Scomber scombrus	-				0
	Serranus cabrilla	-				0
	Serranus hepatus	-				0
	Sillago sihama	1	16.2			37
	Soleasolea	2	9.5	22	17.58 ± 8.83	90
	Sparus aurata	1	25			180
	Trachurus mediterraneus	2	12	13	12.5 ± 0,7	45
	Trichiurus lepturus	37	39	54	45.5 ± 3.12	2300
	Trigloporus lastoviza	-				0
	Upeneusmoluc censis	9	9.5	14.2	11.9 ± 1.52	150
	Upeneus pori	39	7.5	14.5	11.85 ± 1.14	600

Trawling	Species	Number of specimens	Length, cm			Weight, g
			min	max	average	
	Uranoscopus scaber	1	18			90
	Oxyurichthys petersi	-				0
Trawling 2	*Apogonfas ciatus*	10	9.8	11	10.29 ± 0.27	190
	Apogon smithi	4	10.2	12.8	11.45 ± 1.06	100
	Arnoglos suskeslerii	-				0
	Callionymus filamentosus	-				0
	Chelidonichthys lucerna	1	26.5			180
	Cynoglossus sinusarabici	1	12.9			18.2
	Citharus linguatula	31	12	16.5	14.77 ± 0.99	840
	Dasyatis pastinaca	1	40			2250
	Epinephelus caninus	-				0
	Equulites klunzingeri	87	3	10	7.46 ± 1.45	510
	Gymnura altavela	-				0
	Lagocephalus sceleratus	-				0
	Lagocephalus spadiceus	19	7.7	16.6	10.19 ± 1.89	380
	Mullus barbatus	16	10	16.5	14.13 ± 2.09	580
	Nemipterus randalli	4	15	22.5	19.12 ± 3.32	330
	Pagellus erythrinus	-				0
	Raja clavata	5	13	30	17.5 ± 7.07	950
	Rhinobatos cemiculus	-				0

Trawling	Species	Number of specimens	Length, cm			Weight, g
			min	max	average	
Trawling 2	*Saurida undosquamis*	47	8	38	18.97 ± 10.13	4000
	Scomber scombrus	2	19	21	20.00 ± 1.41	100
	Serranus cabrilla	3	16.5	17,2	17.23 ± 0.75	180
	Serranus hepatus	12	8.5	11.2	9.59 ± 0.76	165
	Sillagos ihama	-				0
	Soleasolea	-				0
	Sparus aurata	-				0
	Trachurus mediterraneus	2	20.5	22	21.25 ± 1.06	160
	Trichiurus lepturus	4	43.5	50.5	46.87 ± 3.03	270
	Trigloporus lastoviza	1	16			45
	Upeneus moluccensis	2	11.5	12.0	11.75 ± 0.35	30
	Upeneus pori	2	12	12	12	30
	Uranoscopus scaber	1	23.5			240
	Oxyurichthys petersi	1	17.3			20

Species *Equulites klunzingeri* was represented in the catch by the maximum number of specimens, but, owing to small size, its share in the total catch was small (10 %). Species, considerably contributing to the catch weight, are *Gymnura altavela* (trawling 1)and *Sauridaundos quamis*(trawling 2).

Given below are characteristics of fish species found in the catch.

Apogon fasciatus (White, 1790) (ord. Perciformes, fam. Apogonidae). Widely spread in the Indo-Pacific area at the depth 2-128 m. Its habitat is close to reefs, thick macrophytes and sandy soils. Feeds on plankton and bottom crustacea. Was found near the Mediterranean coast of Turkey after 2010. maximum registered length: 10.3 cm. Well adapted in the Eastern Mediterranean. Commercially insignificant.

Apogonsmithi (Kotthaus, 1970) (ord. Perciformes, fam. Apogonidae). Widely spread in the Indo-Pacific area at the depth 22-230 m. Prefers slimy bottom. Found for the first time in the Mediterranean Sea in 2007 near Israeli coast; found in the Gulf of Iskenderun in 2008. Average length of specimens of this species: 5-10 cm. The length of specimens found in the catch: 10.2-13.5 cm. Well adapted in the Eastern Mediterranean. Commercially insignificant.

Callionymus filamentosus (Valenciennes, 1837) (ord. Perciformes, fam. Callionymidae). Usually found near sandy or clayey bottom at the depth of 16 - 350 m in the Indo-Pacific area. Feeds on bottom crustacean and worms. Found near the Mediterranean coast of Turkey in 1994. Commercially insignificant.

Chelidonichthys lucerna (Linnaeus, 1758) (ord. Scorpaeniformes, fam. Triglidae). Dwells in the Mediterranean Sea and the Eastern Atlantic, usually found along the Turkish coast. Dwells near sandy, clayey and pebbly bottom, from shallow waters to the depth up to 300 m. maximum length: 75 cm. Feeds on small fish, crustacean and molluscan shellfish. Commercially significant.

Citharus linguatula (Linnaeus, 1758) (ord. Pleuronectiformes, fam. Citharidae). Dwells in the Mediterranean Sea and the Eastern Atlantic, usually found at the depth up to 300 m. Usually found near the Aegean and Mediterranean coasts of Turkey, at the depth exceeding 30 m, near sandy and slimy bottom. Maximum length: 30 cm, usually 15 - 20 cm long. Big-size specimens are commercially significant to a certain extent.

Cynoglossus sinusarabici (Chabanaud, 1931) (ord. Pleuronectiformes, fam. Cynoglossidae). This species is the Red Sea endemic, which intruded the Eastern Mediterranean via the Suez Canal and was found for the first time near the coast of Israel. This species is numerous in the Gulf of Iskenderun and found along the Turkish coast, from Hatay to the Gulf of Fethiye. Dwells near sandy bottom, at the depth up to 135 m. Feeds on benthos invertebrates. Maximum length: 20 cm. Commercially insignificant.

Dasyatis pastinaca (Linnaeus, 1758) (cl. Chondrichthyes, ord. Dasyatiformes, fam. Dasyatidae). Dwells in the East Atlantic and the Mediterranean Sea near sandy and slimy bottom at the depth up to 200 m. Feeds on near-bottom fish, crustacea and molluscan shellfish. This is big-size species, with disk diameter reaching 140 cm. Listed in the IUCN Red List, Section “Data insufficient”. Commercially significant.

Epinephelus caninus (Valenciennes, 1843) (ord. Perciformes, fam. Serranidae).Dwells near rocky and sand-rocky substrates of the Eastern Atlantic and the Mediterranean Sea. Found in the areas: from shallow waters to the depth of up to 400 m. Specimens 167 cm long, weighing 78 kg, were found. Has high commercial significance. Population decrease is observed near the East Mediterranean coast of Turkey. Listed in the IUCN Red List, Section “Data insufficient”.

Equulites klunzingeri (Steindachner, 1898) (ord. Perciformes, fam. Leiognathidae). This species is the Red Sea endemic, which intruded the Eastern Mediterranean via the Suez Canal and was found for the first time near the coast of Syria. Numerous near the Aegean and Mediterranean coasts of Turkey. Maximum length: 11 cm. Feeds on small invertebrates. Forms thick schools in the Gulf of Iskenderun. Commercially insignificant.

Gymnura altavela (Linnaeus, 1758) (cl. Chondrichthyes, ord. Dasyatiformes, fam. Gymnuridae). Spread in tropical and subtropical areas of the Atlantic ocean and, as well, in the Mediterranean Sea. Dwells near sandy and slimy bottoms, from shallow waters to the depth of up to 100 m, along entire seacoast of Turkey. Big-size species, with wing spread reaching 4 m. Feeds on near-bottom fish and invertebrates. Commercially insignificant. Listed in the IUCN Red List, Section “Vulnerable”.

Lagocephalus sceleratus (Gmelin, 1789) (ord. Tetraodontiformes, fam. Tetraodontidae). Widely spread in the Indo-Pacific area. This is benthos-pelagic species, found at the depth up to 100 m. Numerous near the Aegean and the Mediterranean coasts of Turkey. May reach the length of 110 cm, but the length of usually found specimens is 40 cm. Feeds on benthos invertebrates. Commercially insignificant as poison fish.

Lagocephalus spadiceus (Richardson, 1845) (ord. Tetraodontiformes, fam. Tetraodontidae). Benthos-pelagic species widely spread in the Indo-Pacific area. Numerous in the Gulf of Iskenderun and found along entire Mediterranean coast of Turkey. Average length: 15-20 cm, but may be as long as 40 cm. Feeds on bottom invertebrates. Commercially insignificant as poison fish.

Mullus barbatus (Linnaeus, 1758) (ord. Perciformes, fam. Mullidae).Dwells near slimy and sandy bottom of the Eastern Atlantic and in the Mediterranean Sea. Dwells in shallow waters, but can be found at the depth of 300 m. Average length: 15-20 cm, but may be as long as 30 cm. Feeds on benthos invertebrates. Commercially significant; caught near the coast of Turkey.

Nemipterus randalli (Russell, 1986) (ord. Perciformes, fam. Nemipteridae).Dwells in the western part of the Indian Ocean and in the Red Sea. Found near sandy and slimy bottoms, at the depth of up to 200 m. In the Mediterranean, found for the first time near the coast of Israel. Found near entire Mediterranean coast of Turkey, from the Gulf of Iskenderun to the Gulf of Fethiye. Feeds on benthos invertebrates. May be as long as 30 cm. Resembles *Pagellus erythrinus*. Not very palatable, does not have high commercial significance.

Oxyurichthys petersi (Klunzinger, 1871) (ord. Perciformes, fam. Gobiidae). Spread in the Indo-Pacific area. Found for the first time in the Mediterranean Sea in 1983. Near the

Mediterranean coast of Turkey, found near slimy bottom at the depth of up to 50 m. Feeds on small benthos invertebrates and is commercially insignificant.

Pagellus erythrinus (Linnaeus, 1758) (ord. Perciformes, fam. Sparidae). Dwells in the East Atlantic and the Mediterranean Sea, usually on sand-rocky substrates, from shallow waters to the depth of up to 300 m. Average length: 20-25 cm, may be as long as 60 cm. Has high commercial significance.

Raja clavata (Linnaeus, 1758) (cl. Chondrichthyes, ord. Rajiformes, fam. Rajidae). Widely spread in the East Atlantic and the Mediterranean Sea. Dwells near slimy bottoms, from shallow waters to the depth of up to 500 m. Feeds on near-bottom fish and invertebrates. Commercially insignificant. Listed in the IUCN Red List, Section "Next to be endangered".

Rhinobatos cemiculus (Linnaeus, 1758) (cl. Chondrichthyes, ord. Rajiformes, fam. Rhinobatidae). Dwells in the East Atlantic and the Mediterranean Sea, near all types of bottom, at the depth of up to 100 m. Has high abundance near the Gulf of Iskenderun. May be long enough (up to 240 cm).Feeds on fish and invertebrates. Commercially significant. Listed in the IUCN Red List, Section "Endangered".

Sauridaundos quamis (Richardson, 1848) (ord. Aulopiformes, fam. Synodontidae). Widely spread in the Indo-Pacific area. In the Mediterranean, found for the first time near the coast of Israel. Numerous near Mediterranean coast of Turkey, found as well in the Aegean Sea. Prefers sandy-slimy bottom and may dwell at the depth of up to 350 m. Average length of this species: 20-30 cm, but it may be as long as 50 cm. Predominantly feeds on benthos-pelagic fish and, to a lesser degree, - on decapods. Commercially significant.

Scomber colias (Linnaeus, 1758) (ord. Perciformes, fam. Scombridae).Pelagic species, dwelling in the Atlantic and the Mediterranean Sea. Commercially significant.

Serranus cabrilla (Linnaeus, 1758) (ord. Perciformes, fam. Serranidae). Dwells in the East Atlantic and the Mediterranean Sea, from shallow waters to the depth of up to 500 m. Often found in thick *Posidonia oceanica*, on sandy and rocky substrates of the Aegean and the Mediterranean Seas, and, as well, in the Sea of Marmara and the Black Sea. Average length: 15-20 cm. Feeds on small fish and invertebrates. Commercially insignificant.

Serranus hepatus (Linnaeus, 1758) (ord. Perciformes, fam. Serranidae). Found in the East Atlantic and the Mediterranean Sea, from shallow waters to the depth of up to 100 m. As well numerous in the Sea of Marmara and the Aegean Sea. Commercially insignificant.

Sillagos ihama (Forsskal, 1775) (ord. Perciformes, fam. Sillagidae). Widely spread in the Indo-Pacific area. In the Mediterranean, found for the first time near the coast of Lebanon. Usually found near sandy substrates near the South Aegean and Mediterranean coasts of Turkey. Average length: 20-25 cm. Forms small populations and has low commercial significance.

Soleasolea (Linnaeus, 1758) (ord. Pleuronectiformes, fam. Soleidae). Usually found near sandy substrates at the depth of up to 150 m in the East Atlantic and the Mediterranean Sea. Feeds on small-size benthos invertebrates. May be as long as 70 cm; average length: 30 - 35 cm. Commercially significant.

Sparus aurata (Linnaeus, 1758) (ord. Perciformes, fam. Sparidae). Widely spread in the East Atlantic and the Mediterranean Sea. Dwells near all types of bottom, enters estuaries, found in areas - from shallow waters to the depth of up to 150 m. Feeds on benthos invertebrates. Average length: 35-40 cm, but may be 70 cm long. Has high commercial significance.

Trachurus mediterraneus (Steindachner, 1868) (ord. Perciformes, fam. Carangidae). Spread in the Mediterranean and nearest areas of the Atlantic Ocean. Migrating species, forming large schools. Found both in shallow waters and in open water areas.

Trichiurus lepturus (Linnaeus, 1758) (ord. Perciformes, fam. Trachinidae). Found in all the seas of the world at the depth of 0-500 m. Usually dwells near slimy substrates; migrates vertically. Adults feed on fish and molluscan shellfish; young fish feed on plankton.

Trigloporus lastoviza (Bonnaterre, 1788) (ord. Atheriniformes, fam. Triglidae). Spread in the East Atlantic, near East African coast and in the Mediterranean. Found near sandy and slimy substrates, from shallow waters to the depth of up to 150 m. Feeds on benthos invertebrates. May be as long as 40 cm; average length: 25-30 cm. Has low commercial significance.

Upeneus moluccensis (Bleeker, 1855) (ord. Perciformes, fam. Mullidae). Widely spread in the Indo-Pacific area, predominantly in shallow waters, near sandy and slimy substrates; may dwell at the depth of up to 100 m. In the Mediterranean, found for the first time near the coast of Palestine. Usually found in areas from the Aegean to the Mediterranean Seas. Feeds on small-size benthos invertebrates. Average length: 15-20 cm. Commercially significant in the East Mediterranean countries.

Upeneus pori (Ben-Tuvia&Golani, 1989) (ord. Perciformes, fam. Mullidae). Like other species related to genus *Upeneus*, this species is spread in the western part of the Indian ocean only. Dwells near shallow sandy and slimy substrates. In the Mediterranean, found for the first time in the Gulf of Iskenderun. Usually found near the Mediterranean and Aegean coasts of Turkey. Has low commercial significance.

Uranoscopus scaber (Linnaeus, 1758) (ord. Perciformes, fam. Uranoscopidae). Dwells in the East Atlantic and the Mediterranean Sea, near sandy bottom, at the depth of 0 - 400 m. Feeds on near-bottom fish and invertebrates. May reach the length of 40 cm. Commercially insignificant.

MEASURES FOR REDUCTION OF NEGATIVE EFFECT OF WATER AREA FLORA AND FAUNA AT NPP'S SAFETY

The service water supply system serves to provide cooling water to normal operation consumers and consumers of safety systems located on the site of Akkuyu NPP, Units 1, 2, 3, 4.

The service water supply system is of once-through design with single circulation of cooling seawater through the heat-exchanging equipment.

The source of the service water supply system of Akkuyu NPP is seawater of the Mediterranean Sea.

Total cooling water flow-rate per one Power Unit is 216136 m^3/hr (in round figures: 220000 m^3/hr), for four Power Units is correspondingly 864544 m^3/hr (in round figures: 880000 m^3/hr).

Cooling seawater is taken from Akkuyu Bight of Mediterranean supply cooling seawater through pipelines to the turbine condensers and closed cooling water systems for consumers of the reactor compartment, turbine compartment and other consumers. Cooling seawater is then discharged by residual pressure along the discharge header and off-take channel through siphon wells into Akkuyu Bight of Mediterranean Sea.

Medium purification trash-racks and water polishing rotary meshes of mechanical purification facilities are designed in the water intake portions of the pump stations.

Trash-racks are to be available to prevent ingress of trash and macroalgae in water intake facility, and the fish protection structure as well against ingress of fish and invertebrates.

For prevention of biological fouling of equipment and water conveyance lines, cooling seawater is processed by sodium hypochlorite.

After passage of cooling seawater via all water conveyance lines and equipment, sodium hypochlorite in water looses its properties when it is discharged into the sea. Consequently, it does not influence chemical composition of seawater.

Water intake and water discharge hydraulic works, their layouts and protection measures against biological fouling discussed herein are preliminary; they will be finally accepted at the design stage of the Design Project Report.

NPP safety risk assessment of bio-fouling processes of water intake structures and provision of their trouble-free operation and also efficiency of fish protection structures will be considered during Akkuyu NPP design development.

REFERENCE LIST

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7/2. Marine flora and fauna inventory. Ali Cemal Gucu, Zahit Uysal, Yeşim Ak Orek. Middle East Technical University. Institute of marine sciences. Erdemli-MERSİN. MAY 2009

7/3. Marine hydrological survey works. Stage II-III. 2011

8. HUMAN INDUCED EXTERNAL EVENTS

This chapter has been developed in accordance with Turkish Nuclear Regulations "Regulation on Nuclear Power Plant Sites" published in Official Gazette dated 21/03/2009 and numbered 27176 [8/1] and "Guide on the format and content of the NPP site report" GK-GR-01 [8/2].

Article 12 (1) of the Regulation on Nuclear Power Plant Sites [8/1] sets the screening probability equal to 10^{-7} events/a for events to be investigated. The screening distance value for each type of event will be determined for each particular type of source (stationary and mobile) using a conservative approach such that the effects of interacting events beyond this distance should not be considered further.

Information provided in Chapter 3, "Nearby Industrial Installations and Activities Around Site", is used to prepare Chapter 8 for evaluation of potential Design Basis External Events (DBEE).

In accordance with Article 13 [8/1], all facilities and activities within 10 km of the site, including the site itself, and having hazard potential should be identified. The 10 km distance is established as the initial screening distance value (SDV). Those beyond these distances but that may be important for safety of the proposed plant should also be included in the list.

Analysis of industrial activities within 10-km zone and within larger area was performed in [8/4], [8/7]. Chapter 3 of this report describes the locations, distances and routes of industrial installations and activities around the Akkuyu NPP site. According this chapter, on the territory of the site there is no facilities that have hazard potential for NPP.

In the 10-km zone the following facilities and activities could present a hazard for NPP:

- Roads: the highway D-400 Adana-Antalya. Possible events are explosions, delayed ignition after occurrence of burning gas clouds, dispersion of toxic and asphyxiant chemicals and radioactive materials, fires of vehicles moving on the road;
- Quarries: Possible events are explosions, fires of equipment;
- Gas stations - possible events are explosions and fires;
- Sea transport - collisions to water intake structures of nuclear power plant, dispersion of liquid and solid materials, fires;
- Air transport - collisions to nuclear power plant, fires.

The nuclear power plant area is surrounded by forestry area. The valley slopes are covered with a sparse wood, mainly coniferous trees without underwood, or brush, which is a fire source. So another possible hazard is forest fire.

8.1 EXPLOSIONS

The potential explosion sources identified in Chapter 3 are as follows:

- Explosion of a vehicle on the highway;
- Explosion in the quarries
- Explosion of the Gas stations
- Explosion on a vessel in the bay.

Potential explosion sources within the NPP 10-km radius area are shown in Figure 8/1.

8.1.1 EXPLOSION OF A VEHICLE ON THE HIGHWAY

For certain events a deterministic approach may be used to establish an acceptable SDV. For example, for explosions from a mobile source or stationary source typically a plant does not need any analysis for reflected overpressures of less than 6.9 kilopascals (kPa) or 1 pound per square inch (psi). It is provided in USNRC Regulatory Guide 1.91 [8/3] where it is stated that a method for establishing safe distances from a postulated event can be based on a level of peak positive incident overpressure below which no significant damage would be expected. In the judgment of the USNRC staff that, for the structures, systems, and components of concern, this level can be conservatively chosen at 1 psi (6.9 kPa) [8/3] The method for establishing the safe distances for explosive materials is based on a level of peak positive incident overpressure and is given by the following quantity distance relationship:

$$R \geq k \cdot W^{1/3}$$

Where *R* is the distance in meters from the exploding charge of *W* kilograms of TNT (or TNT equivalent). With *R* in meters and *W* in kg, k = 18.

The nearest highway is located approximately 2.26 km north at the point of nearest approach to the site. This is less than the 10-km initial SDV. Due to the lack of industrial facilities in the area, the commodity traffic is expected to be minimal with the potentially hazardous materials transported expected to be LPG bottles, gasoline and diesel fuel. None of the materials pose a hazardous toxic cloud threat at this distance. There is only a potential for an explosion event.

Although it is not anticipated that the traffic on the highway will carry large explosive cargos requiring consideration, the potential effect of a truck explosion is conservatively evaluated as follows. Per Regulatory Guide 1.91, the maximum probable hazardous cargo for a single highway truck is conservatively given as 23 000 kg TNT equivalent. The distance for 1 psi is given as:

$R \geq 18 \cdot 23000^{\frac{1}{3}} = 511\ \text{m}$

Since, the closest highway is located 2260 meters from the site; there would be no adverse effects even if there were transport of explosive substances via the highway. Therefore, there are no hazardous clouds or explosive hazards due to the highway requiring further consideration.

Nevertheless the Design envisages impact of horizontal-traveling shock wave with front pressure of 30 kPa and duration of wave contraction phase up to 1 s [8/8].

8.1.2 EXPLOSION IN THE QUARRIES

There is one active stone quarry located approximately 8.3 km from the NPP site. The only potentially hazardous materials at the quarry would be explosives. Due to the large separation distance of 8.3 km from the Akkuyu site there will not be any potential effects of an accidental or planned detonation at the quarry. Examination of the above equation shows that the quantity of explosives required to be detonated to yield a 1 psi pressure at this distance is unrealistic.

$$W = \left(\frac{R}{k}\right)^3 = \left(\frac{8300}{18}\right)^3 = 9.8\ 10^7\ \text{kg TNT equivalent}$$

Therefore, there is no feasible explosive hazard due to the quarry requiring consideration.

Enez Construction Co. is responsible with the rehabilitation of the highway between Mersin-Antalya. The company would use explosives for road construction in order to loosen the rocks to be removed. The application is temporary and there will be no explosive depot in Büyükeceli as soon as the construction of highway is completed.

8.1.3 EXPLOSION OF THE GAS STATIONS

There are two gas stations within the limits of 10 km zone. The closest gas station to the Akkuyu NPP site is approximately 3.3 km to the east located on the highway in Büyükeceli. It is separated from the site by elevations up to 250 m. The Gas Station in Büyükeceli (EUROIL) does not have any LPG tank; no LPG is present in the station. The nearest LPG tanks only exist in the Ağaçlı Shell Station at 5,300 meter distance to the NPP site close to Sipahili and BPET and SOIL station more than 11,000 meter in distance in Yeşilovacık.

Per section 8.3.1 the distance for a 23,000 kg TNT equivalent explosion to yield a 1 psi (6.9 kPa) peak positive pressure is 511 meters. This bounds any potential hazard from the gas station located at a distance of 3300 meters.

8.1.4 EXPLOSION ON A VESSEL IN THE BAY

The other potential source of explosion is explosion on a boat in the water area.

Probability assessment of cargo vessel accidents was carried out in 1977 and was based on the following assumptions [8/5]:

- total number of conveyances of hazardous cargoes in the coastal waters of Turkey is: 30 000 voyages per year;
- number of accidents: 1 each 5 years, i.e. $6.7 \cdot 10^{-6}$ voyages per year;
- total length of Turkish coastal line is 3 000 km.

Number of conveyances of hazardous cargoes close to the Akkuyu NPP per year:

- vessels with explosive substances – 4;
- vessels with hazardous liquids – 16;
- oil tankers – 900.

Shipping through the channel between Turkey and Cyprus in 1977 approximately amounted to 500 to 1000 movements per year with a tendency to grow. Most of these were made in the immediate proximity to the coast, i.e. 2-9 km for small-size ships (500-1 000 t) and 9-13 km for large-tonnage vessels (1 000-50 000 t). An overwhelming part of the shipping was executed by oil tankers from the Middle East region or belonged to the Iskenderun oil refinery.

According to the information from the Ministry for Transportation, Mediterranean Sea port and Maritime Traffic Management, in 1977 number of vessels transporting explosive or inflammable materials amounted to 10-20 ships per year.

Figure 8/1 – Potential Explosion Sources within the NPP 10-km Radius Area

Table 8/1 presents distances taken into account for assessment of impact at the Akkuyu NPP site.

Table 8/1 – Critical Distance for Impact to Seacoast, km

Event	Impact critical distance	Distance to the shore at accident moment
Explosion of chemical substances	5	5
Leak of liquid and volatile substances	10	10
Oil leak	50	10

Accident probability in the water area associated with explosion, under the adopted assumptions, was evaluated in 80-s of XX century as $4.4\cdot10^{-8}$[8/5]. Since it is less than 10^{-7}, it does not need any further investigation, because it doesn't fall under Art. 12 of [8/1].

At present time sea transportation and transportation of hazardous substances are not carried out within the 10-km zone, according to the letter from General Directorate on Sea Transportation [8/9].

Storage of fuel at fishing and tourist boats is insignificant, not more than the maximum probable hazardous cargo for a single highway truck. An explosion in the water area at a distance of the first kilometers from the seashore will not affect the NPP.

8.2 DELAYED IGNITION AFTER OCCURRENCE OF BURNING GAS CLOUDS; DISPERSION OF TOXIC AND ASPHYXIANT CHEMICALS AND RADIOACTIVE MATERIALS

The Akkuyu NPP site is situated at the seacoast and is separated from the remaining locality by hills up to 200-250 m high. In such a natural valley there are no man-made facilities which can be source of drifting gas clouds, poisonous or asphyxiating chemical and radioactive matter. There are no such surface permanent facilities outside the valley within the 10-km zone.

A probability of an accident in the water area associated with initiation of gas cloud was evaluated in 80-s of XX century as $3.6 \cdot 10^{-7}$. At the same time the probability of event occurrence at the site (within 10-km zone) was $1 \cdot 10^{-9}$[8/5].

According to the mentioned above letter from General Directorate of Sea Transportation of Undersecretariat of Maritime Affairs [8/9], sea transportation and carriage of hazardous substances are not carried out within the Akkuyu NPP site 10-km zone nowadays.

Long-duration fire at the Büyükeceli gas station can’t act as surface stationary source of asphyxiant gas due to small size of smoke origin and also because the NPP site is well-protected by the surface topography. This will lead to smoke trail scattering on the way to the site.

Tank car accident can act as surface mobile source of drifting clouds. Tank car can transport gas or gas-forming matter on the highway separated from the site by chain of hills.

Forest fire can be considerable source of asphyxiant gas (Figure 8/2).

The Design envisages integrity and ventilation of premises that are important for safety and also personal protection equipment for duty personnel (respirators).

Figure 8/2 – MODIS Terra satellite imagery (8 July 2008) shows that the forest fire is still active and the ash plume has already reached to Cyprus.

8.3 FIRES DUE TO EXTERNAL REASONS

The Akkuyu NPP site is located on seashore and is separated from the surrounding area by hills up to 200 m high. In such a natural valley there are no man-made facilities which can become a source of fire. According to the information, submitted by the authorities of Turkey in January 2012 and presented in Chapter 3, there are no industrial facilities within the NPP site vicinity (radius approximately 10 km).

The Akkuyu NPP area is surrounded by forests. Forest fires are common in the area during the hot, dry summer months.

The valley slopes are covered with a sparse wood, mainly presented by local coniferous trees without underwood, or brake, which is a fire source. So fire occurred in 2008 in Gülnar and its surroundings, has almost abolished the entire sylva. In order to restore the region natural structure, the Ministry for Environment and Forestry has activated some projects on forest planting.

General Directorate of Forestry labeled the project area as 1st degree forest fire sensitivity area (Figure 8/3).

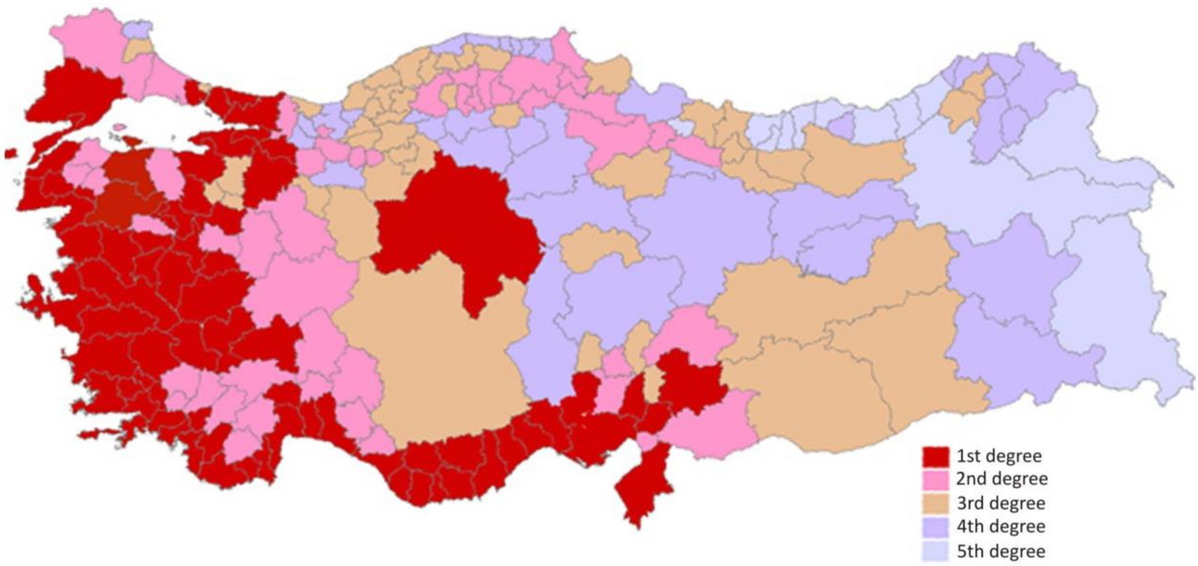

Figure 8/3 – Forest Fire Sensitivity Map

Past Turkish forest fire data, published by General Directorate of Forestry, are presented in Tables 3 and 4 of [8/4]. According the data presented in those tables, the annual average number of forest fires occurred in Mersin province during the last 10 years is 70, and they have occupied about 700 hectares. Mersin province has been ranked on 13-th place by number of fires and on 6-th place by area affected among all Turkish provinces.

The list of forest fires in Gülnar, Silifke and Aydıncık Districts, as it is published by The Natural Disaster Archive of Turkey (TUAA), is presented in Table 5 of the same report [8/4]. The image of the last fire in the list (occurred in Mersin/Gulnar/Beydili on July 8-th 2008) is presented on Figure 8/2.

In addition, more detailed data was requested from the Mersin Regional Directorate of Forestry in order to determine the frequency, distribution and size of the fire affected areas in the vicinity of the power plant. Data, that includes the forest fires that have occurred between the years 1992-2012, was obtained [8/19].

The potential impact of forest fire at the NPP will be evaluated later, at the PSAR stage. It is clear that engineering measures are available to cope with this hazard. Cleared areas extending on all sides of the Akkuyu NPP can provide a substantial defensible zone in the event of a fire originating in the woodlands or grasslands or spreading to those areas as result of on- or off-site activities. The protected area of the power Unit can include a cleared area of sufficient size to afford substantial protection in the event of a fire.

It is not expected that there would be any hazardous effects from fires or heat fluxes associated with wild fires.

The other potential source of fire is a fire on a vessel in the water area. However, it can be considered that fire in the water area will not cause heat affect at the NPP.

Akkuyu NPP Design envisages fire resistance (refractoriness) of safety related buildings and structures and in-site fire extinguish weapon.

8.4 COLLISIONS TO WATER INTAKE STRUCTURES OF NUCLEAR POWER PLANT

Thought sea transport and transportation of hazardous substances are not carried out within the Akkuyu NPP site 10-km zone, there are many touristic or fishing boats in the water area.

Collision of ships or boats with hydraulic facilities followed by explosion, oil spill, fire will be estimated at the next stages.

Entering of incidentally dispersed oil into water intake structures and other important systems of the plant should be taken into account.

The important data for the risk assessment studies is the travel frequency and size of the ships which carry flammable and explosive liquids (crude oil). The available statistical information regarding the ship traffic can be given only on the port bases. No data is available either for the transit ships or the route of the ships. Therefore, the statistical data of the ships which carry flammable and explosive liquids and stop in one of ports close to the NPP site were requested. Tanker traffic which is composed of ships carrying LPG, LNG, crude oil and petroleum products in Mersin, Taşucu, İskenderun and Antalya ports were obtained. Also, all ship traffic in the mentioned ports was provided. related information (marine traffic and accident statistics) was acquired from the official website of the ministry of Transportation, Maritime Affairs and Communication.

The entire marine activities for the last 12 years, 2001 to 2012, at the Antalya, Mersin, İskendurun, and Tasucu Port Bases will be considered in the study. The travel frequency and size of the ships carrying dangerous goods cargo (e.g., crude oil) will be analyzed. No data is available for ships transiting the region without any port calls, or the actual routes of the ships, the traffic load in the vicinity of the NPP site is assumed to be the sum of the number of ships that is recorded at the Mersin, Taşucu and İskenderun ports.

The assumptions made for the risk analysis, and the data considered in the analysis are as follows:

1) Marine accident data: Ministry of Transportation, Maritime Affairs and Communication divides marine accidents into 7 regions (Antalya, Çanakkale, İstanbul, İzmir, Mersin, Samsun and Trabzon). In this analysis, only Mersin region accidents data is used. Number of marine accidents: There are all together 72 marine accidents in the Mersin region between January, 2001 and December, 2012 (including tankers and all other ship types). Out of these 72 marine accidents, four of them are related to medical evacuations; so, the total number of accidents is reduced to 68. And within the 68 marine accidents, seven of them involved ships carrying dangerous goods.

2) Marine traffic around NPP region: Mersin, İskenderun and Taşucu port data is used to estimate the marine traffic. To calculate the potential impact of marine accidents to the NPP, ship's "route distance" had to be assumed. Since marine accident data is bound by Mersin region only it is assumed that the route distance would be approximately 70 km; which is the distance from Mersin Port to the assumed limits of Mersin Region

The probability of the event and its consequences, as well as measures to prevent or mitigate such event should be addressed on the PSAR stage.

8.5 COLLISIONS TO NUCLEAR POWER PLANT

Probability of civil and military aircraft crash was estimated in 1978 on the basis of data acquired in 1978 and moderately interpolated up to 2000 [8/5],[8/6].

A total number of performed civil flights by the international routes amounted in 1977 to 150 flights per day with a predicted increase of approximately to 1000 flights in 2000. A volume of military and local civil flights was estimated in 1977 as negligible.

Probability estimation of civil aircraft crash based on the following assumptions [8/5]:

– volume of air transportation via corridors: 1500 flights/day;

– quantity of accidents: $1 \cdot 10^{-9}$ accidents/travel km;

– 40 % of all accidents occur at flight route;

– effective width of air corridors above or near the NPP: 60 km;

– NPP safety zone: 20 000 m^2 = 0.02 km^2.

According to these data the following assessments were obtained:

– probability of civil aircraft crash – $5 \cdot 10^{-8}$/year;

– probability of military aircraft crash – $0.9 \cdot 10^{-6}$/year.

The assessments of aircraft crash onto the NPP, acquired in 1978 need to be actualized.

Required for such computations updated figures on aircraft crashes that have been recorded in the country in 1959-2007 are given in Table 8/2[8/4].

Table 8/2 – Historical Data on Aircraft Crashes

Location	Date	Loss of Life	Number of Injuries
Adana	08.03.1962	11	0
Ankara	19.01.1960	42	0
Ankara	21.12.1961	27	7
Ankara	01.02.1963	14	0
Ankara	23.12.1979	41	4
Ankara	16.01.1983	47	20
Diyarbakir	08.01.2003	75	5
Isparta	19.09.1976	154	0
Isparta	30.11.2007	57	0
İstanbul	30.01.1975	42	0
İzmir	26.01.1974	66	7
Other	25.02.2009	9	84
Trabzon	26.05.2003	75	0
Van	23.04.1959	12	0
Van	29.12.1994	57	14
Total		729	141

It is also required to estimate probability of loss in flight of aerial bomb or emergency actuation of an air-to-ground missile because military aviation routes cross the 10-km zone.

Turkish Authorities consider the possibility to move air corridors away from the NPP site [8/10]. However, the Akkuyu NPP Design will contain measures related to a crash of different types of aircrafts, taking into account requirements [8/8, 8/20]. Allowance of such impact in the Design exceeds impact of flying objects caused by in-site explosion or tornado.

The Design provides that a large commercial aircraft crash will be considered as beyond-design basis accident.

8.6 DISPERSION OF LIQUID AND SOLID MATERIALS

In the natural valley of Akkuy NPP sit location there are no man-made facilities which can be a source of toxic or corrosive fluids.

There is no industrial facility to discharge corrosive liquids within 10 km effective area of the power plant. The only possible discharges around the project area are domestic waste water produced from the residents. Some residents have waste water treatment plants while some others such as Büyükeceli town has no treatment facility. The domestic waste waters of the Büyükeceli town are collected in septic tanks and then used for irrigation of the forest surrounding the town.

An oil spill in the water area is a liquid waste source and it may affect the Akkuyu NPP.

A probability of an accident in the water area associated with oil products spill, under the adopted assumptions with account of wind direction and velocity, was evaluated in 80-s of XX century as $1 \cdot 10^{-4}$ [8/5]. At the same time an eventuality of event occurrence at the site was $2.5 \cdot 10^{-5}$. Table 8/1 presents distances taken into account for assessment of impact at the Akkuyu NPP site.

Nowadays sea transport and carriage of hazardous substances including oil products are not carried out within the Akkuyu NPP 10-km zone [8/9].

The important data for the risk assessment studies is the travel frequency and size of the ships which carry flammable and explosive liquids (crude oil). After the discussion with the responsible authority, it was learned that the only available statistical information regarding the ship traffic can be given on the port bases. No data is available either for the transit ships or the route of the ships. Therefore, the statistical data of the ships which carry flammable and explosive liquids and stop in one of ports close to the NPP site were requested. Tanker traffic which is composed of ships carrying LPG, LNG, crude oil and petroleum products in Mersin, Taşucu, İskenderun and Antalya ports were obtained. Also, all ship traffic in the mentioned ports was provided.

An accident in the water area beyond a zone with the radius of 10 km, accompanied by petroleum products leakage, will be a subject of further investigation in the framework of design documentation preparation.

8.7 EDDY CURRENTS AND ELECTROMAGNETIC INTERFERENCE

According to Letter of the Directorate General of Industry of the Ministry of Science, Industry and Technology [8/11], within the radius of 10 km there are no facilities able to cause electromagnetic oscillations.

Similar information has been provided by internal offices of the Ministry of Transportation, Marine Affairs and Communication, namely: Directorate General of Motor Transport [8/12], Directorate General of Infrastructure Investments [8/13], Counsel on Navigation of the Department of Strategy and Development [8/14], Directorate General of Highways [8/15], Directorate General of State Airport Authority [8/16].

There are 3 basic stations within 10 km [8/17], reporting to the Ministry of Transportation, Marine Affairs and Communications [8/18].

The NPP Design takes into consideration mutual electromagnetic influence of NPP components and provides protective measures.

8.8 CONCLUSIONS

Table 8/3 provides a summary of the external event evaluation.

Table 8/3 – List of DBEE Potential Sources for Akkuyu NPP site

DBEE Source	Distance >10 km	Additional Evaluation Required	Potential Impact to NPP	Action Required
Rivers	yes	no	no	no
Harbors	yes	no	no	no
Civilian Airports	yes	no	no	no
Military airports	yes	no	no	no
Highway	no	yes	no	no
Railroads	yes	no	no	no
Industrial facilities	yes	no	no	no
Gas Stations	no	no	no	no
EMF sources	yes	no	no	no
Pipelines	yes	no	no	no
Oil wells	yes	no	no	no
Quarries	no	no	no	no
Forest fires	no	yes	no	See section 8.3
Large oil spill	yes	yes	not analyzed yet	Prevention, if necessary
Hazardous water borne shipping	yes	no	no	no
Commercial, recreational boats	no	yes	none expected	See section 8.4
Air Corridors	no	yes	none expected	See section 8.5

The analysis of the locations of industrial facilities and industrial activities around the site (Section 3) as well as the analysis of external impacts onto the site due to man-induced activities has not found exclusion factors for the NPP construction on the Akkuyu site. In fact, the Akkuyu site is exceptionally well situated with respect to external hazards of human origin.

Possible negative impacts can be mitigated by design technical decisions and administrative measures, like relocation of air corridors or prohibition of the coastwise trade and fishing within a radius of 10 km.

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8/10. Letter No B.11.1.SGH.0.12.02.04/44-332 from General Directorate of Civil Aviation of Ministry of Transportation Maritime Affairs and Communication, dated 09.01.2012

8/11. Letter № B.14.0.SGM.0.10.00.01/103-01/000054 of the Directorate General of Industry of the Ministry of Science, Industry and Technology, dated 03.01.2012

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8/13. Letter № B.11.0.DLH.0.11.00.01/727 from Directorate General of Infrastructure Investments, dated 13.02.2012

8/14. Letter № B.02.1.DNM.0.65.04.619/930 from Counsel on Navigation of the Department of Strategy and Development, dated 12.01.2012

8/15. Letter № B.11.1.TCK.0.77.03.00-710.05-0023 from Directorate General of Highways, dated 06.01.2012

8/16. Letter № B.11.2.DHM.0.65.04.00-602-12076 from Directorate General of State Airport Authority, dated 20.02.2012

8/17. Letter of the Department of Spectral Observations of the Agency of Scientific Technologies and Communications № B.23.1.BTK.0.12.303.03/5847/2658 of 23.01.2012

8/18. Letter № B.11.0.SGB.0.05.619.99-240 from the Department of Strategy and Development of the Ministry of Transportation, Marine Affairs and Communication, dated 25.01.2012

8/19. Letter № B.23.1.OGM.1.21.13.00-225.99-542/10850 from Mersin Regional Directorate of Forestry, dated 28.07.2012

8/20. Guide on Specific Design Principles, 2012

9. RADIOLOGICAL IMPACT OF THE PLANT

Radiological impact of the NPP on the environment is mainly due to gaseous effluents. The design provides for estimations of the effective dose to a member of the critical group of population living in the vicinity of Akkuyu NPP due to radioactive gaseous effluents from the containment of the reactor under normal and abnormal operating conditions (incidents) of the units, design-basis accidents and design extension conditions (beyond-design basis accidents without fuel melting and severe accidents).

Preliminary analyses presented in this report are made for the meteorological conditions of Akkuyu NPP site with application of the verified and certified computer codes. Fission Products (FP) primary coolant radioactivity was calculated using the RELWWER-UNI code - expanded version of the RELWWER-2.0 code [9/1] with a module that includes empirical model to account for high fuel burn-up. Radioactive releases and public exposure doses are calculated using LEAK3 code [9/2] and DOZA_M code [9/3] respectively.

Results of this analysis can be used for determination of the Emergency zones boundaries, for the purposes of Radiation protection as well as preliminary initial data for optimization of design solutions at the next stages of Akkuyu NPP designing.

9.1 DEBK CONDITION

9.1.1 GENERAL STATEMENTS

Double ended break of the main circulating pipeline Dnom of 850 mm (Large Break LOCA) followed by total blackout for 56 hours is considered to be the maximum possible (severe) accident postulated as DEBK condition at Akkuyu NPP that results in the ultimate accidental release of radionuclides to the atmosphere and maximum radiological consequences in the environment. Parameters of the ultimate accidental release for Akkuyu NPP are assumed the same as for the reference plant (NVNPP-2) design. Detailed description of the maximum possible accident (DEBK) analysis will be provided in the PSAR for Akkuyu NPP.

During the severe accident (DEBK condition), the radiological consequences depend on the released radioactivity, the meteorological conditions during the early phase of the accident. The public exposure dose changes with the distance and depends on the wind direction.

The results of calculation of exposure dose distribution in terms of short-and long-term DEBK releases based on reference NPP and taking into account the site topography will be submitted at the stage of Site Parameters Report.

9.1.2. PARAMETERS OF THE ULTIMATE ACCIDENTAL RELEASE IN DEBK CONDITION

Radionuclide composition and activity of the ultimate accidental release to the environment are given Table 9/1.1 [9/4].

Table 9/1.1 – Radionuclide composition and activity of the ultimate accidental release Bq

Radionuclide	Radionuclides release through the containment passive ventilation system at elevation H=79 m	Radionuclides release due to containment bypass at elevation H=0 m
^{99}Mo	$4{,}75\cdot10^{12}$	$4{,}75\cdot10^{13}$
^{90}Sr	$1{,}09\cdot10^{11}$	$1{,}09\cdot10^{12}$
^{91}Sr	$1{,}89\cdot10^{11}$	$1{,}89\cdot10^{12}$
^{89}Sr	$1{,}34\cdot10^{12}$	$1{,}34\cdot10^{13}$
^{106}Ru	$6{,}91\cdot10^{11}$	$6{,}91\cdot10^{12}$
^{103}Ru	$2{,}08\cdot10^{12}$	$2{,}08\cdot10^{13}$
^{131}I*	$3{,}45\cdot10^{12}$	$3{,}16\cdot10^{13}$
^{132}I*	$4{,}28\cdot10^{12}$	$3{,}93\cdot10^{13}$
^{132}Te	$3{,}82\cdot10^{12}$	$3{,}82\cdot10^{13}$
^{131m}Te	$7{,}54\cdot10^{10}$	$7{,}54\cdot10^{11}$
^{133}Te	$1{,}21\cdot10^{2}$	$1{,}21\cdot10^{3}$
^{133}Xe	$7{,}49\cdot10^{15}$	$7{,}49\cdot10^{13}$
^{137}Cs	$4{,}00\cdot10^{11}$	$4{,}00\cdot10^{12}$

Radionuclide	Radionuclides release through the containment passive ventilation system at elevation H=79 m	Radionuclides release due to containment bypass at elevation H=0 m
^{134}Cs	$6{,}40 \cdot 10^{11}$	$6{,}40 \cdot 10^{12}$
^{136}Cs	$9{,}94 \cdot 10^{10}$	$9{,}94 \cdot 10^{11}$
^{140}Ba	$3{,}68 \cdot 10^{12}$	$3{,}68 \cdot 10^{13}$
^{140}La	$2{,}90 \cdot 10^{12}$	$2{,}90 \cdot 10^{13}$
^{141}Ce	$5{,}77 \cdot 10^{11}$	$5{,}77 \cdot 10^{12}$
^{143}Ce	$2{,}93 \cdot 10^{11}$	$2{,}93 \cdot 10^{12}$
^{144}Ce	$4{,}38 \cdot 10^{11}$	$4{,}38 \cdot 10^{11}$
** cumulative release of molecular, aerosol and organic iodine is specified*		

The results presented in Table 9/1.1 show that the ultimate accidental release is equivalent to a release of 300 TBq 131 I [9/19]. This result complies with the fifth level of the INES scale of events. Certain protective measures may be required at such release (for example, local sheltering and/or evacuation) to prevent or minimize the health risks.

The following distribution of physical and chemical iodine forms in the emission is conservatively suggested to calculate the exposure dose for the human thyroid gland: molecular iodine (I_2) - 40 %, aerosols - 40 %, organic compounds of iodine (methyl iodide, CH_3I) - 20 % [9/5]. Release duration is conservatively assumed for 1 hour.

9.1.3 METEOROLOGICAL CONDITIONS

The meteorological conditions of Akkuyu NPP site (air dispersion, stability class of the atmosphere, mixing layer and wind directions) are presented in Chapter 4 and specified in the reference document [9/6], the information of these conditions is used for evaluation of the radiological consequences.

The meteorological conditions for evaluation of radiological consequences in DEBK were selected considering Akkuyu NPP site data presented in Tables 9/1.2 and 9/1.3 [9/6].

Table 9/1.2 – Recurrence of atmosphere stability categories at Akkuyu site meteorological station

Surveys data	Recurrence, %					
	Stability categories					
	A	B	C	D	E	F
Akkuyu site station, 2009-2011	7,9	10,8	2,6	35,8	14,7	28,3

Table 9/1.3 – Recurrence of wind speed during 2009-2011 at Akkuyu site meteorological station

Elevation, m	Wind speed gradations, m/s	Recurrence, %
10	0,0-0,5	4,3
	0,6-1,5	15,4
	1,6-3,5	53,9
	3,6-5,5	20,3
	5,6-10,5	6,0

Data presented in Table 9/1.3 show that the recurrence of wind speed within the range from 0,6 to 5,5 m/s is about 90% in the vicinity of Akkuyu NPP. For that reason the public exposure doses are conservatively evaluated for all categories of atmosphere stability as per Pasquill classification on the basis of Akkuyu site data [9/6] with selection of inherent wind speeds presented in Table 9/1.4.

Table 9/1.4 –Inherent wind speed specific for different categories of atmosphere stability as per Pasquill classification [9/5]

Category of atmosphere stability as per Pasquill	A	B	C	D	E	F
Specific wind speed at elevation 10 m, m/s	1	2	3	4,5	3	2

For the conservative analysis, the evaluation of radiological consequences of the accident under consideration is made by the envelope (bounding) method, i.e. calculation of exposure dose to an individual being in open air on the plume path axis in any distance from the source of release is made for each category of atmosphere stability, and the maximum result was assumed as the final dose assessment.

The meteorological conditions (state of atmosphere stability, speed and direction of wind and others) are assumed to remain constant during the entire extension of the release dispersion.

9.1.4 SPECIFIC FEATURES OF THE TERRITORY IN THE DIRECTION OF RELEASE DISPERSION

The landscape crossed by areas of grass, bushings, trees etc. is assumed to define the ground surface roughness factor (z0 = 0.5 m).

9.1.5 METHODOLOGY AND SOFTWARE USED FOR EVALUATION OF PUBLIC EXPOSURE DOSES

Evaluation of radiological consequences in the environment of the accident under consideration is made with application of the Software SULTAN [9/20].

Dose conversion factors for evaluation of the public exposure are used in accordance with [9/7, 9/8, 9/9, 9/10].

9.1.6 EVALUATION OF GROUND SURFACE CONTAMINATION IN DEBK CONDITION

The results of the evaluation for the specific radionuclide ground contamination are presented in Table 9/1.5.

Table 9/1.5 – Specific radionuclide ground contamination, Bq/m^2

Distance from NPP, km	^{89}Sr	^{90}Sr	^{103}Ru	^{106}Ru	^{131}I	^{134}Cs	^{137}Cs
1	$2{,}0·10^{7}$	$1{,}7·10^{6}$	$3{,}2·10^{7}$	$1{,}1·10^{7}$	$5{,}8·10^{7}$	$9{,}8·10^{6}$	$6{,}1·10^{6}$
2	$6{,}7·10^{6}$	$5{,}4·10^{5}$	$1{,}0 ·10^{7}$	$3{,}4·10^{6}$	$1{,}6·10^{7}$	$3{,}2·10^{6}$	$2{,}0·10^{6}$
3	$3{,}3·10^{6}$	$2{,}7·10^{5}$	$5{,}2·10^{6}$	$1{,}7·10^{6}$	$7{,}6·10^{6}$	$1{,}6·10^{6}$	$1{,}0·10^{6}$
4	$2{,}0·10^{6}$	$1{,}7·10^{5}$	$3{,}2·10^{6}$	$1{,}1·10^{6}$	$4{,}3·10^{6}$	$9{,}8·10^{5}$	$6{,}1·10^{5}$
5	$1{,}4·10^{6}$	$1{,}1·10^{5}$	$2{,}1·10^{6}$	$7{,}0·10^{5}$	$2{,}7·10^{6}$	$6{,}5·10^{5}$	$4{,}1·10^{5}$
6	$1{,}0·10^{6}$	$8{,}1·10^{4}$	$1{,}6·10^{6}$	$5{,}2·10^{5}$	$1{,}9·10^{6}$	$4{,}8·10^{5}$	$3{,}0·10^{5}$
8	$6{,}2·10^{5}$	$5{,}0·10^{4}$	$9{,}6·10^{5}$	$3{,}2·10^{5}$	$1{,}1·10^{6}$	$3{,}0·10^{5}$	$1{,}8·10^{5}$
10	$4{,}3·10^{5}$	$3{,}5·10^{4}$	$6{,}7·10^{5}$	$2{,}2·10^{5}$	$6{,}8·10^{5}$	$2{,}0·10^{5}$	$1{,}3·10^{5}$
12	$3{,}1·10^{5}$	$2{,}5·10^{4}$	$4{,}8·10^{5}$	$1{,}6·10^{5}$	$4{,}7·10^{5}$	$1{,}5·10^{5}$	$9{,}2·10^{4}$
14	$2{,}2·10^{5}$	$1{,}8·10^{4}$	$3{,}4·10^{5}$	$1{,}1·10^{5}$	$3{,}5·10^{5}$	$1{,}1·10^{5}$	$6{,}6·10^{4}$
16	$1{,}7·10^{5}$	$1{,}4·10^{4}$	$2{,}7·10^{5}$	$9{,}0·10^{4}$	$2{,}7·10^{5}$	$8{,}3·10^{4}$	$5{,}2·10^{4}$
18	$1{,}4·10^{5}$	$1{,}1·10^{4}$	$2{,}2·10^{5}$	$7{,}2·10^{4}$	$2{,}1·10^{5}$	$6{,}6·10^{4}$	$4{,}2·10^{4}$
20	$1{,}1·10^{5}$	$9{,}3·10^{3}$	$1{,}8·10^{5}$	$5{,}9·10^{4}$	$1{,}7·10^{5}$	$5{,}4·10^{4}$	$3{,}4·10^{4}$
25	$7{,}6·10^{4}$	$6{,}2·10^{3}$	$1{,}2·10^{5}$	$3{,}9·10^{4}$	$1{,}1·10^{5}$	$3{,}6·10^{4}$	$2{,}3·10^{4}$
30	$5{,}2·10^{4}$	$4{,}3·10^{3}$	$8{,}1·10^{4}$	$2{,}7·10^{4}$	$7{,}8·10^{4}$	$2{,}5·10^{4}$	$1{,}6·10^{4}$
40	$2{,}9·10^{4}$	$2{,}3·10^{3}$	$4{,}4·10^{4}$	$1{,}5·10^{4}$	$4{,}4·10^{4}$	$1{,}4·10^{4}$	$8{,}5·10^{3}$
50	$1{,}8·10^{4}$	$1{,}5·10^{3}$	$2{,}8·10^{4}$	$9{,}2·10^{3}$	$3{,}0·10^{4}$	$8{,}5·10^{3}$	$5{,}3·10^{3}$
60	$1{,}2·10^{4}$	$9{,}9·10^{2}$	$1{,}8·10^{4}$	$6{,}1·10^{3}$	$2{,}4·10^{4}$	$5{,}5·10^{3}$	$3{,}5·10^{3}$
70	$9{,}6·10^{3}$	$8{,}1·10^{2}$	$1{,}5·10^{4}$	$5{,}0·10^{3}$	$1{,}8·10^{4}$	$4{,}6·10^{3}$	$2{,}9·10^{3}$
80	$8{,}3·10^{3}$	$7.0·10^{2}$	$1{,}3·10^{4}$	$4{,}3·10^{3}$	$1{,}5·10^{4}$	$3{,}9·10^{3}$	$2{,}5·10^{3}$
90	$7{,}3·10^{3}$	$6{,}2·10^{2}$	$1{,}1·10^{4}$	$3{,}8·10^{3}$	$1{,}3·10^{4}$	$3{,}4·10^{3}$	$2{,}2·10^{3}$
100	$6{,}3·10^{3}$	$5{,}3·10^{2}$	$9{,}8·10^{3}$	$3{,}3·10^{3}$	$1{,}1·10^{4}$	$3{,}0·10^{3}$	$1{,}9·10^{3}$
125	$4{,}5·10^{3}$	$3{,}8·10^{2}$	$6{,}9·10^{3}$	$2{,}3·10^{3}$	$7{,}2·10^{3}$	$2{,}1·10^{3}$	$1{,}3·10^{3}$

9.1.7 EVALUATION OF PUBLIC EXPOSURE DOSES

The public doses are evaluated as follows:

1) child thyroid gland dose (1-2 years old) and adult thyroid gland dose (elder than 17 years) - due to inhalation intake of iodine isotopes;
2) adult whole body dose - due to inhalation intake, external exposure from the radioactive plume and direct radiation from the underlying surface for the first two and ten days;
3) adult lungs dose - due to inhalation intake, external exposure from the radioactive plume and direct radiation from the underlying surface for the first two days;
4) adult (bone) marrow dose - due to inhalation intake, external exposure from the radioactive plume and direct radiation from the underlying surface for the first two days.

The results of public exposure dose evaluations for Akkuyu NPP in DEBK conditions taking into account the data shown in Table 9/1.1 and [9/10, 9/23] are given in Table 9/1.6.

Table 9/1.6 – Results of the public exposure dose evaluations in DEBK condition

Distance from NPP, km	The committed dose to thyroid gland[1], mGy		Dose to the whole body, mSv		Dose to lungs, mGy	Dose to bone marrow, mGy
	Children	Adults	for 2 days	for 10 days		
0,3	5100	2300	169	223	270	35
0,5	3700	1700	125	164	200	25
0,8	2400	1000	74	99	120	15
1,0	1500	660	48	64	76	9,7
1,2	1200	550	39	52	62	8,0
1,4	1000	440	32	43	50	6,4
1,6	800	350	25	34	40	5,1
1,8	600	270	20	27	31	4,0
2	460	210	15	20	23	3,0
3	230	100	7,2	10	11	1,4
4	142	63	4,4	5,8	6,2	0,8
5	96	43	3,0	3,9	4	0,52
6	71	33	2,3	3,0	3,2	0,41
7	55	26	1,8	2,3	2,3	0,3
8	45	20	1,4	1,8	1,8	0,24
10	32	14	0,94	1,2	1,2	0,16
12	25	11	0,74	0,95	0,94	0,12
14	19	9	0,59	0,74	0,68	0,088
16	16	7,5	0,49	0,61	0,55	0,071
18	14	6,4	0,41	0,52	0,44	0,058
20	12	5,5	0,35	0,43	0,35	0,046

Distance from NPP, km	The committed dose to thyroid gland[1], mGy		Dose to the whole body, mSv		Dose to lungs, mGy	Dose to bone marrow, mGy
25	8,9	4,1	0,25	0,31	0,24	0,031
30	7,1	3,3	0,20	0,24	0,17	0,022
40	5	2,4	0,14	0,16	0,092	0,012
50	3,8	1,8	0,10	0,11	0,055	0,0071

[1] - The committed dose of the thyroid irradiation is defined as the total dose in the organ after the radioactive material ingress during the entire exposure time. The exposure time corresponds to the complete decay time or biological decay of the radionuclides from the thyroid.

Chapter 10 provides for the basis of the emergency planning zones boundaries and the urgent protective actions taking into account IAEA safety standards.

9.2 NORMAL OPERATION CONDITIONS

9.2.1 GENERAL

Evaluations of the releases from the reactor containment under normal operation conditions to the environment were made for the following states:

- reactor operation at rated power (nominal power);
- reactor cool down during shutdown for planned preventive maintenance (PPM);
- reactor head opening for PPM.

Radioactive gaseous and aerosol releases from the reactor in normal operation may occur due to the following processes:

- uncontrolled primary coolant leak and further migration of volatile and gaseous fission products, purification on the filters of vent systems and further release thought the ventilation stack to the environment during reactor operation at power and cool down of the reactor during shutdown for PPM;
- direct release of volatile radionuclides from the reactor vessel to the containment, purification on the filters of emergency-repair vent system and further release thought the ventilation stack to the environment during reactor head opening for maintenance after cold shutdown;
- transfer of noble radioactive gases by venting from the deaerator to the gas treatment system, purification of radioactive substances on the filters of vent system and gas treatment system and further release of radionuclides through the ventilation stack to the environment.

The specific activities of fission products (FP) in the primary coolant corresponding to the design limit of activity (DL) are taken as input data (source term) for evaluations of radioactive release. The activities are calculated for reactor operation at power and during spike process (reactor shutdown and cool down). In this case the radioactive release targets and public exposure dose constraints (dose quotes) shall be ensured at design parameters of filters and localization systems. In accordance with current European practice [9/11] and Russian regulation SP AS-03 [9/12], the targets for public exposure dose corresponding to each of the gaseous release and liquid discharge targets are established at the minimum significant level of 10 μSv/year and comprises the cumulative dose formed at power operation, during cool down and reactor head opening for maintenance. In case public exposure dose is proved to be below this level no further optimization of radiation protection is required.

As per SP AS-03 requirements [9/12] the total dose quote for public members in normal operation of all units of the NPP is established at 100 μSv/year (50 μSv/year for each of the gaseous releases and liquid discharges). The total dose quote corresponds to the gaseous release/liquid discharge limits.

In case of abnormal operating conditions (incidents) in one of the NPP units an increased short-term release of FP to the environment may occur. In this case reactor cool down is required, if specific activities of FP in the primary coolant reach the safe operation limit of activity (SOL) that shall be in compliance with the total dose quote (100 μSv/year) for each of the incident events [9/11, 9/12].

9.2.2 EVALUATION OF GASEOUS FP RELEASES TO THE ENVIRONMENT

In normal operation the FP release from the reactor containment occurs due to uncontrolled leaks of the primary coolant that must not exceed 0,1 t/h. The evaporated uncontrolled primary coolant leaks are delivered to the atmosphere of steam generator (SG) boxes and further removed to the vent stack by the containment exhaust vent systems with total flow rate about 3000 m^3/h.

Since entire uncontrolled primary coolant leak is evaporated and becomes steam, all the radionuclides in this coolant are delivered to the atmosphere of SG boxes. The iodine is released to the atmosphere of SG boxes in three physical and chemical forms: molecular, organic and aerosol.

It is assumed that in normal operation of the reactor at power and cool down conditions the iodine is released to the atmosphere of SG boxes in the molecular form (9 %), organic form (1 %) and aerosols (90 %) [9/22].

It was also assumed that iodine is released to the containment only in molecular form during reactor head opening for maintenance.

Each of the iodine forms has different purification coefficients of the vent system filters that result in a different ratio of the iodine forms released to the atmosphere through the vent stack (see Table 9/2.1).

Radionuclides release from the reactor containment to the atmosphere at power operation, during cool down and reactor head opening for maintenance is calculated with LEAK3 computer code [9/2]. The results are presented in Table 9/2.1 and in Table 9/2.2 for FP activity in the primary coolant corresponding to DL and SOL respectively.

Contribution of C-14 to dose in case of VVER type reactors is negligibly small compared to the doses due to FP release and it is not accounted for in this report. Other short-lived radionuclides (noble gases) are not considered as well due to low contribution to the exposure dose.

More detailed evaluation of gaseous releases for Akkuyu NPP will be provided in PSAR.

Table 9/2.1 – Radionuclides' releases to the environment for operation, during cool down and reactor head opening for maintenance, calculated for activity in the primary coolant corresponding to DL

Radionuclide	Integral release at reactor power operation during core life time, Bq	Integral release during 36 hours at reactor cool down, Bq	Release at reactor head opening for maintenance, Bq
Kr-85 m	$1{,}34\cdot10^{12}$	$4{,}32\cdot10^{9}$	$2{,}66\cdot10^{7}$
Kr-85	$1{,}92\cdot10^{12}$	$1{,}50\cdot10^{7}$	$8{,}38\cdot10^{8}$
Kr-87	$9{,}63\cdot10^{11}$	$2{,}25\cdot10^{9}$	0
Kr-88	$3{,}42\cdot10^{12}$	$9{,}39\cdot10^{9}$	$1{,}73\cdot10^{5}$
Kr-89	$2{,}75\cdot10^{10}$	$2{,}58\cdot10^{7}$	0
Kr-90	$3{,}30\cdot10^{9}$	$4{,}19\cdot10^{6}$	0
Sr-90	$9{,}21\cdot10^{2}$	$4{,}24\cdot10^{0}$	0
mI-131	$4{,}16\cdot10^{7}$	$3{,}30\cdot10^{6}$	$2{,}63\cdot10^{8}$
OI-131	$6{,}18\cdot10^{7}$	$5{,}60\cdot10^{6}$	0
aI-131	$3{,}48\cdot10^{7}$	$3{,}08\cdot10^{6}$	0
Xe-133	$7{,}71\cdot10^{12}$	$5{,}33\cdot10^{10}$	$2{,}15\cdot10^{12}$
Cs-134	$8{,}08\cdot10^{6}$	$5{,}66\cdot10^{4}$	0
Xe-135	$8{,}65\cdot10^{12}$	$3{,}41\cdot10^{10}$	$3{,}42\cdot10^{10}$
Cs-137	$1{,}26\cdot10^{7}$	$8{,}40\cdot10^{4}$	0
Xe-138	$1{,}91\cdot10^{11}$	$3{,}3\cdot10^{8}$	0
Co-60	$6{,}10\cdot10^{2}$	$3{,}00\cdot10^{2}$	0

Table 9/2.2 – Radionuclides' releases to the environment during cool down and reactor head opening for maintenance calculated for activity in the primary coolant corresponding to SOL

Radionuclide	Integral release during 36 hours at reactor cool down, Bq	Release at reactor head opening for maintenance, Bq
Kr-85 m	$3{,}23\cdot10^{10}$	$1{,}99\cdot10^{8}$
Kr-85	$9{,}77\cdot10^{7}$	$5{,}45\cdot10^{9}$
Kr-87	$1{,}61\cdot10^{10}$	0

Radionuclide	Integral release during 36 hours at reactor cool down, Bq	Release at reactor head opening for maintenance, Bq
Kr-88	$6{,}73 \cdot 10^{10}$	$1{,}24 \cdot 10^{6}$
Kr-89	$1{,}79 \cdot 10^{8}$	0
Kr-90	$2{,}88 \cdot 10^{7}$	0
Sr-90	$1{,}61 \cdot 10^{1}$	0
mI-131	$2{,}94 \cdot 10^{7}$	$2{,}34 \cdot 10^{9}$
oI-131	$4{,}98 \cdot 10^{7}$	0
aI-131	$2{,}74 \cdot 10^{7}$	0
Xe-133	$4{,}88 \cdot 10^{11}$	$1{,}97 \cdot 10^{13}$
Cs-134	$3{,}50 \cdot 10^{5}$	0
Xe-135	$8{,}04 \cdot 10^{10}$	$8{,}04 \cdot 10^{10}$
Cs-137	$5{,}00 \cdot 10^{5}$	0
Xe-138	$1{,}19 \cdot 10^{9}$	0
Co-60	$3{,}00 \cdot 10^{2}$	0

9.2.3 EVALUATION OF PUBLIC EFFECTIVE DOSE DUE TO GASEOUS RELEASES

Evaluations of the effective dose for a long-term (annual) release of radionuclides in normal operation of the reactor at rated power is made using the method [9/13] and applying equations of statistics theory of atmospheric diffusion with Pasquill's stability classification system. For short-term release of radionuclides during reactor cool down and reactor head opening for maintenance is used DOZA_M computer code [9/3].

Table 9/2.3 presents the input data on average annual meteorological conditions in the Akkuyu NPP site vicinity [9/14] referring to the information presented in Chapter 4. This input data is used for evaluation of public effective dose due to the long-term annual release of radionuclides from the NPP by the method [9/13]. The average annual meteorological data is given for 16 sectors around the territory of Akkuyu NPP and specify the probability of wind speed distribution for different weather categories from A to F (from ultimately unstable to moderate stable atmosphere as per Pasquill's classification).

For evaluations of effective dose from the short-term release of radionuclides from the NPP with application of DOZA_M code [9/3] weather conditions are assumed constant.

Topography (roughness parameter) of the Akkuyu NPP site vicinity was assumed equal to 0.5 m for land (the landscape crossed by areas of grass, bushings, trees etc.) and 0,01 m for the sea surface.

As a critical group of the population children in the age from one to two years are considered.

Height of radioactive release from the NPP to the environment is assumed at elevation 110 m (height of ventilation stack from the sea level).

The joint frequency distribution of atmospheric stability category and wind speed was defined for 16 sectors of the area of Akkuyu NPP location in terms of initial meteorological data for the Akkuyu NPP site.

For every possible combination of the atmospheric stability category and wind speed doses were calculated at different distances from the radiation source by DOZA_M software. Therefore, the contribution to annual dose of population for every possible weather category combined with specific wind speed was defined.   The obtained values were summed up using the joint probability for all 16 sectors of the area of Akkuyu NPP location.

Table 9/2.3 – The joint frequency distribution of atmospheric stability category and wind speed in 16 sectors of Akkuyu NPP site vicinity, %

Stability category	Wind speed,m/s	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
A	0,5	0,0	0,05	0,079	0,009	0,006	0,006	0,012	0,007	0,007	0,023	0,052	0,03	0,007	0,003	0,004	0,008
	1,5	0,1	0,18	0,282	0,033	0,021	0,021	0,043	0,027	0,024	0,084	0,186	0,107	0,024	0,011	0,013	0,028
	3,5	0,4	0,63	0,988	0,115	0,072	0,072	0,149	0,094	0,085	0,294	0,651	0,375	0,085	0,038	0,047	0,098
	5,5	0,1	0,237	0,372	0,043	0,027	0,027	0,056	0,035	0,032	0,111	0,245	0,141	0,032	0,014	0,018	0,037
	10,5	0,0	0,071	0,112	0,013	0,008	0,008	0,017	0,011	0,01	0,033	0,074	0,042	0,01	0,004	0,005	0,011
B	0,5	0,0	0,069	0,108	0,013	0,008	0,008	0,016	0,01	0,009	0,032	0,071	0,041	0,009	0,004	0,005	0,011
	1,5	0,1	0,246	0,386	0,045	0,028	0,028	0,058	0,037	0,033	0,115	0,254	0,146	0,033	0,015	0,018	0,038
	3,5	0,6	0,862	1,351	0,157	0,099	0,099	0,204	0,128	0,116	0,402	0,891	0,512	0,116	0,052	0,064	0,134
	5,5	0,2	0,324	0,509	0,059	0,037	0,037	0,077	0,048	0,044	0,151	0,335	0,193	0,044	0,02	0,024	0,05
	10,5	0,0	0,098	0,153	0,018	0,011	0,011	0,023	0,014	0,013	0,045	0,101	0,058	0,013	0,006	0,007	0,015
C	0,5	0,0	0,017	0,026	0,003	0,002	0,002	0,004	0,002	0,002	0,008	0,017	0,01	0,002	0,001	0,001	0,003
	1,5	0,0	0,059	0,093	0,011	0,007	0,007	0,014	0,009	0,008	0,028	0,061	0,035	0,008	0,004	0,004	0,009
	3,5	0,1	0,207	0,325	0,038	0,024	0,024	0,049	0,031	0,028	0,097	0,214	0,123	0,028	0,013	0,015	0,032
	5,5	0,0	0,078	0,122	0,014	0,009	0,009	0,018	0,012	0,011	0,036	0,081	0,046	0,011	0,005	0,006	0,012
	10,5	0,0	0,023	0,037	0,004	0,003	0,003	0,006	0,003	0,003	0,011	0,024	0,014	0,003	0,001	0,002	0,004
D	0,5	0,1	0,228	0,357	0,042	0,026	0,026	0,054	0,034	0,031	0,106	0,236	0,135	0,031	0,014	0,017	0,035
	1,5	0,5	0,816	1,279	0,149	0,094	0,094	0,193	0,121	0,11	0,38	0,844	0,485	0,11	0,05	0,061	0,127
	3,5	2,0	2,856	4,477	0,521	0,328	0,328	0,675	0,425	0,386	1,331	2,952	1,698	0,386	0,174	0,212	0,444
	5,5	0,7	1,076	1,686	0,196	0,124	0,124	0,254	0,16	0,145	0,501	1,112	0,64	0,145	0,065	0,08	0,167
	10,5	0,2	0,323	0,507	0,059	0,037	0,037	0,076	0,048	0,044	0,151	0,334	0,192	0,044	0,02	0,024	0,05
E	0,5	0,0	0,094	0,147	0,017	0,011	0,011	0,022	0,014	0,013	0,044	0,097	0,056	0,013	0,006	0,007	0,015
	1,5	0,2	0,335	0,525	0,061	0,038	0,038	0,079	0,05	0,045	0,156	0,346	0,199	0,045	0,02	0,025	0,052
	3,5	0,8	1,173	1,838	0,214	0,135	0,135	0,277	0,174	0,158	0,547	1,212	0,697	0,158	0,071	0,087	0,182
	5,5	0,3	0,442	0,692	0,081	0,051	0,051	0,104	0,066	0,06	0,206	0,457	0,263	0,06	0,027	0,033	0,069
	10,5	0,0	0,133	0,208	0,024	0,015	0,015	0,031	0,02	0,018	0,062	0,137	0,079	0,018	0,008	0,01	0,021
F	0,5	0,1	0,18	0,282	0,033	0,021	0,021	0,043	0,027	0,024	0,084	0,186	0,107	0,024	0,011	0,013	0,028
	1,5	0,4	0,645	1,011	0,118	0,074	0,074	0,153	0,096	0,087	0,301	0,667	0,384	0,087	0,039	0,048	0,1
	3,5	1,6	2,258	3,539	0,412	0,259	0,259	0,534	0,336	0,305	1,053	2,334	1,342	0,305	0,137	0,168	0,351
	5,5	0,6	0,85	1,333	0,155	0,098	0,098	0,201	0,126	0,115	0,396	0,879	0,506	0,115	0,052	0,063	0,132
	10,5	0,1	0,255	0,401	0,047	0,029	0,029	0,06	0,038	0,035	0,119	0,264	0,152	0,035	0,016	0,019	0,04

Types of public exposure considered in this evaluation are as follows:

- external exposure from radionuclides released in the plume and those settled on the ground surface;
- internal exposure from radionuclides delivered to the human body by inhalation intake, and ingestion of the contaminated food stuffs.

External exposure dose from ground surface contamination is assumed for public members in open air. Conservative input data that is used for evaluation of internal exposure is presented in Table 9/2.4 [9/15], [9/16]. Full information on food consumption for population in Akkuyu NPP site vicinity is not available at present. More detailed information on agricultural crop production, drinking water usage and food consumption will be considered at design stage.

Table 9/2.4 – Annual food consumption and inhalation rate for population

Parameter	Children (1-2 year old)	Adults
Annual food consumption:		
Milk products, l/a	300	250
Water and beverages, m^3/a	0,26	0,60
Meat, kg/a	40	100
Vegetables, kg/a, including:	153	410
– cereal product (wheat)	54	–
– potatoes	84	–
– cabbage	10	–
– cuke (salads)	5	–
Inhalation rate, m^3/s (m^3/a)	$4{,}44 \cdot 10^{-5}$ (1400)	$2{,}66 \cdot 10^{-4}$ (8400)

The effective dose for the critical group of population at different distances from Akkuyu NPP is presented in Tables 9/2.5 – 9/2.7. The elevation of the release of radionuclides to the environment is considered 110 m; the primary coolant activity corresponds to DL and different states of operation.

The effective dose for the critical group of population at different distances from Akkuyu NPP due to the releases in case of primary coolant activity corresponding to SOL is presented in Tables 9/2.8 and 9/2.9. The release of radionuclides to the environment is considered at elevation 110 m.

Table 9/2.5 – Effective dose for critical group of population at different distances for release of radionuclides at elevation 110 m, the primary coolant activity corresponding to DL and nominal power, Sv.

Distance, km	N	NNE	NE	ENE	E	ESE	SE	SSE
0,5	$1,03·10^{-7}$	$1,36·10^{-7}$	$2,05·10^{-7}$	$3,65·10^{-8}$	$2,82·10^{-8}$	$2,82·10^{-8}$	$1,48·10^{-8}$	$1,11·10^{-8}$
0,8	$1,10·10^{-7}$	$1,45·10^{-7}$	$2,19·10^{-7}$	$3,87·10^{-8}$	$2,98·10^{-8}$	$2,98·10^{-8}$	$2,40·10^{-8}$	$1,80·10^{-8}$
1	$1,12·10^{-7}$	$1,48·10^{-7}$	$2,24·10^{-7}$	$3,95·10^{-8}$	$3,04·10^{-8}$	$3,04·10^{-8}$	$2,48·10^{-8}$	$1,86·10^{-8}$
1,3	$1,10·10^{-7}$	$1,46·10^{-7}$	$2,20·10^{-7}$	$3,86·10^{-8}$	$2,98·10^{-8}$	$2,98·10^{-8}$	$2,53·10^{-8}$	$1,89·10^{-8}$
1,5	$1,06·10^{-7}$	$1,40·10^{-7}$	$2,11·10^{-7}$	$3,70·10^{-8}$	$2,85·10^{-8}$	$2,85·10^{-8}$	$2,59·10^{-8}$	$1,93·10^{-8}$
1,8	$9,72·10^{-8}$	$1,28·10^{-7}$	$1,94·10^{-7}$	$3,38·10^{-8}$	$2,59·10^{-8}$	$2,59·10^{-8}$	$2,64·10^{-8}$	$1,97·10^{-8}$
2	$9,10·10^{-8}$	$1,20·10^{-7}$	$1,82·10^{-7}$	$3,15·10^{-8}$	$2,42·10^{-8}$	$2,42·10^{-8}$	$2,63·10^{-8}$	$1,96·10^{-8}$
3	$6,48·10^{-8}$	$8,59·10^{-8}$	$1,30·10^{-7}$	$2,21·10^{-8}$	$1,69·10^{-8}$	$1,69·10^{-8}$	$2,28·10^{-8}$	$1,69·10^{-8}$
4	$5,14·10^{-8}$	$6,82·10^{-8}$	$1,03·10^{-8}$	$1,74·10^{-8}$	$1,32·10^{-8}$	$1,32·10^{-8}$	$1,87·10^{-8}$	$1,38·10^{-8}$
5	$3,80·10^{-8}$	$5,04·10^{-8}$	$7,67·10^{-8}$	$1,27·10^{-8}$	$9,53·10^{-9}$	$9,53·10^{-9}$	$1,45·10^{-8}$	$1,06·10^{-8}$
6	$3,23·10^{-8}$	$4,28·10^{-8}$	$6,52·10^{-8}$	$1,07·10^{-8}$	$7,99·10^{-9}$	$7,99·10^{-9}$	$1,22·10^{-8}$	$8,84·10^{-9}$
8	$2,22·10^{-8}$	$2,95·10^{-8}$	$4,51·10^{-8}$	$7,16·10^{-9}$	$5,31·10^{-9}$	$5,31·10^{-9}$	$8,11·10^{-9}$	$5,82·10^{-9}$
10	$1,78·10^{-8}$	$2,38·10^{-8}$	$3,64·10^{-8}$	$5,67·10^{-9}$	$4,17·10^{-9}$	$4,17·10^{-9}$	$6,40·10^{-9}$	$4,56·10^{-9}$
12	$1,43·10^{-8}$	$1,92·10^{-8}$	$2,94·10^{-8}$	$4,50·10^{-9}$	$3,28·10^{-9}$	$3,28·10^{-9}$	$5,15·10^{-9}$	$3,65·10^{-9}$
14	$1,26·10^{-8}$	$1,69·10^{-8}$	$2,59·10^{-8}$	$3,91·10^{-9}$	$2,84·10^{-9}$	$2,84·10^{-9}$	$4,52·10^{-9}$	$3,19·10^{-9}$
16	$9,94·10^{-9}$	$1,34·10^{-8}$	$2,06·10^{-8}$	$3,03·10^{-9}$	$2,18·10^{-9}$	$2,18·10^{-9}$	$3,58·10^{-9}$	$2,51·10^{-9}$
18	$9,07·10^{-9}$	$1,23·10^{-8}$	$1,89·10^{-8}$	$2,75·10^{-9}$	$1,96·10^{-9}$	$1,96·10^{-9}$	$3,27·10^{-9}$	$2,28·10^{-9}$
20	$7,34·10^{-9}$	$9,90·10^{-9}$	$1,53·10^{-8}$	$2,17·10^{-9}$	$1,53·10^{-9}$	$1,53·10^{-9}$	$2,64·10^{-9}$	$1,83·10^{-9}$
25	$5,30·10^{-9}$	$7,17·10^{-9}$	$1,11·10^{-8}$	$1,53·10^{-9}$	$1,06·10^{-9}$	$1,06·10^{-9}$	$1,91·10^{-9}$	$1,30·10^{-9}$
30	$4,00·10^{-9}$	$5,43·10^{-9}$	$8,42·10^{-9}$	$1,13·10^{-9}$	$7,74·10^{-10}$	$7,74·10^{-10}$	$1,44·10^{-9}$	$9,67·10^{-10}$

Table 9/2.5 (continued)

Distance, km	S	SSW	SW	WSW	W	WNW	NW	NNW
0,5	$1,05·10^{-8}$	$2,44·10^{-8}$	$4,80·10^{-8}$	$8,67·10^{-8}$	$3,06·10^{-8}$	$2,16·10^{-8}$	$2,32·10^{-8}$	$3,31·10^{-8}$
0,8	$1,70·10^{-8}$	$3,97·10^{-8}$	$7,83·10^{-8}$	$9,21·10^{-8}$	$3,24·10^{-8}$	$2,28·10^{-8}$	$2,45·10^{-8}$	$3,50·10^{-8}$
1	$1,75·10^{-8}$	$4,11·10^{-8}$	$8,14·10^{-8}$	$9,43·10^{-8}$	$3,31·10^{-8}$	$2,32·10^{-8}$	$2,50·10^{-8}$	$3,58·10^{-8}$
1,3	$1,79·10^{-8}$	$4,22·10^{-8}$	$8,35·10^{-8}$	$9,26·10^{-8}$	$3,24·10^{-8}$	$2,27·10^{-8}$	$2,44·10^{-8}$	$3,50·10^{-8}$
1,5	$1,83·10^{-8}$	$4,31·10^{-8}$	$8,55·10^{-8}$	$8,88·10^{-8}$	$3,10·10^{-8}$	$2,17·10^{-8}$	$2,33·10^{-8}$	$3,35·10^{-8}$
1,8	$1,86·10^{-8}$	$4,40·10^{-8}$	$8,75·10^{-8}$	$8,15·10^{-8}$	$2,82·10^{-8}$	$1,97·10^{-8}$	$2,12·10^{-8}$	$3,06·10^{-8}$
2	$1,85·10^{-8}$	$4,40·10^{-8}$	$8,74·10^{-8}$	$7,63·10^{-8}$	$2,64·10^{-8}$	$1,83·10^{-8}$	$1,98·10^{-8}$	$2,86·10^{-8}$
3	$1,59·10^{-8}$	$3,82·10^{-8}$	$7,66·10^{-8}$	$5,42·10^{-8}$	$1,84·10^{-8}$	$1,27·10^{-8}$	$1,37·10^{-8}$	$2,00·10^{-8}$
4	$1,29·10^{-8}$	$3,15·10^{-8}$	$6,33·10^{-8}$	$4,30·10^{-8}$	$1,45·10^{-8}$	$9,87·10^{-9}$	$1,07·10^{-8}$	$1,57·10^{-8}$
5	$9,97·10^{-9}$	$2,47·10^{-8}$	$5,00·10^{-8}$	$3,17·10^{-8}$	$1,05·10^{-8}$	$7,04·10^{-9}$	$7,65·10^{-9}$	$1,14·10^{-8}$
6	$8,31·10^{-9}$	$2,08·10^{-8}$	$4,23·10^{-8}$	$2,69·10^{-8}$	$8,80·10^{-9}$	$5,87·10^{-9}$	$6,39·10^{-9}$	$9,59·10^{-9}$
8	$5,46·10^{-9}$	$1,41·10^{-8}$	$2,89·10^{-8}$	$1,84·10^{-8}$	$5,86·10^{-9}$	$3,83·10^{-9}$	$4,20·10^{-9}$	$6,42·10^{-9}$
10	$4,27·10^{-9}$	$1,12·10^{-8}$	$2,31·10^{-8}$	$1,48·10^{-8}$	$4,62·10^{-9}$	$2,97·10^{-9}$	$3,27·10^{-9}$	$5,06·10^{-9}$
12	$3,41·10^{-9}$	$9,08·10^{-9}$	$1,88·10^{-8}$	$1,19·10^{-8}$	$3,65·10^{-9}$	$2,31·10^{-9}$	$2,55·10^{-9}$	$4,00·10^{-9}$
14	$2,97·10^{-9}$	$8,01·10^{-9}$	$1,67·10^{-8}$	$1,04·10^{-8}$	$3,16·10^{-9}$	$1,97·10^{-9}$	$2,19·10^{-9}$	$3,47·10^{-9}$

Distance, km	S	SSW	SW	WSW	W	WNW	NW	NNW
16	$2{,}33 \cdot 10^{-9}$	$6{,}41 \cdot 10^{-9}$	$1{,}34 \cdot 10^{-8}$	$8{,}26 \cdot 10^{-9}$	$2{,}43 \cdot 10^{-9}$	$1{,}49 \cdot 10^{-9}$	$1{,}66 \cdot 10^{-9}$	$2{,}68 \cdot 10^{-9}$
18	$2{,}12 \cdot 10^{-9}$	$5{,}88 \cdot 10^{-9}$	$1{,}23 \cdot 10^{-8}$	$7{,}53 \cdot 10^{-9}$	$2{,}20 \cdot 10^{-9}$	$1{,}33 \cdot 10^{-9}$	$1{,}49 \cdot 10^{-9}$	$2{,}43 \cdot 10^{-9}$
20	$1{,}70 \cdot 10^{-9}$	$4{,}80 \cdot 10^{-9}$	$1{,}01 \cdot 10^{-8}$	$6{,}07 \cdot 10^{-9}$	$1{,}72 \cdot 10^{-9}$	$1{,}02 \cdot 10^{-9}$	$1{,}15 \cdot 10^{-9}$	$1{,}91 \cdot 10^{-9}$
25	$1{,}20 \cdot 10^{-9}$	$3{,}51 \cdot 10^{-9}$	$7{,}47 \cdot 10^{-9}$	$4{,}37 \cdot 10^{-9}$	$1{,}20 \cdot 10^{-9}$	$6{,}86 \cdot 10^{-10}$	$7{,}80 \cdot 10^{-10}$	$1{,}34 \cdot 10^{-9}$
30	$8{,}93 \cdot 10^{-10}$	$2{,}68 \cdot 10^{-9}$	$5{,}72 \cdot 10^{-9}$	$3{,}29 \cdot 10^{-9}$	$8{,}80 \cdot 10^{-10}$	$4{,}90 \cdot 10^{-10}$	$5{,}61 \cdot 10^{-10}$	$9{,}87 \cdot 10^{-10}$

Table 9/2.6 – Effective dose for critical group of population at different distances for a release of radionuclides at elevation 110 m, the primary coolant activity corresponding to DL and for reactor cool down, Sv.

Distance, km	Effective dose, Sv
0,5	$3{,}80 \cdot 10^{-7}$
0,8	$2{,}18 \cdot 10^{-7}$
1	$1{,}82 \cdot 10^{-7}$
1,3	$1{,}64 \cdot 10^{-7}$
1,5	$1{,}53 \cdot 10^{-7}$
1,8	$1{,}50 \cdot 10^{-7}$
2	$1{,}44 \cdot 10^{-7}$
3	$1{,}04 \cdot 10^{-7}$
4	$9{,}43 \cdot 10^{-8}$
5	$8{,}45 \cdot 10^{-8}$
6	$7{,}37 \cdot 10^{-8}$
8	$5{,}82 \cdot 10^{-8}$
10	$4{,}76 \cdot 10^{-8}$
12	$4{,}60 \cdot 10^{-8}$
14	$4{,}37 \cdot 10^{-8}$
16	$4{,}12 \cdot 10^{-8}$
18	$3{,}75 \cdot 10^{-8}$
20	$3{,}34 \cdot 10^{-8}$
25	$2{,}61 \cdot 10^{-8}$
30	$2{,}05 \cdot 10^{-8}$

Table 9/2.7 – Effective dose for critical group of population at different distances for a release of radionuclides at elevation 110 m, the primary coolant activity corresponding to DL and reactor head opening for maintenance, Sv.

Distance, km	Effective dose, Sv
0,5	$1{,}21 \cdot 10^{-5}$
0,8	$6{,}79 \cdot 10^{-6}$
1	$5{,}74 \cdot 10^{-6}$
1,3	$5{,}17 \cdot 10^{-6}$
1,5	$4{,}87 \cdot 10^{-6}$
1,8	$4{,}74 \cdot 10^{-6}$
2	$4{,}52 \cdot 10^{-6}$
3	$3{,}20 \cdot 10^{-6}$
4	$2{,}88 \cdot 10^{-6}$
5	$2{,}56 \cdot 10^{-6}$
6	$2{,}19 \cdot 10^{-6}$
8	$1{,}82 \cdot 10^{-6}$
10	$1{,}44 \cdot 10^{-6}$
12	$1{,}37 \cdot 10^{-6}$
14	$1{,}24 \cdot 10^{-6}$
16	$1{,}12 \cdot 10^{-6}$
18	$9{,}86 \cdot 10^{-7}$
20	$8{,}51 \cdot 10^{-7}$
25	$5{,}96 \cdot 10^{-7}$
30	$4{,}17 \cdot 10^{-7}$

Table 9/2.8 – Effective dose for critical group of population at different distances for a release of radionuclides at elevation 110 m, the primary coolant activity corresponding to SOL and for reactor cool down, Sv.

Distance, km	Effective dose, Sv
0,5	$2{,}90 \cdot 10^{-6}$
0,8	$1{,}66 \cdot 10^{-6}$
1	$1{,}39 \cdot 10^{-6}$
1,3	$1{,}25 \cdot 10^{-6}$
1,5	$1{,}17 \cdot 10^{-6}$
1,8	$1{,}14 \cdot 10^{-6}$
2	$1{,}09 \cdot 10^{-6}$
3	$7{,}93 \cdot 10^{-7}$
4	$7{,}17 \cdot 10^{-7}$
5	$6{,}41 \cdot 10^{-7}$
6	$5{,}58 \cdot 10^{-7}$
8	$4{,}59 \cdot 10^{-7}$

Distance, km	Effective dose, Sv
10	$3{,}60 \cdot 10^{-7}$
12	$3{,}42 \cdot 10^{-7}$
14	$3{,}20 \cdot 10^{-7}$
16	$3{,}05 \cdot 10^{-7}$
18	$2{,}76 \cdot 10^{-7}$
20	$2{,}48 \cdot 10^{-7}$
25	$1{,}92 \cdot 10^{-7}$
30	$1{,}50 \cdot 10^{-7}$

Table 9/2.9 – Effective dose for critical group of population at different distances for a release of radionuclides at elevation 110 m, the primary coolant activity corresponding to SOL and reactor head opening for maintenance, Sv.

Distance, km	Effective dose, Sv
0,5	$1{,}08 \cdot 10^{-4}$
0,8	$6{,}04 \cdot 10^{-5}$
1	$5{,}10 \cdot 10^{-5}$
1,3	$4{,}60 \cdot 10^{-5}$
1,5	$4{,}33 \cdot 10^{-5}$
1,8	$4{,}22 \cdot 10^{-5}$
2	$4{,}02 \cdot 10^{-5}$
3	$2{,}85 \cdot 10^{-5}$
4	$2{,}57 \cdot 10^{-5}$
5	$2{,}28 \cdot 10^{-5}$
6	$1{,}95 \cdot 10^{-5}$
8	$1{,}61 \cdot 10^{-5}$
10	$1{,}28 \cdot 10^{-5}$
12	$1{,}18 \cdot 10^{-5}$
14	$1{,}08 \cdot 10^{-5}$
16	$8{,}87 \cdot 10^{-6}$
18	$8{,}2 \cdot 10^{-6}$
20	$7{,}57 \cdot 10^{-6}$
25	$5{,}30 \cdot 10^{-6}$
30	$3{,}70 \cdot 10^{-6}$

The results presented in Tables 9/2.5 – 9/2.7 show that the cumulative effective dose to a member of the critical group of population due to gaseous releases from one unit of Akkuyu NPP at 800 m distance is 7,23 μSv/year, which is less than the minimum significant level of 10 μSv/year (the evaluation is made for primary coolant activity corresponding to DL and release at elevation 110 m).

The total value for cumulative effective dose for Akkuyu NPP (four units) will depend on the PPM schedule. For the most unfavorable case (PPM of all four units within one year) and using the Tables 9/2.5 – 9/2.7 it it is easy to calculate that the total effective dose will not exceed 30 μSv/year. This value is less than the dose quote of 50 μSv/year established for gaseous releases in normal operation of all units of the NPP. If PPM is conducted only at one unit within a year while the other three units operate at nominal power, the cumulative effective dose of the critical group of population will make up 7.9 μSv/year. More detailed analysis of the public exposure dose and gaseous release limits for Akkuyu NPP will be provided in PSAR.

Tables 9.2/3 – 9.2/5 show the population irradiation doses resulted from annual nuclides release from Akkuyu NPP depending on the distance and direction. The calculations of population irradiation doses are given for the distances up to 80 km. These data are obtained through DOZA_M programme, which algorithm takes into account *D/Q* ratio. While the calculation of atmospheric dispersion factors χ / Q the mentioned programme uses the information of repeated stable atmospheric categories in the area of Akkuyu NPP site (section 4, tables 4/3.12, 4.3/13).

The result in Tables 9/2.8 and 9/2.9 show that the cumulative effective dose to a member of the critical group of population due to the radioactive releases from one unit of Akkuyu NPP after cool down and reactor head opening makes up 62.1 μSv/year at 800 m distance (the evaluation is made for primary coolant activity corresponding to SOL and release at elevation 110 m). This value is less than the dose quote of 100 μSv/year for an incident event at one unit. If an incident occurs at one unit within a year with the assumption that other three units are under normal operation conditions, the cumulative effective dose due to radioactive releases from all four units of Akkuyu NPP makes up 83.8 μSv/year, which is less than the total dose quote of 100 μSv/year. More detailed analysis for each of the incident (design category 2) events will be presented in PSAR.

9.2.4 EVALUATION OF LIQUID FP DISCHARGES TO THE ENVIRONMENT

In accordance with the Russian regulation OSPORB-99/2010, item 5.1.8 [9/17] quality of drinking water is considered acceptable (non-radioactive), and no further measures to reduce radioactivity are necessary, if the radiological criterion doesn’t exceed the minimum significant level (<1) as follows:

$$\sum_{i=1}^{n} \frac{A_i}{IL_i} < 1$$

where A_i – specific activity of i-radionuclide in drinking water, Bq/kg;

IL_i - intervention level to reduce specific activity of i-radionuclide that is established in radiation safety standards NRB-99/2009, Appendix 2-a [9/10], Bq/kg;

n – total number of radionuclides in drinking water.

In accordance with the Russian regulation OSPORB-99/2010, item 5.1.9 [9/17] drinking water requires measures to reduce specific activity of i-radionuclide, if the radiological criterion exceeds the intervention level (IL) within the range (1÷10) required optimization of radiation protection as follows:

$$1 < \sum_{i=1}^{n} \frac{A_i}{IL_i} \leq 10$$

Radioactivity in liquid discharges from Akkuyu NPP to the environment depends on the accumulation of debalance water drains not used in recycle of the NPP process system operation. Debalance water is the volume of water per an unit of time released/discharged into the environment as excessive from NPP systems after the respective cleaning and control. The waste treatment systems with hold-up tanks are effective in reducing the amounts in liquid effluents.

The debalance water drains are controlled by radiation monitoring systems. If specific activity of the debalance water doesn't exceed the acceptable limit established to meet the minimum significant level then it may be discharged to the outlet channel where the debalance water is further mixed with the cooling service water for dilution before discharge to the environment. If the specific activity of the debalance water exceeds the acceptable limit then it is returned for recycling and additional purification. Emergency liquid discharge of radionuclides to the environment is excluded by design means. Structures of the balance water tanks have reliable hydraulic isolation preventing liquid discharges to the ground waters. The design provides for capability of pumping the debalance water drains to the reserved tanks.

Based on the reference plant design (NVNPP-2 PSAR Ch. 10.3.3) [9/21] preliminary evaluations of radionuclides activity in liquid discharges from one unit of the NPP are presented in Table 9/2.10.

Table 9/2.10 – Specific activity of radionuclides in the debalance water system tanks

Radionuclide	Specific activity, Bq/kg	Intervention level, Bq/kg	Radiological criterion (A_i/ IL_i) for one NPP unit	Radiological criterion (A_i/ IL_i) for four NPP units
Br-84	$3{,}40 \cdot 10^{-10}$	-	-	-
Br-87	$2{,}88 \cdot 10^{-13}$	-	-	-
Rb-88	$4{,}79 \cdot 10^{-9}$	-	-	-
Rb-89	$8{,}12 \cdot 10^{-10}$	-	-	-
Sr-89	$1{,}93 \cdot 10^{-5}$	$5{,}30 \cdot 10^{1}$	$3{,}64 \cdot 10^{-7}$	$1{,}456 \cdot 10^{-6}$
Rb-90	$5{,}71 \cdot 10^{-12}$	-	-	-
Sr-90	$2{,}69 \cdot 10^{-6}$	5	$5{,}37 \cdot 10^{-7}$	$2{,}148 \cdot 10^{-6}$
Sr-91	$3{,}76 \cdot 10^{-8}$	-	-	-
Sr-92	$1{,}41 \cdot 10^{-9}$	-	-	-
Mo-99	$1{,}91 \cdot 10^{-7}$	$2{,}30 \cdot 10^{2}$	$8{,}32 \cdot 10^{-10}$	$3{,}328 \cdot 10^{-9}$
Ru-103	$5{,}01 \cdot 10^{-5}$	$1{,}90 \cdot 10^{2}$	$2{,}64 \cdot 10^{-7}$	$1{,}056 \cdot 10^{-6}$
Ru-106	$1{,}13 \cdot 10^{-5}$	$2{,}00 \cdot 10^{1}$	$5{,}67 \cdot 10^{-7}$	$2{,}268 \cdot 10^{-6}$
Rh-106	$1{,}13 \cdot 10^{-5}$	$2{,}70 \cdot 10^{1}$	$4{,}20 \cdot 10^{-8}$	$1{,}\ 680 \cdot 10^{-7}$
Te-131	$5{,}71 \cdot 10^{-11}$	-	-	-
I-131	$9{,}86 \cdot 10^{-6}$	6,3	$1{,}56 \cdot 10^{-6}$	$6{,}24 \cdot 10^{-6}$
Te-132	$3{,}10 \cdot 10^{-6}$	$3{,}70 \cdot 10^{1}$	$8{,}37 \cdot 10^{-8}$	$3{,}348 \cdot 10^{-7}$
I-132	$3{,}23 \cdot 10^{-6}$	-	-	-
Te-133	$2{,}58 \cdot 10^{-11}$	-	-	-
I-133	$2{,}10 \cdot 10^{-6}$	-	-	-
I-134	$5{,}30 \cdot 10^{-9}$	-	-	-
Cs-134	$2{,}17 \cdot 10^{-1}$	7,3	$2{,}98 \cdot 10^{-2}$	$1{,}192 \cdot 10^{-1}$
I-135	$3{,}22 \cdot 10^{-7}$	-	-	-
Cs-137	$3{,}31 \cdot 10^{-1}$	$1{,}10 \cdot 10^{1}$	$3{,}01 \cdot 10^{-2}$	$1{,}204 \cdot 10^{-1}$
Cs-138	$1{,}29 \cdot 10^{-8}$	-	-	-
Ba-139	$4{,}00 \cdot 10^{-9}$	-	-	-
Ba-140	$9{,}91 \cdot 10^{-6}$	$5{,}30 \cdot 10^{1}$	$1{,}87 \cdot 10^{-7}$	$7{,}48 \cdot 10^{-7}$
La-140	$1{,}50 \cdot 10^{-5}$	$6{,}90 \cdot 10^{1}$	$2{,}17 \cdot 10^{-7}$	$8{,}68 \cdot 10^{-7}$
Ce-141	$8{,}99 \cdot 10^{-5}$	$2{,}00 \cdot 10^{2}$	$4{,}49 \cdot 10^{-7}$	$1{,}796 \cdot 10^{-6}$
Ce-144	$1{,}53 \cdot 10^{-4}$	$2{,}70 \cdot 10^{1}$	$5{,}66 \cdot 10^{-6}$	$2{,}264 \cdot 10^{-5}$
Pr-144	$1{,}53 \cdot 10^{-4}$	-	-	-
Na-24	$1{,}28 \cdot 10^{-3}$	-	-	-

Radionuclide	Specific activity, Bq/kg	Intervention level, Bq/kg	Radiological criterion (A_i/ IL_i) for one NPP unit	Radiological criterion (A_i/ IL_i) for four NPP units
Cr-51	$8{,}26\cdot10^{-8}$	-	-	-
Mn-54	$3{,}16\cdot10^{-8}$	-	-	-
Fe-59	$4{,}81\cdot10^{-8}$	$7{,}70\cdot10^{1}$	$6{,}25\cdot10^{-10}$	$2{,}50\cdot10^{-9}$
Co-58	$2{,}62\cdot10^{-7}$	$1{,}90\cdot10^{2}$	$1{,}38\cdot10^{-9}$	$5{,}52\cdot10^{-9}$
Co-60	$2{,}73\cdot10^{-7}$	$4{,}10\cdot10^{1}$	$6{,}66\cdot10^{-9}$	$2{,}664\cdot10^{-8}$
Zr-95	$4{,}14\cdot10^{-5}$	$1{,}50\cdot10^{2}$	$2{,}76\cdot10^{-7}$	$1{,}104\cdot10^{-6}$
Nb-95	$6{,}14\cdot10^{-5}$	$2{,}40\cdot10^{2}$	$2{,}56\cdot10^{-7}$	$1{,}024\cdot10^{-6}$
Zr-97	$1{,}06\cdot10^{-6}$	-	-	-
Nb-97	$1{,}14\cdot10^{-6}$	-	-	-
Total	$5{,}5\cdot10^{-1}$		$5{,}98\cdot10^{-2}$	$2{,}40\cdot10^{-1}$

Table 9/2.10 shows that the radiological criterion will not exceed the minimum significant level ($\Sigma A_i/ IL_i = 0.24< 1$) for all four units of Akkuyu NPP in case of liquid discharges from the debalance water system tanks (even without dilution). We may conclude that the public exposure dose due to liquid discharges will not exceed the dose quote 10 μSv/year related to the minimum significant level.

Based on operation experience gained for the NPPs with VVER type reactors the activity of C-14 radionuclide in the primary coolant changes within the range 15÷100 Bq/m^3 (NVNPP-2 PSAR Ch. 10.1.2) [9/21] that is about $6\cdot10^{-2}$ % of the intervention level established in radiation safety standards NRB-99/2009, Appendix 2a [9/10]. Considering the dose coefficient $5{,}8\cdot10^{-7}$mSv/Bq [9/10] in case of C-14 intake with drinking water consumption 0,26 m^3/year (Table 9/2.4) potential exposure dose to the critical group of population may be up to 0,015 μSv/year for one unit of the NPP.

In addition the estimated average annual collective doses due to effluents from NPPs for the period 1998-2002 all over the world show that the total normalized collective dose due to liquid effluents 0,05 man·Sv/(GW·a) is less than the dose due to airborne effluents 0,22 man·Sv/(GW·a) according to UNSCEAR 2008 Report, Table 18 [9/18].

As a result of this evaluation the public exposure dose due to liquid discharges may be conservatively assumed at the level not more than the dose quote 50 μSv/year in normal operation of all four units of the NPP. More detailed analysis of the public exposure dose (with contribution of activation products C-14 and H-3) and liquid discharge limits for Akkuyu NPP will be provided in PSAR.

9.3 CONCLUSIONS

The total dose quote for the public exposure from gaseous releases of all four units of the NPP in normal operation (less than 50 µSv/year at FP activity in the primary coolant corresponding to DL) is met at 800 m distance from Akkuyu NPP. This target is defined in Russian regulations is in agreement with the international requirements and practice.

The total dose quote for the public exposure (less than 100 µSv/year at FP activity in the primary coolant corresponding to SOL, assumed an incident event in one of the NPP units) is met at 800 m distance from Akkuyu NPP. This target is set up by Russian regulations [9/12] and is in agreement with international requirements and practice.

Estimated specific activities of radionuclides in liquid discharges from one unit show that the radiological criterion will not exceed the minimum significant level ($\Sigma A_i / IL_i = 0.24 < 1$) considering all four units of Akkuyu NPP. The public exposure dose due to liquid discharges may be conservatively assumed at the level less than the dose quote 50 µSv/year in normal operation of all four units of the NPP.

Results of the public exposure dose evaluations in DEBK condition (Table 9/1.6) show that emergency planning zones shall be established to implement population protection measures in unlikely case of the severe accident. Chapter 10 provides for the basis of the emergency planning zones boundaries and generic intervention levels for urgent protective actions taking into account IAEA safety standards. Detailed analyses regarding determination of emergency planning zones are going to be performed and the results are going to be submitted in PSAR phase.

As a result of the radiological impact evaluations presented in this chapter we may conclude that there are no insurmountable difficulties in establishing radiation protection measures for the environment, workers and population for the Akkuyu NPP from the point of view of the site characteristics.

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10. EMERGENCY PLANNING

10.1 GENERAL

This chapter consists of:

- basis for the emergency planning zone boundaries;
- analysis of the residential places and population distribution in emergency zones of Akkuyu NPP site vicinity;
- analysis of the existing infrastructure for population protective measures;
- analysis of Akkuyu NPP site vicinity features hampering protective measures to be conducted;
- recommendations on population protection measures (off-site emergency planning);
- procedure for personnel protection measures (on-site emergency planning);
- procedure for dosimetry control organization in radiation accident conditions;
- procedure for prevention and mitigation of accident consequences;
- procedure for arrangement of the emergency notification system.

TAEK requires each NPP to have an approved Emergency Plan (EP) [10/1] before the start of operation. It is an obligatory condition prior to receiving the license for operation. The organization of the Operator to manage accidents according to “Regulation on Specific Principles for Safety of Nuclear Power Plants”, Official Gazette Number: 27027 [10/1], Part Seven Accident Management and Emergency, and Publication No. GS-G-2.1 “Arrangements for Preparedness for a Nuclear or Radiological Emergency” [10/2] shall be presented in the NPP Emergency Plan.

Also all evaluated important Site characteristics discussed in NS-R-3 [10/3] “Site Evaluation for Nuclear Installations” shall be considered when describing and implementing the EP.

IAEA Requirements for Site Evaluation, NS-R-3 [10/3], requires the following:
Paragraph 2.29.

“The external zone for a proposed site shall be established with account taken of the potential for radiological consequences for people and the feasibility of implementing emergency plans, and of any external events or phenomena that may hinder their implementation. Before construction of the plant is started, it shall be confirmed that there will be no insurmountable difficulties in establishing an emergency plan for the external zone before the start of operation of the plant”.

Russian requirements towards the organization of an on-site and off-site emergency preparedness and communications are presented in NP-015-2000 [10/4] (containing 38 Appendices) and NP-005-98, [10/5]. Both Regulations are in compliance with the principles provided in the IAEA Safety Standards [10/2] and [10/6].

The overall objective of emergency response planning is to provide a framework for the administration and implementation of dose savings and possibly immediate lifesaving 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. Effective advance preparation will help ensure protection of the public during a nuclear emergency. The range of possible planning measures is potentially quite large, ranging from no action because the consequences of an accident are unlikely to occur, to planning for the worst possible accident even if its annual exceedance frequency is evaluated to be on the order of 10^{-7} per year.

The state Authorities and the Operator who is involved in design, construction, commissioning, operation and decommissioning activities of nuclear facilities and in manufacturing, transportation and storage of nuclear material, shall establish measures for emergency planning.

Emergency planning measures shall be established through:

- Emergency plans for protection of the population (off-site emergency plan), which regulates the emergency planning zones and determines the actions to be taken by the competent authorities to protect the population, property and environment in case of an accident, and
- Emergency plans for protection of the occupational staff (on-site emergency plan), which determines the actions to be taken by the Operator for accident mitigation and remediation of consequences in co-ordination with the off-site emergency plan.

Preparation, maintenance and co-ordination of the off-site emergency plan (on a national level) shall be the responsibility of competent state and governmental authorities. The preparation of the off-site emergency plan, the provision of material, technical and human resources for its implementation, the maintenance of emergency preparedness and the application of the measures, shall be planned by the corresponding state and/or regional authorities and structures [10/7], [10/6], [10/2].

The Operator shall develop the on-site emergency plan and submit it to TAEK for review and approval, sufficiently prior to the commissioning of the first nuclear facility on site. The on-site plan shall be coordinated and agreed with other state institutions and authorities as required by law.

The on-site emergency plan shall be revised and updated when basic circumstances and conditions change i.e. changes in the legislation connected with the implementation of the plan or change in the number of the nuclear facilities in operation, or periodically – at predetermined time intervals. The plan shall govern the emergency actions for the whole NPP site, reflecting all nuclear facilities situated there and recommending the actions necessary for the unit which is in an emergency situation and other operating units/facilities as well. The plan shall be tested in practice prior to commissioning of first nuclear facility and in the course of operation, and the individual parts of the plan shall be periodically tested and evaluated.

IAEA document GS-R-2, "Preparedness and Response for a Nuclear or Radiological Emergency" [10/6] defines responsibilities for responding to nuclear or radiological emergencies. According to this document a governmental body or organization shall be identified to act as a national coordinating authority. Its functions, among others, are to (1) coordinate the threat assessment for threats within the State, (2) to ensure that the functions and responsibilities of operators and response organizations are clearly assigned and are understood by all response organizations. The national coordinating authority shall be an existing ministry or a standing committee with representatives of all national organizations that play a major part in the response to a nuclear or radiological emergency. This authority shall have the ability to coordinate the response preparedness of all national organizations with roles in preparation for, or response to, nuclear or radiological emergencies, conventional emergencies or criminal activities (e.g. terrorist attacks or threats).

While the Operator is responsible for developing and implementing of the on-site emergency response plans, development of the off-site plans is under the responsibilities of the off-site organizations that include:

1) Local officials: the government and support agencies responsible for providing immediate support to the operator and prompt protection of the public in the site vicinity. This includes the police, fire fighting and civil emergency services or medical personnel, who may be the first to learn of an accident. It may include officials from different States if the facility is near a border;
2) National and regional (province or state) officials: the governmental agencies responsible for planning and response on the national (or regional) level. These agencies are typically responsible for tasks that usually do not need to be implemented urgently to be effective. They include:

a) longer term protective actions; and

b) support of local officials in the event that their capabilities are exceeded;

3) Non-governmental organizations (NGOs).

IAEA GS-G-2.1 [10/2] also defines the organizations which will have obligations to respond to an emergency. Summarizing the above main elements in developing efficient emergency preparedness and response are:

1) Basic responsibilities;
2) Assessment of threats;
3) Establishing emergency management and operations;
4) Identifying, notifying and activating;
5) Taking mitigating actions;
6) Taking urgent protective actions;
7) Providing information and issuing instructions and warnings to the public;
8) Protecting emergency workers;
9) Assessing the initial phase;
10) Managing the medical response;
11) Keeping the public informed;
12) Taking agricultural countermeasures, countermeasures against ingestion and longer term protective actions;
13) Mitigating the non-radiological consequences of the radiation emergency and the response;
14) Conducting recovery operations;
15) Requirements for infrastructure.

The Turkish State Emergency Prevention and Mitigation System will be considered during development of the Emergency Plans for Akkuyu NPP. The organizational relationships and interfaces between all the response organizations shall be established. “Regulation on Nuclear and Radiological National Emergency Preparedness” of TAEK 23934, [10/7] establishes the response duties and responsibilities of the Turkish state authorities during an announced radiological emergency.

10.2 BASIS FORTHE EMERGENCY PLANNING ZONES BOUNDARIES

10.2.1 CRITERIA OF EMERGENCY PLANNING ZONES DEFINITION

The most important step in emergency planning is to define the area where planning and emergency response actions shall be implemented. The environment/geography surrounding the plant and regional meteorology patterns have the largest influence on the patterns of dispersion and transport of radiological fallout from an accident. Knowledge of the types of radioactive materials potentially released is necessary to determine the characteristics of monitoring instrumentation and development of tools for confirming and assessing public radiation exposure.

According to IAEA standards [10/2, 10/6, 10/8] and TAEK guide [10/9, 10/12] three emergency planning zones are proposed to be established:

- **Precautionary action zone** (PAZ) is an area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to reduce the risk of severe deterministic health effects off the site. Protective actions within this area are to be taken before or shortly after a release of radioactive material or an exposure on the basis of the prevailing conditions at the facility [10/6,10/8];
- **Urgent protective action planning zone** (UPZ) is an area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to avert doses off the site in accordance with international standards. Protective actions within this area are to be taken on the basis of environmental monitoring - or, as appropriate, prevailing conditions at the facility. UPZ sizes are defined so that the effective dose to the individuals being at the external boundary in case of maximum possible accident (DEBK condition) should not exceed 10 mSv for first two days, and the expected dose for thyroid glands should not exceed 100 mGy [10/6, 10/8, 10/9, 10/12];
- **Food restriction planning radius** is an area where preparations for effective implementation of protective actions to reduce the risk of stochastic health effects from the ingestion of locally grown food should be developed in advance. In general, protective actions such as relocation, food restrictions and agricultural countermeasures will be based on environmental monitoring and food sampling [10/8].

Definition of the emergency planning zones in Turkey is given in the guide GK-GR-01, concerning the content and form of the NPP Site Report [10/9]. The criteria for boundaries of the emergency planning zones established by the Turkish guide GK-GR-01 [10/9] are in compliance with the IAEA GSR Part 7 (GS-R-2) safety standards [10/6] recommended Generic Intervention Levels (GIL) for urgent protective actions. The Status of the IAEA GSR Part 7 safety standard regarding the emergency planning and preparedness at present is Draft Standard (DS 457). An update of the emergency planning zone boundaries with consideration of GSR Part 7 safety standards and the respective Turkish regulations will be provided when these documents enter into force (expected in Akkuyu PSAR).

The criteria for definition of the above listed emergency planning zones are given in Table 10/2.1 [10/6, 10/8].

Table 10/2.1 – Criteria for definition of the emergency planning zone boundaries

Zone	Criteria that can be exceeded within the boundary of the zone
Precautionary action zone	Absorbed dose from radiation with low LEA (linear energy absorption) on the organ or tissue for the first two days: Bone marrow - 1 Gy Lungs -6 Gy
Urgent protective action planning zone	Effective dose on the whole body* 10 mSv Dose commitment on thyroid gland** 100 mGy
Food restriction planning radius	Specific activity of radionuclides in food stuff designated for common consumption, milk, infant food and drinking water: 1 kBq/kg for ^{134}Cs, ^{137}Cs, ^{103}Ru, ^{106}Ru, ^{89}Sr; 0,1 kBq/kg for ^{90}Sr, ^{131}I; 10^{-3}kBq/kg for ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu
** - effective dose from inhalation delivery, direct radiation of cloud and 48-hour direct radiation of ground* *** - critical group – children from 1 to 2 years old.*	

Double ended break of the main circulating pipeline D_{nom} 850 mm (Large Break LOCA) followed by total blackout for 56 hours is considered to be the maximum possible (severe) accident postulated as DEBK condition at Akkuyu NPP that results in the ultimate accidental release of radionuclides to the atmosphere and maximum radiological consequences in the environment. The radiological impact analysis for the severe accident postulated as DEBK condition is provided in Chapter 9.

10.2.2 PRECAUTIONARY ACTION ZONE

Table 9/1.6 provided in Chapter 9 shows that in case of DEBK the absorbed doses to bone marrow and lungs for the first two days will not exceed the criteria for precautionary action zone specified in Table 10/2.1. Based on this result and applying the criteria according [10/6] and [10/9], there is no need to establish a precautionary action zone around Akkuyu NPP. Final decision should be taken after development and approval of PSAR.

10.2.3 URGENT PROTECTIVE ACTION PLANNING ZONE

Table 9/1.4 provided in Chapter 9 shows that in case of DEBK the exposure doses to child's thyroid glands can exceed 100 mGy at the distances from the source as far as 5 km.

Effective dose to the whole body in case of DEBK can exceed the criteria for urgent protective action planning zone at the distances from the source up to 2.4 km.

Therefore, it is offered to establish the boundary of the urgent protective action planning zones around each of Akkuyu NPP units at 5 km radius. The urgent protective action planning zone around all four units of Akkuyu NPP is defined as a circle of 5.4 km radius, since the distance from the geometric center of the NPP to each power unit does not exceed 0.4 km. Therefore, the circle of 5.4 km radius will include the urgent protective action planning zones (5.0 km) established for each of the NPP units.

10.2.4 FOOD RESTRICTION PLANNING RADIUS

The size of food restriction planning radius identified on the basis of the predicted content of radionuclides Cs-134, Cs-137, I-131, Ru-103, Ru-106, Sr-89 and Sr-90 after DEBK in the local food stuff designated for common consumption, milk, infant food and drinking water.

In case of DEBK the radionuclides release to atmosphere only. In case of their ingress into the water areas the radioactive effect through food chains will be insignificant, and specific radioactivity of radionuclides will be by some level less than the relevant criteria given in table 10/2.1. In view of the above the calculation of emergency planning are is made based on radionuclide release from radioactive plume on the earth surface.

At the conservative assumption that DEBK condition with ultimate accidental releases will occur within the most dangerous vegetating period (before the cropping) the specific activity of radionuclides i in the local foodstuff j will be calculated by the equation:

$$A_i^j = K_i^j \cdot \chi_j \, , \qquad (10\text{-}1)$$

Where:

– K_i^j - conversion factor for «transition of radionuclide *i* from the surface contamination to the content in food stuff *j* » during short-time precipitations within the most dangerous vegetating period (before cropping), m^2/kg (m^2/l);

– χ_i - density of ground surface contamination with radionuclides *i*, Bq/m^2.

Values of K_i^j are given in the documents [10/10, 10/11].

According to equation (10-1) the specific activity (content) of radionuclides Cs-134, Cs-137, I-131, Ru-103, Ru-106, Sr-89, Sr-90 in local foodstuffs after DEBK were calculated using the densities of ground surface contamination χ_i evaluated in Table 9/1.3 provided in Chapter 9 for different distances from the NPP and the values K_i^j listed in the studies [10/10, 10/11].

Based on evaluations of the specific activity (content) of radionuclides the boundary of food restriction planning radius should be set at the distance of up to 80 km from Akkuyu NPP to meet the appropriate criteria in Table 10/2.1. This distance is preliminary, and it is based on the calculation. In the unlikely case of accident the exact distance is determined based on the real measurement of the local foodstuff in radiation monitoring.

10.2.5 EMERGENCY PLANNING ZONES AROUND AKKUYU NPP

As a result of evaluations above the boundaries of the emergency planning zones established around all units of Akkuyu NPP are given in Table 10/2.2.

Table 10/2.2 – Boundaries of the emergency planning zones around Akkuyu NPP

Zone	Zone radius, km
Precautionary action zone	No need to establish
Urgent protective action planning zone	5,4
Food restriction planning radius	80

Figures 10/2.1, 10/2.2 and 10/2.3 provide the diagrams of emergency planning zones around Akkuyu NPP.

Figure 10/2.1 – Urgent protective action planning zone around Akkuyu NPP (UPZ)

Figure 10/2.2 – Food restriction planning radius around Akkuyu NPP

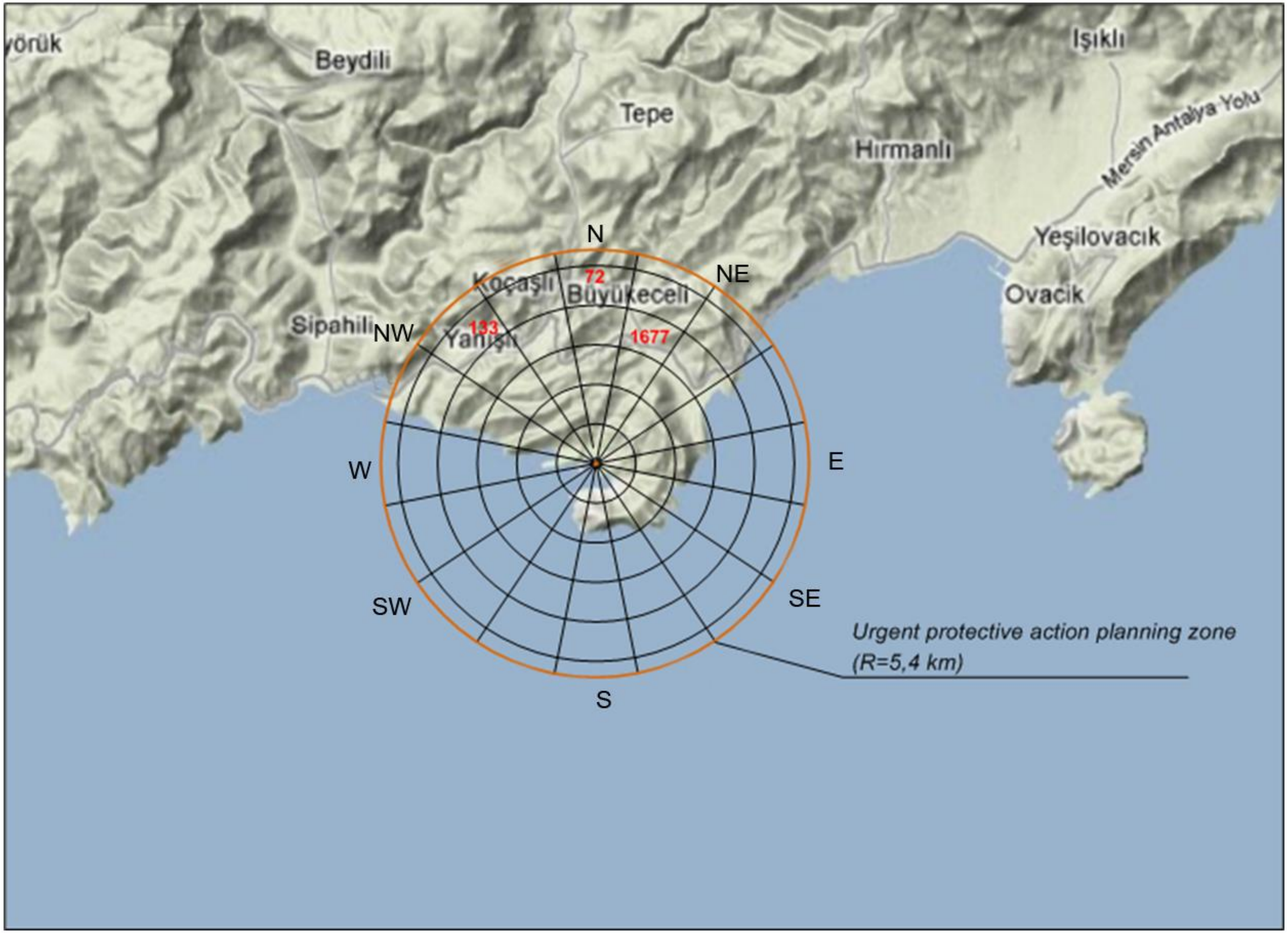

Figure 10/2.3 – Population distribution in the urgent protective action planning zone (UPZ)

10.3 ANALYSIS OF THE RESIDENTIAL PLACES AND POPULATION DISTRIBUTION IN EMERGENCY ZONES OF AKKUYU NPP SITE VICINITY

10.3.1 POPULATION IN THE URGENT PROTECTIVE ACTION PLANNING ZONE

The Akkuyu NPP site is in a coastal area where the population density and distance from population centers are favorable.

According to Chapter 2 there are three existing residential places to be included within the urgent protective action planning zone (radius of UPZ external boundary is 5.4 km, and radius of UPZ internal boundary is 0.8 km equals to the Health Protection Zone): Büyükeceli, Koçaşlı, Yanışlı and the NPP settlement to be constructed (Tables 10/3.1, 10/3.2, Figure 10/2.3).

Table 10/3.1 – Settlements located within UPZ

District	Residential place	Distance to Akkuyu NPP site, center, km	Total number of residents	Male	Female
Gülnar	Büyükeceli	3.1	1677	859	818
	Koçaşlı	4.6	72	32	40
	Yanışlı	4.3	133	71	62
	NPP settlement	2.4	4500	3150	1350
Total number of residents			6382		

Table 10/3.2 – Distribution of the population within UPZ

Distance, km	N	NNW	NW	WNW	W	WSW	SW	SSW
0.8 – 1	0	0	0	0	0	0	0	0
1 – 2	0	0	0	0	0	0	0	0
2 – 3	0	0	0	0	0	0	0	0
3 – 4	0	0	0	0	0	0	0	0
4 – 5	72	0	133	0	0	0	0	0
5 – 5.4	0	0	0	0	0	0	0	0

To be continued

Distance, km	S	SSE	SE	ESE	E	ENE	NE	NNE
0.8 – 1	0	0	0	0	0	0	0	0
1 – 2	0	0	0	0	0	0	0	0
2 – 3	0	0	0	0	0	0	4500	0
3 – 4	0	0	0	0	0	0	0	1667
4 – 5	0	0	0	0	0	0	0	0
5 – 5.4	0	0	0	0	0	0	0	0

Population of three existing villages within the UPZ is 1882 persons as per TÜİK address-based data in 2010 (Table 10/3.1). Total number of the residents in the urgent protective action planning zone is projected about 6382 persons, including the NPP settlement. There is no division between children and adults in these settlements [10/4], but taking into account age-group distribution shown for Gülnar district (Figure 10/3.1) about 126 children at the age up to 4 years can live in the mentioned residential places (Büyükeceli, Koçaşlı, Yanışlı) according to the data as of 2010.

The measures for protection of the nomadic people are the same as it is described below for the residential population. At present there is no data on number of the nomadic people within the urgent protective action planning zone. Additional resources for evacuation of the nomadic people should be considered in off-site emergency plans upon agreement with the local authorities.

In case of evacuation of population from the Urgent protective action planning zone it should be performed with sufficient number of vehicles justified in the Akkuyu NPP PSAR and specified in emergency plans.

Age groups	Number
0 − 4	1923
5 − 9	2126
10 − 14	2559
15 − 19	2352
20 − 24	1977
25 − 29	1897
30 − 34	1892
35 − 39	2058
40 − 44	1717
45 − 49	1945
50 − 54	1368
55 − 59	1450
60 − 64	1283
65 − 69	1254
70 − 74	1084
75 − 79	872
80 − 84	537
85 − 89	193
90+	64
Total	28551

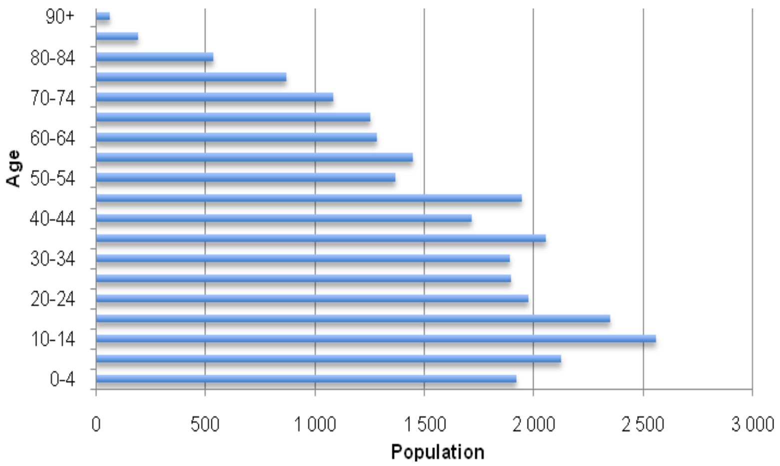

Figure 10/3.1 – Age groups – Gülnar (TÜİK, 2010)

10.3.2 POPULATION IN THE FOOD RESTRICTION PLANNING RADIUS

Population of two Turkish provinces (Mersin, Karaman) is partially included in the Food restriction planning radius of about 80 km radius around Akkuyu NPP.

10.3.3 POPULATION CENTERS

Population center is an overcrowded center comprising more than 25000 residents (USNRC, 1996). There are three such centers or settlements with the population more than 25000 residents within 80 km radius from the central point of the site.

Silifke (about 44 km from the site), Anamur (about 64 km from the site) and Mut (about 56 km from the site) belong to these centers. Moreover, it is supposed that Bozyazi will be classified as one of these centers by 2040.

At the same time none of the population centers is included in the urgent protective action planning zone.

10.4 ANALYSIS OF THE EXISTING INFRASTRUCTURE FOR POPULATION PROTECTIVE MEASURES

10.4.1 EXISTING INFRASTRUCTURE FOR SHELTERING

There are no protective structures and shelters in UPZ. There are also unavailable medical institutions and penal jurisdictions, hotels, geriatric homes, recreation centers. There are no industrial, commercial and departmental institutions and enterprises. The population of this zone will come to about 6382 residents by the first power unit commissioning.

Taking into account that to shelter population either special protective structures, or premises, buildings and structures having the biggest protection coefficient are required, and in view of the fact that UPZ is hardly populated evacuation seems to be more efficient than sheltering. Therefore, special engineering-technical measures to protect population within UPZ are not required. Thus, population evacuation from UPZ should be considered in emergency plans as the most effective (first priority) protective measure, as no delay is allowed in protective actions due to radiological assessments.

10.4.2 EXISTING INFRASTRUCTURE FOR EVACUATION

10.4.2.1 Organizational measures for evacuation

Nowadays there are no organizational measures to provide evacuation of the population from the UPZ including collecting evacuation points, intermediate evacuation points, allocated transport vehicles, as well as areas, where evacuated people must be located.

The population centers with the developed infrastructure, life-support systems and location in sufficient distance from the source of emergency are reasonable to be selected as possible centers for receiving evacuated people. According to the available data, Silifke may be chosen as for population evacuation from UPZ (Table 10/4.1). The more specific area will be identified later.

Table 10/4.1 – Possible centers for receiving evacuated people in case of accident at Akkuyu NPP

District center	Number of residents (TÜİK, 2010)	Distance from the boundary of UPAPZ, km	Direction	Evacuation route
Silifke	53151	37	ENE	Adana-Antalya highway

Silifke seems to be the most favorable from viewpoint of receiving and life support of the evacuated people.

The final selection of the place for temporary accommodation of personnel, their family members and population will be done when developing the plans for personnel and population protection. Muster areas and places for temporary accommodation will be agreed with the local governmental bodies prior to approval of these plans in accordance with the statutory procedure.

At present the IAEA GSR Part 7 safety standard regarding the emergency planning and preparedness is with a status of Draft Standard (DS 457). It will be considered during preparation of the emergency plans. A detailed analysis of the possible evacuation routes, centers for receiving of evacuated people and required technical and human resources will be performed in PSAR and specified in emergency plans.

10.4.2.2 Transport network

Highways

The site is connected with Buyukeceli located 3 km north-east from the site through asphalt road.

Express highway Adana-Antalya connected with Akkuyu NPP site through 4,5 km road, as well as local roads can be used for evacuation.

Other types of transport

The nearest airport in Adana city is located as far as about 200 km from the NPP site. There is a railway service in Mersin (~ 110 km) и Tarsus cities. Travelling by sea is realized through Mersin harbor (~ 110 km) and Silifke – Taşucu ferry quay (~ 32 km).

Therefore, the other types of transport except for motor vehicles seem to be unacceptable for evacuation.

10.4.3 EXISTING INFRASTRUCTURE TO TAKE IODINE PROPHYLAXIS

In case of accident the IAEA GSG-2 and GSR Part 3 safety standards [10/20], [10/17] Turkish Regulation on Nuclear and Radiological National Emergency Preparedness (published in the official gazette No. 23934, 15.10.2000) [10/7] and Russian regulations on radiation safety NRB-99/2009 recommend iodine prophylaxis, i.e. taking stable iodine (potassium iodide) takes place only in case of release or probability of release of radioactive iodine. Otherwise it is useless.

Application of the stable iodine medicines prevents the radioactive iodine entry into thyroid glands. Efficiency of the iodine prophylaxis is maximal if it takes place immediately after emergency. Optimal doses of the stable iodine lead to blockage of radioactive iodine accumulation in the thyroid glands providing protection against irradiation.

The existing infrastructure for iodine prophylaxis required as a protective measure is provided by the departments of Turkish Ministry of Health [10/7].

10.5 ANALYSIS OF AKKUYU NPPSITE VICINITY FEATURES HAMPERING PROTECTIVE MEASURES

10.5.1 AKKUYU NPP SITE VICINITY FEATURES HAMPERING THE EVACUATION MEASURES

The most important facts hampering the population evacuation in case of accident at NPP in the terms of existing transport infrastructure are as follows:

- unavailable alternative transports routes to NPP;
- restricted possibility of arrival at the adjacent to the NPP settlements;
- topography features contributed to radioactive contamination spots in case of accident at NPP.

The only road leading from the highway and settlements to the NPP is the mentioned asphalt road. In case of severe radiation accident, and radioactive release moved to the road (particularly along the road) high gamma-radiation fields occur at the road sections. Unavailability of alternative transport routes prevents to evacuate the personnel not participated in emergency mitigation measures or leads to additional exposure doses.

Restricted possibility of coming to the adjacent settlements in case of radioactive plume movement in north, northeast or northwest direction, and radioactive contamination of Adana-Antalya highway considerably hamper conducting of the protective measures.

Adana-Antalya highway is at the distance of about 3 km from the NPP. In case of severe accidents high radiation fields may occur at this highway. It will be impossible or hardly possible to come to the settlements for the personnel and equipment participating in protective measures. In any case movement of the transport vehicles on the road will be accompanied by additional exposure dose and radioactive contamination. Possibility of coming to the settlements from external to the NPP side seems to be problem. The access to these settlements and return in order to conduct protective measures is through the territories, which are closer to the NPP than the settlements themselves. All these circumstances can hamper the conducting of the protective measures because of additional exposure of the emergency workers and population, as well as equipment radioactive contamination.

Hilly landscape of Akkuyu NPP site vicinity contributes to formation of local radioactive contamination spots in case of severe radiation accident because of significant differences in elevations and predominant wind directions (along the hills). Measures for population protection should be planned taking into account possibility of forming the spots with high radiation fields (including people and equipment travel routes) hampering the efforts undertaken by the emergency workers.

The road to the Akkuyu NPP and the nearest settlement are at a higher elevation than the NPP, so they would not be damaged or blocked by the tsunami inundation. Akkuyu NPP is an end point of the road, so no traffic is expected during an emergency toward the NPP, the nearest settlements should be evacuated outwards of it. In the case of tsunami event combined with the emergency situation on site, the evacuation of people by the sea would most likely not be possible but may be studied at a later stage.

In view of the above the NPP design will provide for development of the transport infrastructure to overcome existing deficits in facilitating the evacuation of the personnel and population, and implementation of measures to manage the severe accident consequences.

While development of the NPP design in the part of the measures targeted at protection of the personnel and population an additional route for evacuation and delivery of means and resources by sea will be considered to mitigate the accident consequences.

10.5.2 AKKUYU NPP SITE VICINITY FEATURES HAMPERING SUPPLY OF HUMAN AND ENGINEERING RESOURCES FOR ACCIDENT MITIGATION MEASURES

Features of Akkuyu NPP location area hampering supply of the human and engineering resources for accident mitigation measures are the same as in the previous section. Possibility of urgent supply of the human and engineering resources on the highway Adana-Antalya may be fully eliminated by failure to come to NPP and settlements caused by high radioactive contamination of the access roads. Therefore, the basic reason for significant difficulties with the protective measures is the probability of high-level radiation fields on the road in the crossover point of Adana-Antalya highway and access roads to the NPP and the settlements located within UPZ.

10.5.3 ADVERSE CONDITIONS FOR EMERGENCY RESPONSE

10.5.3.1 General

The following natural hazards can be adverse conditions for emergency response in Akkuyu NPP site vicinity:

1) Geological/topography factors

   – Landslips

– Danger of the hard rock shift

2) Hydrological factors

– Flooding of the coastal zones (tsunamis)

– Intensive local precipitation

3) Meteorological factors

– Snowstorms

– Ice rain

– Inversion

– Fog

– Hurricane/tornado

4) Seismic factors

– Soil seismic vibrations

– Faults shifting.

In general, two types of external hazards need to be considered [10/12]. The first types are extreme events that are considered beyond design basis and that actually cause the radiological accident. The identification of these events is generally done using the results of the external events probabilistic risk assessment (PSA). Those external events that contribute significantly to the core damage frequency (CDF) or large early release frequency (LERF) are selected. For the Akkuyu NPP, such an analysis is not yet available. From hazard analyses performed for the Akkuyu NPP site, it is known that earthquakes and tsunamis dominate external events. This is a common feature for coastal sites of the Eastern Mediterranean Sea. The choice of these two events as potential beyond design basis hazards is also indicative of the post Fukushima lessons learned.

The second type of external hazard to be considered does not take part in the initiation of accident sequences leading to the radiological emergency. However, their occurrence (not necessarily with their maximum values) during a radiological emergency is not ‘incredible’. Some examples of these events are: fog, sand/dust storms, snow storms, etc. Some NPP sites, due to their location, may be subject to these hazards during a significant number of days per year.

At the Akkuyu Site, the concurrence of independently occurring common external hazards with a radiological emergency is not considered to be probable. Sandstorms and snowstorms can be ruled out due to climatic reasons. Fog is not a frequently occurring phenomenon but it is possible. Along with other weather conditions such as thunder storms, fog may be considered as a concurrent condition with a radiological emergency. However, the likelihood is very small and counter measures are available.

Despite the fact that all the above mentioned hazards can have effect on emergency response in case of radiation accident at Akkuyu NPP, they are not critical and can be smoothed by emergency planning, namely:

– increase in reliability of the emergency planning measures (appropriate distribution of emergency-rescue services, medical institutions, increased seismic protection of the buildings and roads, strengthen foundations and support structures);

– reservation of the emergency planning measures (reservation of communication and emergency notification systems, engineering networks, access roads to NPP and evacuation);

– detailed analysis of the natural hazards while development of the plans for personnel and population protection measures in case of radiation accident at Akkuyu NPP.

10.5.3.2 Seismic factors

Fault displacement in the site vicinity is not expected to impact implementation of an emergency plan. This area (about a 15 km radius) has been well studied using geophysics, aerial photographs and surface geology including trenching and age dating of material [10/13], [10/14]. This is discussed in much greater detail in Chapter 6 of this Report. On the basis of these detailed studies, it is concluded that hazard from fault displacement at least in the site vicinity will not impede upon envisage emergency measures and the infrastructure to be used as part of these measures.

In the case that the radiological accident is caused by earthquake vibratory ground motion, it is possible that transportation on the existing main road may be disrupted due to landslides, road bed deformation or bridge (overpass) failures. As the Mersin- Antalya highway is the only road that would serve as an evacuation route, it is clear that strengthening of this roadway or providing for alternatives would be important before the plant goes into operation.

Sheltering of staff and workers on-site is foreseen and will be described in the design stage.

In addition, there is the capability to deliver goods/equipment and support in case of emergency via land and sea routes with exception of tsunami event.

10.5.3.3 Tsunami

Tsunami hazard analysis for the Akkuyu NPP is the subject of METU report, Tsunami and Seiche Hazard Assessment for Akkuyu NPP Site Project [10/15]. The studies presented in the

Report include the following: data acquisition and processing for determination of bathymetry and topographical data, evaluation of site investigation results, estimation of future sea level changes, checking of catalogues of historical earthquakes and tsunamis in the Mediterranean Sea, selection of the most critical tsunami sources, numerical modeling of worst case scenarios and computation of possible tsunami impacts, preparation of inundation maps, and analyses of non-seismically induced tsunamis including landslide modeling and seiche hazard assessment for the Akkuyu NPP site.

Earthquake induced tsunamis and non-seismically induced tsunamis have been studied. In this report several tsunami sources have been examined in relation to their possible effects on the Akkuyu Region in the Eastern Mediterranean. Several seismic tsunami scenarios, including landslide originated (non-seismic) tsunami scenarios were tested.

Tsunami modeling has been performed on the basis of geological capability considerations with due account for available earthquake and tsunami data, bathymetric and topographic data in sufficient resolution, selection of possible or credible tsunami scenarios, and selection and application of the validated and verified numerical tools for tsunami generation, propagation, inundation and visualization.

Taking into account tide effect and global warming, the investigations of the tsunami hazard are in progress and design basis values will be determined during PSAR development.

In order to provide a basis for the statements made above regarding the safety of the roadways (to be used in case of a radiological emergency) in relation to coastal flooding, it is sufficient to point out that the design basis coastal flooding run up value will be approximately 10 meters above mean sea level. The Mersin – Antalya highway as well as the connection road from this highway to the site are tens of meters above the expected design basis coastal flooding level.

10.6 RECOMMENDATIONS ON POPULATION PROTECTION MEASURES (OFF-SITE EMERGENCY PLANNING)

Restriction and decrease in population irradiation in case of accidents are achieved through protective measures. The protective measures are conducted in case of population irradiation doses exceed the dose criteria stated by the Governmental bodies.

Therefore, while decision making on a character of the protective measures according to [10/6, 10/16, 10/17] it should be guided by grounding, optimization principles and reference levels.

10.6.1 SOURCES OF RADIOLOGICAL IMPACT

In case of accident it is necessary to undertake the activities targeted at protection of population and personnel against ionizing radiation sources that are radioactive release as a radioactive plume or stream in the atmosphere, radioactive precipitation on the surface of soil, buildings, clothes [10/6, 10/8].

10.6.2 EMERGENCY RESPONSE PURPOSES

The purposes of the emergency response are as follows [10/6, 10/16]:

a) Prevention of the deterministic effects of exposure through:

- protection measures conducting before or immediately after release/discharge of radionuclides or exposure caused by emergency damage of the reactor core;
- prevention of the population and personnel exposure in the doses exceeding threshold ones leading to the deterministic effects.

b) Decrease in the risk of the stochastic effects (mainly cancer and heavy genetic effects) through:

- carrying-out protective measures according to [10/17, 10/18, 10/20];
- prevention of the personnel exposure in the doses exceeding the established limits.

In addition to the purposes mentioned above, it is necessary to take into consideration restoration and ensuring economy stable development, social and legal protection of the population.

10.6.3 RADIATION PROTECTION MEASURES AT DIFFERENT IRRADIATION WAYS

Choice of the personnel radiation protection measures, as well as their efficiency is defined, above all, by activity and nuclide composition of the emergency release to environment, as well as by possible irradiation ways. Complex of the population radiation protection measures is based on necessity either for exclusion or decrease in intensity of the radiation effects sources provided by different ways, or evacuation of the population from radiation effects zone.

Table 10/6.1 shows the protective measures, which can be used to restrict irradiation of the population and personnel, as well as the ways of the radiation effects, which can be decrease effectively by applying every protection measure.

Protective measures are divided in main and additional. Main protective measures include sheltering, iodine prophylaxis, evacuation, resettlement and restriction in consumption of the foodstuffs and water. The other measures listed in Table 10/6.1 belong to additional ones. Additional measures can be as effective as the main. Usually they are not applied independently, but as a complex with the other measures. That is their principle difference from the main protective measures. Only for the main measures there are specified the intervention levels in the international recommendations [10/8, 10/17, 10/20].

After protective measure has been applied population irradiation dose should not exceed a value of the reference level [10/18], which is specified by the State body for effective irradiation dose within the range from 20 to 100 mSv.

Table 10/6.1 – Protective measures depending on irradiation ways

Protective measures	Irradiation ways
Sheltering	External irradiation: radiation from the source, radioactive cloud, precipitation on surface of the earth, building and other objects, precipitation on skin and clothes Internal irradiation caused by inhalation of the radioactive substances from cloud
Iodine prophylaxis	Internal irradiation of the thyroid glands caused by inhalation of the radioactive substances from cloud. Taking stable iodine (potassium iodide) takes place only in case of release or probability of release of radioactive iodine. Application of the stable iodine medicines prevents the radioactive iodine entry into thyroid glands.
Evacuation	External irradiation: radiation from the source, radioactive cloud, precipitation on the earth surface, building and other objects, precipitation on skin and clothes Internal irradiation caused by inhalation of the radioactive substances from cloud.
Permanent and temporary resettlement	External irradiation from radioactive precipitation on the earth surface, buildings and other objects Internal irradiation connected with consumption of the contaminated foodstuffs and water, inhalation of radioactive substances such as dust in case of high wind.

Protective measures	Irradiation ways
Control over foodstuffs and water, restriction in consumption of the decontaminated food and water	Internal irradiation connected with consumption of the contaminated foodstuffs and water
Sanitary treatment of skin, clothes decontamination	External irradiation caused by precipitation on clothes and skin. Internal irradiation caused by radionuclides penetrating into the body through skin and wounds.
Individual protection means of the respiratory organs	Internal irradiation caused by inhalation of the radioactive substances
Regulation of the access to radioactive contaminated zone	External irradiation caused by radioactive precipitation on the earth surface, buildings and other objects. Internal irradiation connected with inhalation of the radioactive substances such as a dust in case of high wind.
Control over contamination of the livestock	Internal irradiation connected with consumption of the contaminated foodstuffs
Restriction and exclusion of the contaminated fertilizing, combustion products etc.	Internal and external irradiation.
Decontamination of soil, buildings, roads	External irradiation caused by radioactive precipitation on the earth surface, buildings and roads. Internal irradiation connected with inhalation of the radioactive substances such as a dust in case of high wind, as well as consumption of the contaminated foodstuffs.
Decontamination of the population property	External irradiation caused by radioactive precipitation. Internal irradiation connected with inhalation of the radioactive substances such as a dust in case of high, as well as consumption of the contaminated foodstuffs.
Decontamination of the public transport vehicles	External irradiation caused by radioactive precipitation. Internal irradiation connected with inhalation of the radioactive substances. Exclude transfer of the radioactive substances from contaminated to clear areas.

Protective measures	Irradiation ways
Restrictions in feeding the animals	Internal irradiation connected with consumption of the contaminated foodstuffs

10.6.4 PROCEDURE FOR EVACUATION MEASURES ORGANIZATION

Measures targeted at the personnel evacuation include:

- defining the place of location of evacuation points and their preparation;
- defining the total number of the personnel to be evacuated, assumed accommodation places;
- calculation of the transport resource to provide the evacuation measures;
- prepare evacuation routes (main and reserve) and provide communication with transport columns;
- defining the priority and transport resources for evacuation;
- defining the estimated time required for the NPP personnel evacuation outside UPZ;
- defining the measures targeted at protection of public order and medical support of the evacuation;
- defining and preparation of the evacuation districts for receiving and life support of the evacuated population.

While planning the evacuation population from UPZ (Buyukeceli, Kocasli, Yanisli and NPP settlements) it is necessary to take into account the following:

- define places of location of the evacuation points and their preparation;
- define total number of the population to be evacuated, age-groups and assumed accommodation places;
- define priority of the settlements evacuation;
- prepare evacuation routes (main and reserve) and provide communication with transport columns;
- calculate the transport resources to provide the evacuation measures;
- define the estimated time to evacuate population outside UPZ;
- define the measures targeted at protection of public order and medical support of the evacuation;

– define and prepare relocation/reception centers for receiving and life-support of the evacuated population.

Population and personnel are evacuated in two stages. At the first stage the evacuated population and personnel are transported to external boundaries of the UPZ (transport vehicles operating within this zone should not cross the boundaries). At the second stage the evacuated population and personnel are faced with medical examination, sanitary treatment with replacement of clothes and shoes. At the evacuation points all the evacuated people are accounted and transported then to the re-settlement places by “clean” transport vehicles;

It is expedient to accommodate the evacuated population according to the following principle: local government body to local government body; organization to organization. This accommodation principle makes it possible to keep integrity of the administrative and territorial units, administration of the organizations, and organize their work in new places and within short deadlines.

Moreover, it is planned to evacuate farm animals and protect water sources and household water supply, foodstuffs, food-raw materials and forage on the evacuation routes.

Population can be evacuated from the UPZ to Silifke (distance is about 37 km) on the highway Adana-Antalya.

Evacuation from the UPZ can be efficient and effective because of small population size, as well as in view of the fact that there are no institutions hampering evacuation here: medical, penal jurisdictions, hotels, geriatric homes, recreation centers and children camps etc.

10.6.5 PROCEDURE FOR ORGANIZATION AND CARRYING-OUT IODINE PROPHYLAXIS

The main purpose of planning and efficient iodine prophylaxis [10/19] is to provide (within the shortest terms) all the population groups, particularly children, with stable iodine medicines.

The iodine prophylaxis should be planned within the frame of general protective measures, which are to be reflected in the corresponding plans in case of radiation accident according to the valid regulatory requirements [10/7] and the IAEA GSG-2 standards [10/20] provided generic criteria for iodine thyroid blocking as the projected equivalent dose to the thyroid at 50 mSv in the first 7 days.

The Plans for the population protection (off-site emergency planning) should consider specific features of the territory infrastructure and local conditions to ensure distribution of the stable iodine medicines. First of all, it is necessary to plan stocks in the medical institutions (for personnel and patients), nursery schools, schools, military units and garrisons, corrective labour camps and in the other place where human is not able of undertaking the independent decision.

The methods of distribution of the stable iodine medicines can be different. But it is very important that they would be reflected in the emergency plan for every settlement at the UPZ territory. Medicines can be stored at home, or received through pharmacy network, supplied by special brigades (groups). The distribution scheme being developed should be worked out based on regular training.

While planning the stock and reserves of the stable iodine medicines it is preferable to choice tablet forms differentiated between adults and children. There should be provided quantitative justification of the required stocks of stable iodine raking into account permanent renewal.

Decision on the staring of the population iodine prophylaxis is made according to the procedure stated by the emergency plans according to the warning and emergency situation regulations. In case of accident with high possibility of the radioactive iodine release it is necessary to provide preventive iodine prophylaxis of the population (before release).

Efficiency of the iodine prophylaxis is defined by timely warning of the population. The population, for which there are provided protection measures, should be informed without delay. At the same time character of the information should be developed well in advance to avoid stress and panics, and required specific instructions, including taking stable iodine medicines, should be given. The population should be informed of the methods of iodine prophylaxis with participation of the corresponding specialists: medics, psychologists.

This population protection method is applicable to the Akkuyu NPP location with the due consideration of its particular characteristics provided that the necessary organization is established, i.e. the stock of stable iodine is available, the system of distribution among the population is available, etc.

Currently the respective high level legislative documents are developed and in force. The lowest level of documents (instructions, procedures) are under elaboration. The specific actions on the iodine prophylaxis will be included in the emergency plans for Akkuyu NPP location.

10.6.6 ORGANIZATION OF SHELTERING POPULATION

Nowadays, UPZ does not comprise engineering arrangements for sheltering the population. In this connection, for sheltering the population that is not provided with protection structures, there shall be selected rooms, buildings and structures with the highest shielding coefficient. Sheltering features of the building and structures for protection from external γ-radiation are presented in

Tables 10/6.2 and 10/6.3. However, population evacuation from the urgent protective action planning zone should be considered in emergency plans as the most effective (first priority) protective measure.

When arranging engineering measures all rooms, buildings and structures planned for sheltering shall be distributed by family names and maintained in continuous readiness to receive people to be sheltered, the population shall be informed about routes to get to the shelters and from the shelters to the points of getting on vehicles for further evacuation. The plan of measures on the population protection shall contain the Section with the calculation of population sheltering in UPZ.

$$Protection\ factor = \frac{Dose\ in\ sheltering\ conditions}{Dose\ in\ open\ air}$$

Table 10/6.2 – Sheltering features of the building and structures for protection from external γ-radiation of radioactive release plume

Building and structures	Protection factor
In open air	1
Transport vehicles	1
Wooden house	0,9
Stone house	0,6
Basement of wooden house	0,6
Basement of stone house	0,4
Large building of commercial or industrial type	less than 0,2*

* - *in a place far from the doors and windows*

Table 10/6.3 – Sheltering features of the building and structures for protection from external γ-radiation of radioactive fallouts

Building and structures	Protection factor
At 1 m height above infinite smooth surface	1
One or two-floored wooden house	0,4
One or two-floored stone (brick) house	0,2*
House basement	0,03-0,1
Three or four-floored structures (500-1000 m^3 per floor): – first and second floor – basement	 0,08* 0,01*
Multi-floored structures (about 1000 m^3 per floor): – upper floors – basement	 0,01 0,005

* - *in a place far from the doors and windows*

This method is applicable to Akkuyu NPP site vicinity, considering the premises having maximum protection coefficient and the most convenient location from viewpoint of further evacuation.

10.6.7 COMBINATION OF THE IODINE PROPHYLAXIS WITH OTHER PROTECTIVE MEASURES

In case of a radiation accident with iodine radionuclide release into the environment the most optimum results owing to emergency reaction (evacuation, sheltering and foodstuff monitoring as well as iodine prophylaxis) can be achieved as a result of combining various protection measures.

It should be noted that while other counter measures ensure protection against external and internal radiation from various radionuclides, the iodine prophylaxis protects only from inhalation radiation from iodine radioisotopes.

Capability and basis for the combination of different protective measures should be considered in the plan of the measures on population protection (off-site emergency plan).

10.6.8 OFF-SITE EMERGENCY PLANNING

To provide the population protection in case of radiation accident in the area of NPP location the following measures should be planned:

1) Emergency notification and communication: priority and procedure of the emergency notification of population and state authorities should be defined;
2) Bringing the management authorities to conditions of preparedness;
3) Engineering protection: the population sheltering within UPZ, in specially prepared premises, buildings and structures is evaluated;
4) Radiation reconnaissance: there is established a procedure for the radiation reconnaissance and monitoring, as well as scope of the submitted (received) information on assessment of the radiation situation, tasks set to different reconnaissance groups;
5) Radiation protection: there is established a procedure for permanent dosimetry control over radioactive contamination of the area, issuing and use of the individual protection means, radiation reconnaissance and dosimetry control devices, accounting of the irradiation doses of the unified system teams fulfilling the measures on protection of population, territories, as well as population living in UPZ. At the same time, according to the valid regulatory documents there is defined possibility and expediency of conducting an individual dosimetry control of the population.

The main measures of the population radioactive protection are chosen (iodine prophylaxis, sheltering, evacuation).

There are pointed out the places for sanitary treatment located at the external boundary of the UPZ (mainly on the evacuation routes) by the efforts of the corresponding unified system teams.

There are provided measures in case of necessity to carry-out decontamination works on some sections of the territory and equipment.

Three are defined the places of storage of IPM, decontamination agents, radiation reconnaissance devices and procedure for their issuance.

Radiation protection means and resources are calculated.

Medical protection: there are developed measures on preparation of the medical institutions for activities in the terms of accident at NPP. The needs are calculated; list of the measures to be undertaken by the organization is specified:

- rendering first medical aids, qualified and specialized medical aids for the persons suffered as a result of accident;
- accumulation and storage of the required number of the employees for staff and out-of-staff medical institutions, including prophylaxis medicines and IPM;
- carrying-out iodine prophylaxis of the personnel and patients who undergo a cure or turn for medical aids;
- evacuation of the medical institutions;
- examination of the population turned to be in the radioactive contaminated area, regular medical check-up and revelation of the persons needed to be hospitalized, expansion of the specialized department and hospitals;
- medical service of the evacuated population;
- expand laboratories in the medical institutions to provide the control over available radioactive substances in foodstuffs, portable water etc.
- sanitary – hygienic and anti-epidemic measures.

Means and resources for medical protection of the population are calculated.

6) Fire-prevention support:
   - provide fire safety on the evacuation routes, CEP, IEP, REP;
   - use of fire equipment at the sanitary treatment points;
   - provide population and unified system team with water;
7) Maintenance of public order:
   - guarding of emergency NPP site;

- maintenance of public order and ensuring citizens safety;
- block UPZ by establishing road blocks;
- provide traffic regulation on the evacuation roads;
- guarding of the most important economy objects and citizens property after completion of the evacuation by regulating and with assistance of special technical means;
- bringing the information of the accident at NPP to the population;
- registration of the evacuated population in the accommodation places and issue the references to their addresses.

8) Evacuation measures;
9) Means and resources engaged to provide population protection; organization of their cooperation.

The Turkish State Emergency Prevention and Mitigation System will be considered during development of the Emergency Plans for Akkuyu NPP. All Turkish legislation included regulatory requirements for emergency planning and interfaces between the off-site organizations and the Operator should be implemented in the Emergency Plans. Preliminary planned actions (possible location of alternative routes and location of ports that are to be used for evacuation, predicted numbers of vehicles to be reserved for evacuation, etc.) and feasibility of the measures will be developed in design stage.

10.7 PROCEDURE FOR PERSONNEL PROTECTION MEASURES (ON-SITE EMERGENCY PLANNING)

10.7.1 ORGANIZATION OF THE MEASURES FOR PERSONNEL PROTECTION

By the moment of physical starting-up of the first NPP Unit there should be met the requirements provided by domestic norms and IAEA recommendations for:

- full sheltering of the largest shift working at NPP;
- providing the personnel with IPM;
- carrying out individual dosimetry control for the NPP personnel;
- preparation of industrial, public and residential buildings and structures at the NPP territory and in the NPP settlement (in case insufficient number of shelters and radiation shelters) for initial sheltering the NPP personnel, and members of their families in case of radiation accident;
- required number of the routes and transport vehicles to provide the modern-level evacuation of the personnel and members of their families;
- preparation of the relocation/reception centers for receiving of the NPP personnel and members of their families to be evacuated;
- warehouses at the NPP territory intended for storage of the equipment, auto-transport vehicles, instruments and property of the NPP rescue teams.

AKKUYU NPP JSC is responsible for providing transportation for the operating personnel and their families. All companies involved in the NPP construction are also responsible for evacuation of their staff, and it must be covered by the emergency plans to be developed by them.

10.7.2 REQUIREMENTS TO RESTRICTION OF IRRADIATION OF THE PERSONNEL PARTICIPATING IN EMERGENCY RESPONSE

According to [10/18] the dose limits are not applicable in case of emergency, when the persons informed of the taken dose on a voluntary basis continue to participate in rescue operations or prevent the catastrophe. For these volunteers participated in the urgent rescue operations limitation of the doses accepted for normal conditions can be mitigated. However, disaster fighters starting to work at the former stages of the restoration operations should be considered as the personnel exposed to professional irradiation. Their protection should be provided according to the personnel radiation protection norms, and their irradiation should not exceed normal limits of the professional irradiation dose recommended by ICRP and IAEA.

While emergency response [10/6] all the reasonable measures should be undertaken so that to maintain the doses received by the personnel at the level lower than double value of the maximum dose limit per year except for rescue operations when the measures should be undertaken to maintain the doses lower than tenfold value of the maximum dose limit per year so that to avoid the health deterministic effects. Moreover, the personnel, participating in the operations when the received doses can approximate tenfold value of the maximum dose limit per year or exceed it, should do it only if the other people profit prevails they own risk.

Upon completion of the emergency stage the personnel participating in the restoration operations such as repair of the plant and buildings, waste burial or decontamination of site and adjacent area should obey the full-scope requirements to professional irradiations.

Table 10/7.1 presents the dose guidance levels to personnel participating in emergency works for performance of different tasks. It is in compliance with Table 4 of IAEA GSG-2 [10/20], and in compliance with Table IV-2 of IAEA GSR Part 3 (Interim), Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [10/17].

Table 10/7.1 – Dose limits of the personnel participating in accident mitigation

Tasks	Dose level [(a)]
Life-saving actions	$H_p(10)$ < 500 mSv[(b), (c)]
Actions to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment	$H_p(10)$ < 500 mSv
Actions to avert a large collective dose	$H_p(10)$ < 100 mSv

Notes:
(a) – These values apply only for the dose from exposure to external penetrating radiation. Doses from exposure to non-penetrating external radiation and from intake or skin contamination need to be prevented by all possible means. If this is not feasible, the effective dose and the equivalent dose to an organ that are received have to be limited to minimize the health risk to the individual in line with the risk associated with the guidance values given here.
(b) – $H_P(10)$ is the personal dose equivalent $H_P(d)$ where d = 10 mm.
(c) - This value may be exceeded under circumstances in which the expected benefits to others clearly outweigh the emergency worker's own health risks, and the emergency worker volunteers to take the action and understands and accepts this health risk.

10.7.3 PERSONNEL RADIATION PROTECTION

Personnel radiation protection is provided by NPP radiation service to prevent or mitigate radiation injury caused by human irradiation and includes as follows:

- assessment of all the types of reconnaissance and radiation situation at the NPP territory within UPZ and development of the offers for the protective measures to be undertaken at the mentioned territories;
- assessment of the radiation situation, control and accounting of individual irradiation doses taken by personnel and persons employed to localize accident and eliminate its consequences;
- arrange monitoring of the radiation situation;
- restrictions of the personnel stay at the NPP site contaminated by radioactive substances, and establishing the modes of the NPP personnel radiation protection depending on the existing situation;
- choice of basic protection measures for the personnel (sheltering, iodine prophylaxis, evacuation) depending on gamma-radiation dose rate and (or) 131 I volume activity in air;
- personnel sanitary treatment;
- control over contamination of overall and skin at the controlled access area exit (CAA), as well as personal clothes while evacuation from the NPP territory;
- repeated control of the body contamination (after decontamination) and registration of dose rate in stomach, lungs and thyroid glands (persons showing 5 μSv/h and more should be examined by spectrometer);
- exclusion or restriction of consumption of water and foodstuffs;
- define the places of storage and number of the emergency stock of IPM, dosimetry devices, as well as procedure for their issuance and use;
- mitigation of the radioactive contamination consequences by efforts of the NPP personnel.

Organization and ensuring the personnel radiation protection will be described in the Plan of measures for personnel protection in case of accident at Akkuyu NPP.

10.7.4 APPLICATION OF IPM BY PERSONNEL

To ensure the effective protection it is necessary to provide the personnel with both efficient individual protective means (IPM) and reliable individual dosimetry control means. The main harmful factors defining the necessity of IPM in case of radiation accident is the radionuclide intake and skin contamination as a result of radionuclide contamination of the area, surfaces of different objects and air. At the same time, it is necessary to protect people who participate in the mitigation actions against toxic substances, oxygen shortage, high temperature and other factors of non-radiation nature accompanying the radiation accident.

In case of surfaces which are heavily contaminated with β- radionuclides, the application of additional IPM will considerably decrease the dose on the skin and lens. It can be achieved if the surface density of the protection materials is in the range 0,5 to 0,6 g/cm^2.

Protective means applied in case of radiation accidents and mitigation of the accident consequences includes the following:

- main overall (union suits, suits, bathrobe, cap, socks made of cotton and mixed fabric) and additional one (dickey, armlet, semi-bathrobe, semi-union suits made of film and rubber-covered materials);
- IPM of the respiratory organs (respirators, filtering gas masks, isolating respiratory apparatus, pneumatic masks, pneumatic helms, pneumatic pea coats etc.);
- isolating suits;
- special shoes (main and additional);
- protective means for hands (rubber, film, cotton gloves and mittens)
- eyes protective means (protective glass, hand screens etc.);
- preventive facilities (hand grips, belts etc.).

All these means in sufficient quantity are planned to be stored in special storage facilities. Nomenclature and quantity of the individual and other protective means will be defined during the development of the Emergency plans. Akkuyu NPP design will include the necessary infrastructure to ensure the storage of the required protective means stocks, devices and special equipment needed in case of accident at NPP.

10.7.5 REQUIREMENTS TO ON-SITE EMERGENCY PLANNING

On-site emergency plan is developed based on BDBA analysis with the worst radiological consequences. This emergency plan is used to develop the needed emergency procedures.

This Plan is prepared by the Operating organization and is to be agreed with the following organizations:

- General Designer,

- administration of the territorial authorities who ensure population protection in case of emergency situations (Emergency Response Team, policy, medical institutions),

- Head of the administration of the area where NPP is located

- Other involved State organizations according to the requirements provided by the regulatory documents of the Republic of Turkey.

Plan of the measures on personnel protection should include comprehensive and detailed information on all the measures planned at NPP, needed resources, staffing, IPM, instruments, equipment, etc., including the following as per [10/6]:

1) description of the measures to be undertaken at the NPP site to provide emergency response, including functions of the persons responsible for management of the on-site work and communication with off-site organizations;
2) conditions, under which emergency situation is announced, including criteria of events classification, list of the officials authorized to announce it, description of the corresponding actions for announcing (warning) of the personnel and state bodies;
3) procedure of initial and consequent assessments of the radiation situation at NPP and beyond it;
4) measures to mitigate the ionizing radiation effects on the personnel both on- and off- site and rendering medical assistance to the people;
5) assessment of the NPP conditions and measures, which will be undertaken at the site to minimize the radioactive releases and mitigate the accident consequences;
6) subordination flowchart and connections including the list of the corresponding means and procedures;
7) list of facilities and emergency equipment, which need to be stored at the specified places;
8) measures, to be undertaken by persons and organizations participating in the plan implementation;
9) conditions for announcing of the emergency situation termination.

The Turkish State Emergency Prevention and Mitigation System will be considered during development of the Emergency Plan for Akkuyu NPP. The Emergency plan will be developed considering the Turkish legislation. The interfaces between the off-site organizations and the Operator will be described in the Emergency Plan as well.

The on-site Emergency plan will be developed before the arrival of the first fuel on the Akkuyu NPP site.

10.7.6 PROTECTED CONTROL POST FOR ACCIDENT MITIGATION AT NPP

The structures of the Protected control post for accident mitigation at NPP (NPP PCP) is located at the NPP territory.

NPP PCP includes internal Emergency Center (EC) at the NPP, which is an on-site element of the organizational structure of the Emergency Prevention and Mitigation System.

The EC performs the functions of a PCP for emergency mitigation actions, as well as working area providing necessary conditions for engineering, technical and information support of the personnel participating in the emergency response.

The EC prevents the transition from the incidents (deviation from normal operation) to an accident, and maintains the accident, if any, within the design limits, prevents transition into uncontrolled conditions, forecasts propagation of the radioactive products, ensures implementation of the Plan of the activities in case of emergency situations and measures directed on personnel and population protection in case of an accident at NPP, coordinates the NPP personnel and recruited manpower cooperation in different conditions.

The EC uses life support systems (ventilation, power supply, lighting, sewage, water supply, heat supply, fire-fighting), systems of communication, emergency announcement, premises radiation monitoring, fire and security alarm system of NPP PCP.

The EC works at all design basis NPP operating modes (normal operation, emergency situation, accident, natural calamities etc.) including beyond design basis accidents.

To provide information support of the emergency response and participate in control over the emergency response the facility is provided with the following groups of premises:

- internal emergency center (EC);
- communication center;
- central post of the automated environmental radiation monitoring system (AERMS);
- Local Emergency Announcement System (LEAS);
- premises for NPP personnel sheltering;
- technical premises;
- life-support (habitability) system rooms.

Location of NPP PCP and its design characteristics will be specified in the Technical Design.

10.8 PROCEDURE FOR DOSIMETRY CONTROL ORGANIZATION IN ACCIDENT CONDITIONS

10.8.1 GENERAL REQUIREMENTS TO ORGANIZATION OF THE DOSIMETRY CONTROL IN ACCIDENT CONDITIONS

The organization of the dosimetry control in the case of an accident shall follow the national requirements related to restriction of the population exposure that, in their turn, should be based on IAEA [10/21] and ICRP [10/18] recommendations.

On-site (as a part of the automated radiation monitoring system - ARMS) and off-site (as a part of the automated environmental radiation monitoring system - AERMS) automated radiation control posts shall be in place to ensure the necessary information to restore of the radionuclides' activity values and to estimate of the changes occurred in the gamma background in the case of a BDBA.

Emergency and repair-restoration works should be carried-out under strict radiation control after radiation reconnaissance. Radiation control procedure is defined taking into account features and conditions of the works to be performed.

Emergency action plans should define the number of radiation reconnaissance groups, number of personnel in each group, routes at the NPP site and adjacent area. Radiation reconnaissance groups should be equipped with devices allowing for estimating gamma radiation dose rate within the range up to 10 Sv/h, IPM, first medical aids and transport vehicles.

The radiation reconnaissance is to identify: gamma-radiation dose rate, levels of the radioactive contamination of the surfaces of premises, equipment and the area. Based on the radiation reconnaissance results the NPP area and premises are divided into zones depending on the radioactive contamination level.

Radiation protection type and on-line dose control and accounting procedure should be defined for the NPP personnel involved in the emergency and repair-restoration works. Dosimeters intended for the personnel should be stored in the places specified in the plan, their stock should provide for at least two sets per each brigade member.

The personnel who leaves the NPP premises after emergency and repair-restoration works should pass obligatory radiation control and sanitary treatment.

10.8.2 ORGANIZATION OF DOSIMETRY CONTROL AND RADIATION RECONNAISSANCE

Dosimetry control and radiation reconnaissance (environmental monitoring) in case of an accident shall be arranged by NPP radiation safety service and conducted in a combination with the other types of reconnaissance.

The head of the radiation safety service is responsible for planning of the radiation reconnaissance, communicating the tasks to the involved personnel, control of their activities, collection, analysis and summarization of of the data, preparation of the corresponding reports to the NPP management.

The radiation reconnaissance is targeted at timely submission of the information of the radioactive contamination and extent of the contamination of NPP territory, UPZ to the NPP management.

The radiation reconnaissance at the NPP site area is conducted continuously using the automated radiation monitoring system (ARMS). The radiation reconnaissance within UPZ is conducted in the locations of the permanent control posts and the automated environmental radiation monitoring system (AERMS) instrumentation (first of all in the direction of emergency release dispersion), on the motor roads, in settlements, on the route NPP site-NPP settlement, on the evacuation routes (if necessary).

Radiation reconnaissance groups and movable radiation laboratory are to be established at NPP.

The reconnaissance groups are staffed and equipped with related special property, radiation and dose control instrumentation.

As part of radiation reconnaissance gamma-radiation dose rate, the volumetric activity of I-131 radionuclide in the air is measured; samples are taken for spectrometry analysis (if necessary); and warning signs (specifying dose rate and time of its measurement) are set in the places of control; protection measures planning zones and obligatory evacuation measures are defined; radiation level in the area, on transportation routes, in the places of performance of rescue and other urgent works are determined; bypass paths or a direction to overcome the different surfaces contaminated with radioactive substances are searched; Radioactive releases and their distribution are monitored.

Procedure for collecting, processing and transmitting the radiation reconnaissance data will be developed when preparing the emergency action plan.

10.8.3 REQUIREMENTS TO DOSIMETRY CONTROL MEANS IN ACCIDENT CONDITIONS

Technical Design provides for development of ARMS, AERMS and justifies serviceability of these systems, authenticity of the handed-over data in the terms of possible radiation accidents (radiation parameters, temperature, humidity, pressure).

Measurement ranges of the RC devices are chosen to be used in these systems based on the values of the measured radiation parameters in the terms of possible accidents.

Control means should provide efficient assessment of the following parameters: release of radioactive substances to environment, radiation parameters of irradiation fields in NPP premises, at the site and in UPZ. It should include receiving the information required to support the personnel actions targeted at mitigation of the accident consequences, emergency situation classification, urgent protective measures at the site and beyond it.

It is necessary to provide efficient submission of the radiation control data to all the officials involved.

10.9 PROCEDURE FOR PREVENTION AND MITIGATION OF ACCIDENTCONSEQUENCES

10.9.1 PROCEDURE FOR EMERGENCY ANNOUNCEMENT

As per IAEA GS-R-2 classification [10/6] there are the following criteria for announcing emergency situation at the NPP (at the facilities in threat category I):

- "General emergency" ("Emergency situation" as per Russian classification) is an emergency involving an actual, or substantial risk of, release of radioactive material or radiation exposure that warrants taking urgent protective actions off the site. Upon declaration of this class of emergency, actions shall be promptly taken to mitigate the consequences and to protect people on the site and within the precautionary action zone and urgent protective action planning zone, as appropriate;
- "Site area emergency" ("Emergency preparedness" as per Russian classification) is an emergency involving a major decrease in the level of protection for those on the site and near the facility. Upon declaration of this class of emergency, actions shall be promptly taken to mitigate the consequences, to protect people on the site and to make preparations to take protective actions off the site if this becomes necessary;
- "Facility emergency" is an emergency involving a major decrease in the level of protection for people on the site. Upon declaration of this class of emergency, actions shall be promptly taken to mitigate the consequences and to protect people on the site. Emergencies in this class can never give rise to an off-site threat;
- "Alert" ("Radiation-dangerous situation" as per Russian classification) is an emergency situation involving an uncertain or significant decrease in the level of protection for the public or people on the site. Upon declaration of this class of emergency, actions shall be promptly taken to assess and mitigate the consequences and to increase the readiness of the on-site and off-site response organizations, as appropriate.

While infringement of the limits and/or terms of Akkuyu NPP safe operation when the emergency situation is announced, as well as in case of threat to NPP safety caused by fire, external natural hazards, infringement of the NPP safety mode, which can lead to radiation accident operating personnel should immediately:

- inform officials of the situation according to the subordination order;
- undertake necessary and admissible measures to render assistance in case of accidents, threat to personnel life or over-irradiation;

– undertake necessary and admissible measures to eliminate the revealed infringement or decrease its consequences.

Having received the information of the facts showing possible radiation-dangerous situation, the corresponding official identifies the existing situation and makes warning according to the procedure specified in emergency plans.

– shift supervisor of the operating organization;
– dispatcher of the corresponding department of power grid;
– medical institution;
– subdivision of fire service guarding the NPP;
– special services guarding the NPP;
– hydro-meteorological bodies serving the NPP;
– administration of the settlements located in the emergency planning zone (emergency planning zones are defined in IAEA Guidelines GS-G-2.1 IAEA [10/2]).

Decision on announcing the emergency situation at NPP brings to all NPP personnel notice through available communication and warning facilities.

Responsibility for undertaking the required measures directed on ensuring the NPP safety in the period of emergency situation is imposed on the corresponding official who arrange a radiation reconnaissance of equipment, premises and communications by efforts of the operating personnel to reveal the reasons, sources and scale of the accident, as well as to make initial assessment of the radiation-dangerous situation (accident) and forecast of the radiation situation beyond the plant.

In case of radiation-dangerous situation or accident at NPP, the NPP managers and local administration immediately warn both the NPP personnel and population living in the emergency planning zone through all available communication and warning facilities.

Population and the personnel of the enterprises and organizations providing NPP functioning and life support are warned according to the Plan of activities in the emergency situations both by NPP managers and local authorities of the settlements located in the emergency planning zone.

Instructions on NPP operating personnel and management actions (attaching the corresponding warning and communication diagrams) are put into force at the stage of reveal of the reasons and sources of emergency situation, and announcing “Facility emergency”, “Site area emergency” and “General emergency” at the NPP site and in emergency planning zones.

10.9.2 PROCEDURE FOR EFFICIENT SUBMISSION OF THE INFORMATION IN CASE OF RADIATION-DANGEROUS SITUATIONS AND ACCIDENTS AT NPP

All the submitted messages of radiation-dangerous situations and accidents at NPP are required be registered specifying date, time of submission and families of the persons handed over and received the information.

After the accident occurred at NPP the corresponding official hands over the shift supervisor of the operating organization and corresponding state officials the following information:

- date and time of the accident;
- conditions of the Power Unit before accident;
- radiation situation in the NPP premises and on adjacent territory;
- assumed accident reasons, brief characteristics, total number of the radioactive products released to environment during accident, their approximate isotope composition;
- the power unit conditions by the time of the information submission;
- brief description of the meteorological conditions in the NPP area at the moment and after accident (air temperature, cloud cover, wind speed and direction at different heights)

10.10 PROCEDURE FOR ARRANGEMENT OF THE EMERGENCY NOTIFICATION SYSTEM

10.10.1 NPP PERSONNEL ANNOUNCEMENT SYSTEM

The NPP personnel emergency announcement system should be designed based on the communication systems developed for NPP. The NPP communication systems both at normal operation and in case of accident should provide:

- stable and reliable communication within the NPP;
- stable and reliable external communication with operating organization and other administrative organizations.

The following communication types (systems) should be provided for NPP:

1) Operative telephone communication that intended for ensuring operative telephone communication and transfer of the commands to operating personnel;
2) Loudspeaker communication. The loudspeaker communication equipment is intended for transfer of the commands from operating to shift personnel in noisy premises.
3) Command-search communication (through loudspeakers) is intended for search and transfer of the commands to shift personnel in noisy premises at the noise level of 80-140 dB;
4) Standby internal radio-communication is intended for communication of the NPP operating personnel in case of accident and wire communication failure normally used in normal operation mode.
5) NPP on-site communication is provided by automated phone station and in-room radio-communication systems.
6) External communication: cellular and satellite communications.

NPP personnel is notified through the announcement devices based on the forecast for NPP territory contamination, taking into account a real meteorological situation.

In case of accident at NPP the announcement comprises brief recommendations for protection measures against negative effects caused by the accident consequences.

10.10.2 POPULATION NOTIFICATION SYSTEM

In case of accident or radiation-dangerous situation the NPP management and local authorities immediately notify the population residents within the emergency planning zones.

The NPP management provides to develop emergency operating procedures and guidelines (with attachment of appropriate announcement and communication diagrams) applied in the phase of emergency diagnostics and accident initiating events.

Emergency notification of the population should comprise brief recommendations of the protection measures against the negative effects caused by consequences. The population is informed of the situation at NPP and implementation of the protective measures through radio-broadcasting network (cable TV, loudspeakers and sirens).

In case of the decision making on evacuation of the population the information of the evacuation starting is broadcasted through the same communication and warning facilities.

10.11 CONCLUSIONS

As a result of assessment in this report the following conclusions may be made:

- The Akkuyu NPP site is in a coastal area with favorable capability for emergency planning. The Site is located in a rural area with a limited population living within the assumed plume exposure pathway Emergency Planning Zone (EPZ). Given the limited population within the plume exposure pathway EPZ and the limited number of local roadways, evacuation planning for the region is anticipated to be relatively easy. Thus population evacuation should be considered in emergency plans as the most effective (first priority) protective measure;
- Preliminary analysis was made to evaluate emergency planning zone boundaries meeting the requirements of IAEA Publications and Turkish regulations. Two emergency planning zones were identified to be applicable for Akkuyu NPP site: the 5,4 km urgent protective action planning zone and the 80 km long term planning zone with limitation to use local foodstuffs;
- In the long term planning zone with limitations of foodstuffs consumption two districts should be considered: Mersin and Karaman;
- A transport infrastructure should be developed near Akkuyu site to facilitate the evacuation of people and implementation of measures to manage the severe accident consequences. The road to the Akkuyu NPP and the nearest settlement are at a higher elevation than the NPP, so they would not be damaged or blocked by the tsunami inundation;
- From hazard analyses performed for the Akkuyu NPP site, it is known that earthquakes and tsunamis dominate external events. This is a common feature for coastal sites of the Eastern Mediterranean Sea. The choice of these two events as potential beyond design basis hazards is also indicative of the post Fukushima lessons learned. For the Akkuyu NPP, an analysis of those external events should be made;
- In the case that the radiological accident is caused by earthquake vibratory ground motion, it is possible that transportation on the existing main road may be disrupted due to landslides, road bed deformation or bridge (overpass) failures. As the Mersin-Antalya highway is the only road that would serve as an evacuation route, it is clear that strengthening of this roadway or providing for alternatives would be important before the plant goes into operation;

- The Mersin – Antalya highway as well as the connection road from this highway to the site are tens of meters above the expected design basis coastal flooding level. There is the capability to deliver goods/equipment and support in case of emergency via land and sea routes with exception of tsunami event.
- The development of additional infrastructure during the NPP construction (building of alternative transport routes to the NPP and at the adjacent to the NPP settlements with consideration of topography features) and respective organizational measures in emergency plans are actions that will ensure the feasibility of the evacuation as a first priority protection measure as well as the supply of human and engineering resources for accident mitigation measures.

The urgent protective measures foreseen in this report will serve as a basis for preparation of the off-site emergency plan measures. Akkuyu NPP JSC is going to collaborate with Mersin Governorship to ensure support during the development of the off-site emergency plan and implementation of the urgent protective measures according to this plan.

From the point of view of site characteristics there are not identified insurmountable difficulties in establishing an emergency plan for the Akkuyu NPP.

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11. ELECTRICAL SYSTEMS

11.1 CONNECTION POSSIBILITIESTONATIONAL GRID

11.1.1 INTRODUCTION

The Akkuyu NPP shall consist of four power units with total installed capacity of about 4800 MW (4 VVER power units 1200 MW each). Basic construction period of Akkuyu NPP is planned for 2014 – 2023. Turkish Electricity Transmission Grid should be ready in full scope for power transfer from Akkuyu NPP one year before Akkuyu NPP unit 1 commissioning. The conceptual 380 kV single line diagram of Akkuyu NPP connection to the grid and the diagram of Akkuyu NPP connection to the 154 kV substation with 380/154 kV autotransformers are presented in Figure 11/1 and Figure 11/2.

11.1.2 OVERVIEW OF TURKISH ELECTRICITY TRANSMISSION GRID

The Turkish Electricity Transmission Grid is composed of 380 kV EHV lines and 154 kV HV lines, 380/154 kV autotransformers and 154 kV step down substations. The transmission grid has standard voltage levels of 380 kV and 154 kV, and it is equipped with sufficient amount of capacitors to compensate reactive power.

Current state of Turkish Electricity Transmission Grid for 380 kV lines is described in Figure 11/3. In the same figure future expansion is shown in dashed lines.

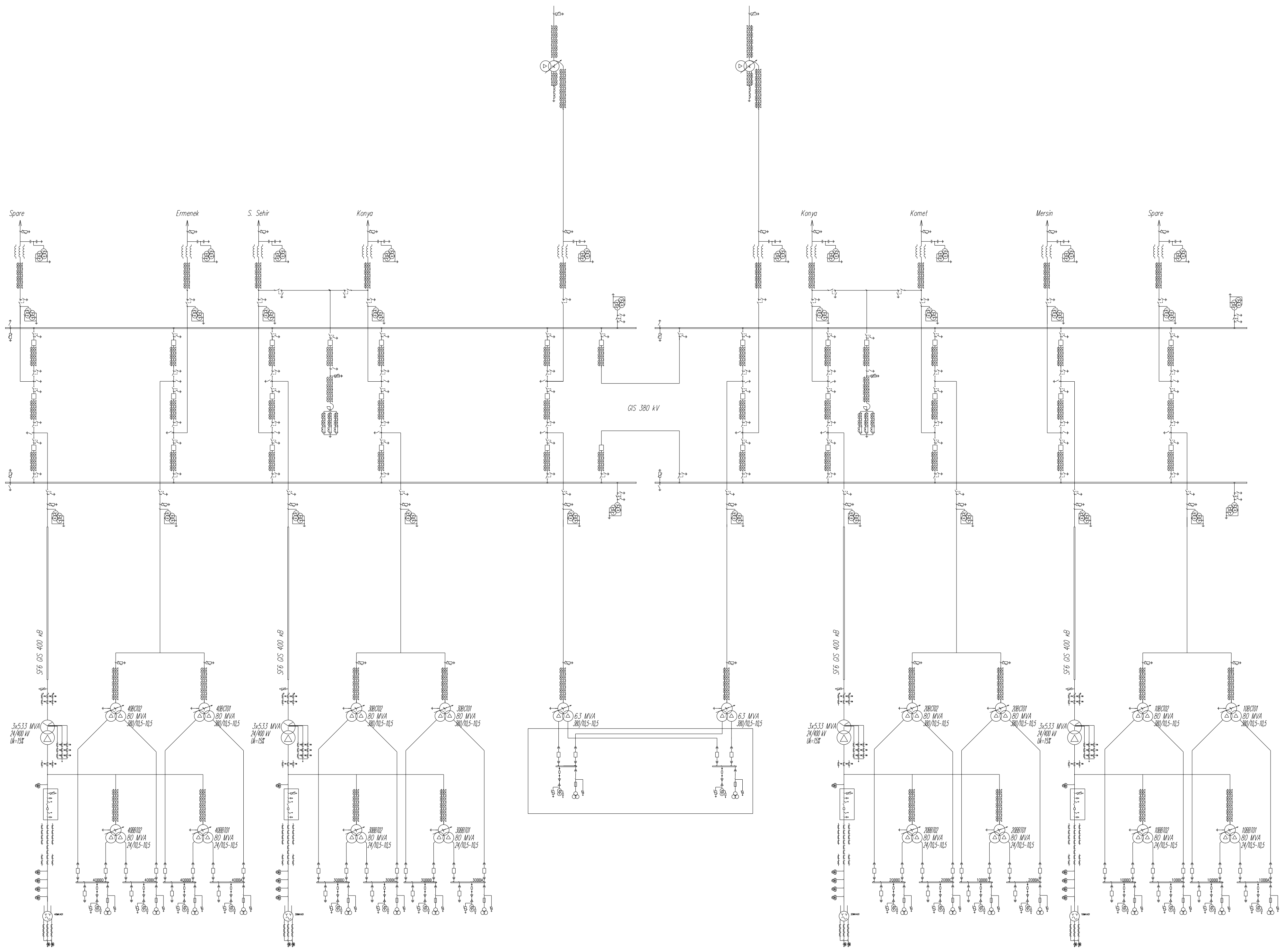


Figure 11/1 – 380 kV single line diagram of Akkuyu NPP connection to the main grid

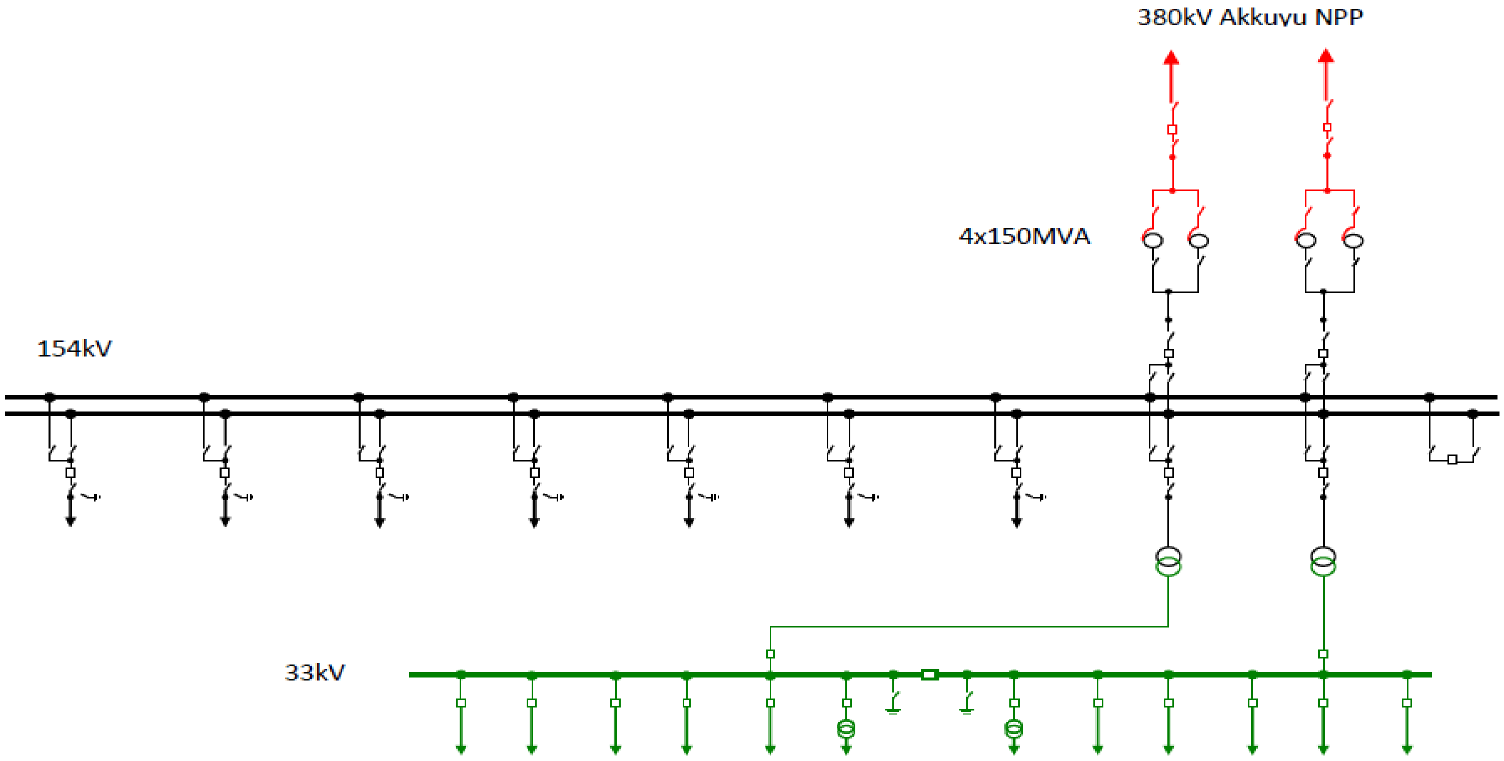


Figure 11/2 – Diagram of Akkuyu NPP connection to the 154 kV distribution network

Figure 11/3 – 380 kV Turkish Electricity Transmission Grid

The existing situation of the transmission system is summarized on Table 11/1 and Table 11/2.

Table 11/1 – Number of Transmission Substations and Capacities by primary voltage levels *(Values for 2008*)

380 kV		154 kV		66 kV and lower		Total	
AMOUNT	CAPACITY (MVA)	AMOUNT	CAPACITY (MVA)	AMOUNT	CAPACITY (MVA)	AMOUNT	CAPACITY (MVA)
174	33220	1010	55584	57	672	1241	89476

Table 11/2 – Length of Transmission Lines (km) *(Values for 2008)*

380 kV	220 kV	154 kV	66 kV	Total
14420.2	84.5	31653.9	508.5	46667.1

154 kV – underground capacity cable length is 162.9 km

380 kV – underground capacity cable length is 12.8 km

There are many existing interconnections between Turkey and neighboring countries. There are also quite a few future interconnections that are planned. These are: 400 kV Akhaltsikhe-Borçka line between Turkey and Georgia, 400 kV HVDC cable under the Black Sea between Turkey and Romania, 400 kV line between Cizre (Turkey) and Musul (Iraq), and HVDC line between Turkey and Iran.

Opening new routes for electricity exchange across the Mediterranean is a key to energy security in the region. Mediterranean countries are working towards establishing a Mediterranean Electricity Ring (MedRing) energy corridor linking power grids from Spain to Morocco through North Africa and Arabia to Turkey. From Turkey, the ring will then link back into the European grid via Greece or Bulgaria.

Turkey is keen to integrate its grid with the EU network to get the benefit of synchronous parallel operation. The Turkish power system could be connected with the Union for the Coordination of Transmission of Electricity (ENTSO-E) system

Akkuyu NPP will be located in the province of Mersin near Turkish Grid consisting of many 380 kV lines as shown in Figure 11/4.

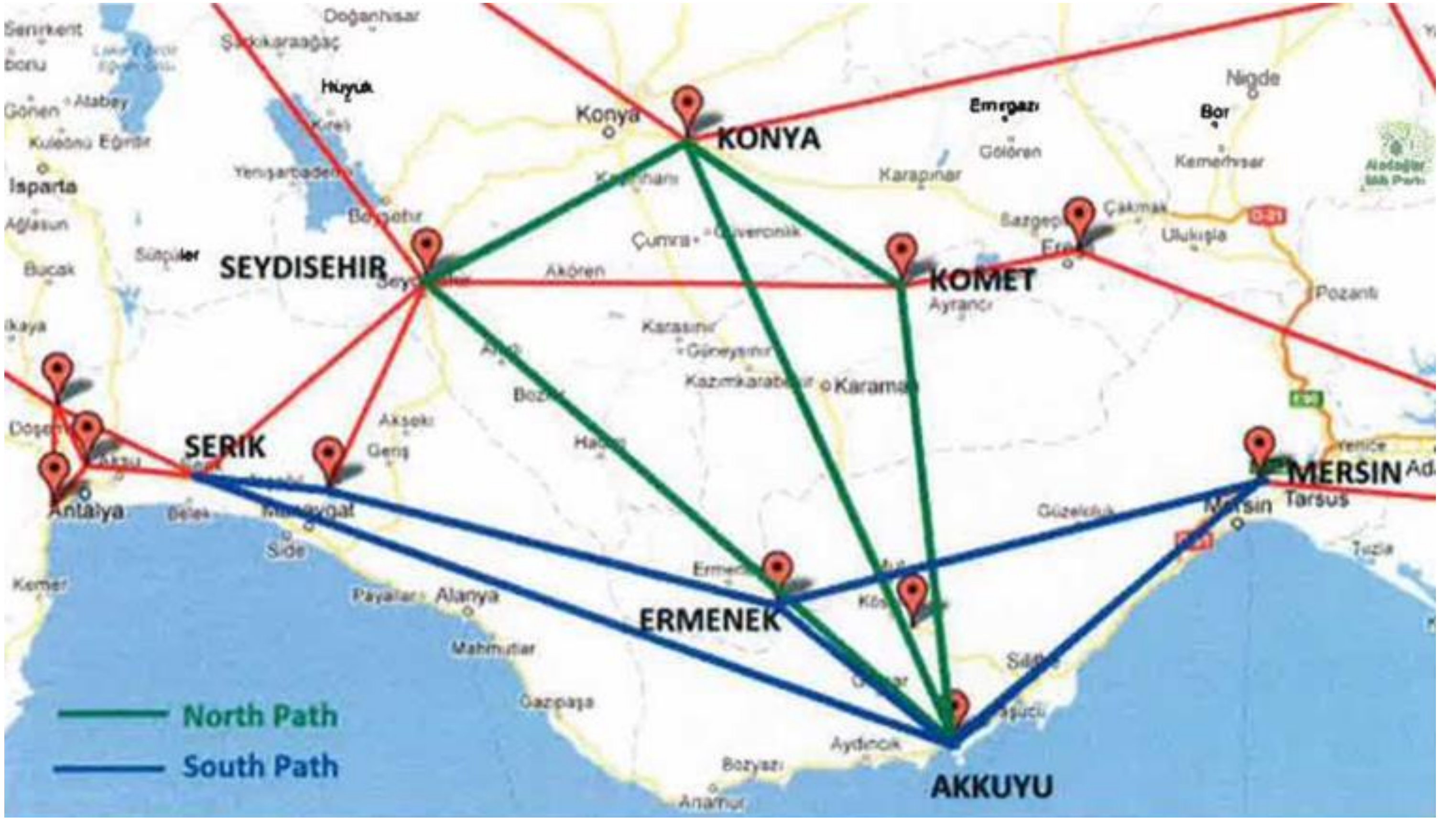


Figure 11/4 – Diagram of Akkuyu NPP location and connection to 380 kV grid

11.1.3 GRID CONNECTIONS

Power output from the Akkuyu NPP will be supplied at 380 kV voltage level. In compliance with this requirement, the NPP will be electrically connected by six power transmission lines to the 380 kV backbone network and by two short-length power transmission lines with 380/154 kV coupling autotransformers to the 154 kV Akkuyu substation connected to the 154 kV distribution network. Metal-clad SF6 gas insulated switchyards will be used to connect the NPP to the main grid at the 380 kV. The 380 kV gas insulated switchyard has a one-and-a-half circuit arrangement (3 circuit breakers for two connections) and 154 kV Akkuyu substation has a two bus-bar circuit arrangement. There will be two 380 kV switchyards close to the plant, one for NPP units 1 and 2 and the other is for NPP units 3 and 4. These two switchyards must be physically separated but electrically connected for high degree of reliable operation.

Configuration of grid connections and equipment ratings as shown in Figure 11/1 and Figure 11/2 are preliminary and may be reviewed and revised as necessary.

11.1.4 MAIN GRID CONNECTION

The function of the main grid connection is:

- generated power output via the unit step-up transformers into the 380 kV system;
- reserve power supply to plant auxiliaries from the 380 kV grid system;
- for the start-up/normal shutdown phase;
- to bring and to keep the plant in a safe condition in the event of an incident;
- to supply auxiliary power when the plant is not in operation.

The NPP units will be connected to the 380 kV main grid by a three-winding 3 x 533 MVA unit step-up transformers. During normal operation of the NPP unit the main generator feeds the produced energy into the 380 kV main grid via the generator circuit breaker and the unit step-up transformer. The auxiliary power supply for normal operation of the NPP unit is performed via two 80 MVA main transformers with on-load tap changers connected between the generator circuit breaker and the unit step-up transformer. Two reserve transformers 80 MVA provide auxiliary power supply of the NPP unit for start-up, shut-down and emergency state.

The transfer from the main to stand-by auxiliary transformers will be performed automatically by switch-over-devices at the 10.5 kV distribution bus-bars. The function is independent for each train by use of one device per train.

The design connection of the Akkuyu NPP to the 380 kV grid via six power transmission lines makes it possible to supply full power output and maintain the static stability of 380 kV grid in normal and abnormal operation even with disconnection of two transmission lines (emergency criterion N-2). Detail of 380 kV power transmission lines for main grid connection is provided in Table 11/3.

Table 11/3 – 380 kV power transmission lines for main grid connection of Akkuyu NPP

№	380 kV power transmission lines	Type and size	Length (km)
1	To SEYDIŞEHIR TM	Pheasant, 3X 1272 MCM ACSR	210
2	To ERMENEK HES	Pheasant, 3X 1272 MCM ACSR	70
3	To KONYA TM	Pheasant, 3X 1272 MCM ACSR	210
4	To MERSIN TM	Pheasant, 3X 1272 MCM ACSR	140
5	To KOMET TM	Pheasant, 3X 1272 MCM ACSR	140
6	To SERIK TM (to be determined)	Pheasant, 3X 1272 MCM ACSR	250

Five of the six power transmission lines in Table 11/3 are the selected lines. The sixth 380 kV line to be determined may be either the Akkuyu NPP – SERIK (new 380 kV substation) line or the Akkuyu NPP – SEYDIŞEHIR line (the second line). The Akkuyu NPP – SERIK line is more preferable than other alternatives based on the existing analysis of static and transient stability.

Although static stability appears to be acceptable, an analysis of transient stability must be performed to ensure that unavailability of transmission lines due to fault will not create unstable grid conditions.

11.1.5 DISTRIBUTION NETWORKCONNECTION

Akkuyu NPP will be connected to the 154 kV distribution network by means of the 380/154 kV Akkuyu substation. The function of the connection to 154 kV distribution network is:

Generated power output into the 154 kV distribution network via four 380/154 kV coupling autotransformers with 150 MVA capacity each and 154 kV Akkuyu substation;

To bring and to keep the plant in a safe condition, i.e. to maintain the main heat sink without the need for emergency diesel start.

The design connections of the Akkuyu NPP to the 154 kV distribution network as shown in Figure 11/1 and Figure 11/2 are very conceptual. 154 kV power transmission lines (number of 154 kV transmission lines, type and size, length) and connection configurations are not available at this stage to describe 154 kV distribution network connections in detail.

11.2 RELIABILITY OF OFFSITE ELECTRICAL POWER

11.2.1 OFFSITE POWER SUPPLY

The offsite power supply system is provided through following grid connections:

- Main grid connection 380 kV and distribution network connection 154 kV for the power transmission and normal start-up and shut-down of the plant.
- Following are the major components of the offsite power system for the Akkuyu NPP:
- Turkish Grid and Transmission Lines Connection to Plant Switchyards;
- Akkuyu Plant Switchyards.

Contributions of the above components towards reliable offsite power system will be discussed to make an overall assessment about the reliability of the offsite power system of the Akkuyu NPP.

11.2.2 TURKISH GRID AND TRANSMISSION LINES CONNECTION TO PLANT SWITCHYARD

Turkish electricity transmission grid with many HV transmission lines, substations, interconnections between countries, and adequate protective equipment and high speed relays can be considered as a reliable source of offsite power system.

Number of adequately sized 380 kV transmission lines to main grid connection from different types of power plants, both thermal and hydraulic, ensures operation without any interruption during normal and abnormal conditions complying with N-2 emergency criterion. Similar approach shall also be considered in designing 154 kV lines to distribution network connection.

11.2.3 AKKUYU PLANT SWITCHYARDS

There will be two 380 kV switchyards, one for the NPP units 1 and 2, and the other is for the NPP units 3 and 4. Both switchyards will be located near the NPP, but there will be physical separation between them to reduce the possibility of losing both at the same time. Also, 380 kV and 154 kV buses of both switchyards will be electrically connected to enhance power supply reliability.

One-and-a-half circuit arrangement for 380 kV gas insulated switchyards and double bus-bar circuit arrangement for 154 kV gas insulated switchyards are appropriate for the reliable grid connection.

In case of fault in the generator, high speed generator circuit breaker will isolate the generator and allow offsite power supply to the plant without interruption.

11.2.4 ASSESSMENT OF OVERALL RELIABILITY OF OFFSITE ELECTRICAL POWER

The above short analysis of major components of offsite power supply for the Akkuyu NPP provides reasonable assurance that it is a reliable system to provide the required power when needed.

A detailed reliability analysis for the offsite power supply must be performed in future considering the duration and frequency of interruption and its impact on the plant performance.

11.3 CONCLUSIONS

Assessment of overall reliability of Akkuyu NPP connections to the main 380 kV grid and 154 kV distribution network allows concluding that Akkuyu NPP site is acceptable for power generation and power supply to the plant auxiliaries, and there is no any exclusion criteria for Akkuyu site selection due to electrical systems.

REFERENCE LIST

11/1. Decree for Connection to National Power Grid of the Republic of Turkey No. 27691 of 03.09.2010

12. PROGRAMS

12.1 QUALITY MANAGEMENT PROGRAM

The objective of the NPP quality assurance program is to regulate the quality assurance activities for the implementation of the main criteria and principles of the NPP safety assurance, which are performed by Akkuyu NPP JSC (hereinafter referred to as the Company) and by the organizations involved in the activities / services for the Company.

Design and reliability of the NPP safety related systems (components), documentation, and various types of activities affecting the NPP safety assurance are areas of the quality assurance activities.

The Company shall elaborate the NPP general quality assurance program, QAP (G), whereas the organizations involved in the activities/services for the Company shall elaborate specific quality assurance programs for the NPP.

The specific quality assurance programs for the NPP (to be elaborated by the organizations involved in the activities/services for the Company) are as follows:

- QAP (DS) – the quality assurance program in the designing of the NPP unit;
- QAP (RP) – the quality assurance program in the development of the NPP reactor plant;
- QAP (DE) – the quality assurance program in the development of the NPP safety related equipment, components and systems;
- QAP (ME) – the quality assurance program in the manufacture of the safety related equipment, components and systems;
- QAP (C) – the quality assurance program in the construction of the NPP Unit;
- QAP (CMG) – the quality assurance program in the commissioning of the NPP Unit;
- QAP (O) – the quality assurance program in the operation of the NPP Unit;
- QAP (DMG) – the quality assurance program in the decommissioning of the NPP Unit.

The list of the quality Programs/Plans currently elaborated is given in Table 12/1

Table 12/1 List of the Quality Programs/Plans

№	Description	KKS number
1	General quality assurance program of the Akkuyu NPP, Units 1, 2, 3, 4	AKU.P.010.&.&&&&&.&&&&.089.PE.0001
2	Configuration management program	AKU.P.010.&.&&&&&.&&&&.089.PT.0002
3	General quality plan	AKU.P.010.&.&&&&&.&&&&.089.PS.0003
4	The quality assurance program	AKU.C.120.&.&&&&&.&&&&.089.PH.0001

General quality assurance program of the Akkuyu NPP

Units 1, 2, 3, 4, AKU.P.010.&.&&&&&.&&&&.089.PE.0001 (hereinafter referred to as QAP (G)) has been elaborated for the quality assurance in the implementation of the Agreement between the Government of the Russian Federation and Government of the Republic of Turkey, of May 12, 2010, related to the cooperation in the construction and operation of the nuclear power plant in the Republic of Turkey, and Order of Akkuyu NPP JSC No. 272 of 10.03.2011, "On the NPP construction project in Turkey".

The QAP (G) covers all the management measures and activities, as well as processes, services and items affecting the safety, reliability and performance.

The QAP (G) requirements apply to all the NPP safety related systems (components), documentation, activities and services affecting the NPP safety assurance and economic efficiency, and the personnel performing these activities and services.

The QAP (G) regulates the business of the Company and organizations involved in the services, with respect to the quality management at the life-cycle stages of the NPP Units:

- top-priority engineering surveys;
- designing;
- construction;
- commissioning;
- operation;
- decommissioning.

The QAP (G) is commensurate with the quality assurance policy of the Company; it is compatible with requirements of the atomic energy codes and regulations, and sets forth the requirements for specific quality assurance programs.

The QAP (G) shall be revised in the event of the Company reorganization, fundamental change of the Company QMS, and/or construction of a new NPP unit.

The current QAP (G) has been elaborated with due consideration of requirements and provisions of the following legislative and regulatory documents:

- Law of the Republic of Turkey on the atomic energy management, No. 2690 of 09.07.1982;
- Resolutions of the Cabinet of Ministers of the Republic of Turkey on nuclear facility licensing, No. 83/7405 of 18.11.1983;
- Provision on the fundamental quality management requirements for safety assurance of nuclear facilities (official newspaper No. 26642 of 13.09.2007);
- IAEA safety requirements No. GS-R-3, Management system for facilities and activities;
- IAEA Safety Guide No GS-G-3.1, Application of the management system for facilities and activities;
- OPB-88/97 (PNAE G-01-011-97), General provisions for ensuring safety of nuclear power plants;
- NP-011-99, Requirements for quality assurance program in the operation of nuclear power plants;
- Other legislative and regulatory documents of the Republic of Turkey and Russian Federation;
- International standards ISO 9000.

General quality plan
Units 1, 2, 3, 4 AKU.P.010.&.&&&&&.&&&&.089.PS.0003

The general quality plan describes the methods, organizational measures, as well as safety assurance management activities considering the whole life cycle of the Akkuyu NPP.

The form and scope of this General quality plan comply with the requirements set forth in the "IAEA safety standards and regulations", provisions of the ISO 9000 Standards, as well as Turkish NPP safety regulatory documents ("Provision on the fundamental quality management requirements for safety assurance of nuclear facilities ").

The general quality plan is a basic document for performing the various activities at all the life-cycle stages of the Akkuyu NPP. It shall be observed by all the employees to be involved in the implementation of this program.

The general quality plan shall be applied at the following stages:

- Site survey

– Designing

– Construction

– Commissioning

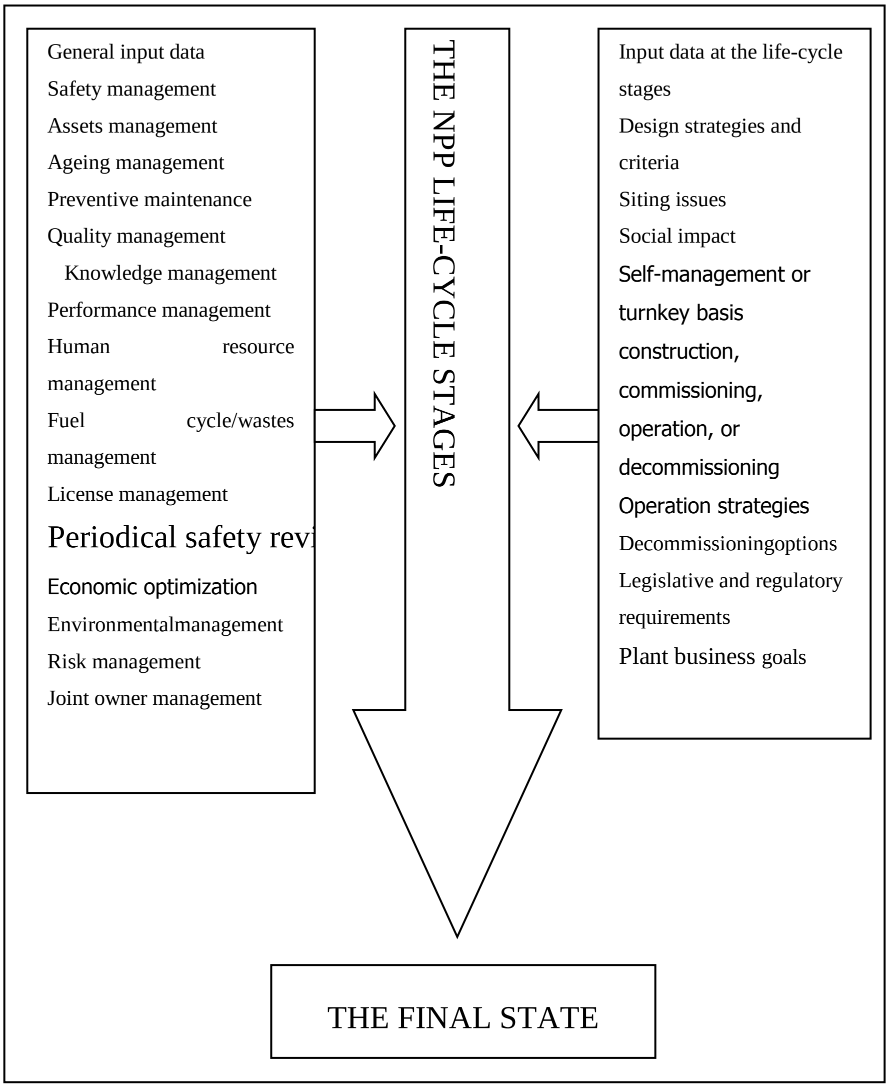
– Operation

– Decommissioning.

Quality plans are elaborated by the organizations involved in the activities and services for the Company in the implementation of the Akkuyu NPP Project in accordance with the Schedule of works on the contractual commitments and the general quality plan.

The general quality plan is a document describing the procedures, organizational measures, as well as quality assurance management activities with due consideration of the whole life-cycle of the Akkuyu NPP.

*Input data on the NPP life-cycle management are given below.



**- input data on the Akkuyu NPP life-cycle management in accordance with IAEA-TECDOC-1305 "Safe and effective nuclear power plant life cycle management towards decommissioning."*

Configuration management program

Units 1, 2, 3, 4. AKU.P.010.&.&&&&&.&&&&.089.PT.0002

Nuclear facilities need the configuration management program (hereinafter Program) to manage the document coverage and NPP design basis, to determine theoretical and practical solutions for nuclear plant business-processes as concerns setting and keeping the NPP design basis. This documents describes the principles, methods, processes and technologies to be used for the Akkuyu NPP project configuration management in the designing, construction, commissioning, operation, and decommissioning (hereinafter, "all the Akkuyu NPP stages").

The Akkuyu NPP configuration management program is the fundamental document for further elaboration of the configuration management plans, procedures of the configuration management system and other resources for the development and application of the NPP Program.

The Akkuyu NPP configuration management program is an integrated process to provide for:

– the compliance of the NPP constructions, systems and components, computer software/ IT solutions with the approved design requirements;
– adequate reflection of the physical and functional characteristics of the NPP systems and components in the plant documents and information systems.

The Akkuyu NPP program is the fundamental document for further elaboration of the configuration management plans, procedures of the configuration management system and other resources for the development and application of the NPP Program.

The particular goals of the Akkuyu NPP program are as follows:

– to determine the requirements for the Akkuyu NPP configuration management;
– to determine the components and objectives of the Program;
– to determine the responsibilities and structure of the program, program interface;
– to determine the IT solutions and configuration management program;
– to set the configuration management concept, standard terms and definitions;
– to describe the interfaces and business processes of the Akkuyu NPP required for the implementation of the configuration management as a Company quality management tool;

- to describe the relations between the Akkuyu NPP configuration management and the Program of the configuration management System.

The program is suitable for the Akkuyu NPP project configuration management at all the stages of the Akkuyu NPP.

The program applies to the Akkuyu NPP as regards the operating structure of the plant, physical configuration of the systems and components, designing, design basis, accounting records, and operation and maintenance procedures. Besides, the scope of the Program includes the software and IT solutions, which cover information of the configuration and knowledge management at all the stages of the Akkuyu NPP.

The quality assurance program in the top-priority engineering surveys
Units 1, 2, 3, 4. AKU.C.120.&.&&&&&&.&&&&&.089.PH.0001

The quality assurance program in the top-priority engineering surveys describes the quality assurance program in the top-priority engineering surveys for siting the Akkuyu NPP in the Republic of Turkey (hereinafter referred to as the QAP (ES)).

The QAP (ES) has been elaborated for the performance of the activities as concerns: "Top-priority engineering surveys on the Akkuyu NPP site in Turkey" for elaboration of the EIA (Environment Impact Assessment) documents included in the package of documents to be submitted with the applications for licenses required for the NPP construction in Turkey." The QAP (ES) requirements apply to the top-priority engineering surveys and investigations for the pre-project preparation for the Akkuyu NPP construction as specified in the Contract terms and conditions.

The QAP (ES) has been elaborated in accordance with the following requirements:

- Federal Law "On atomic energy use", federal codes and regulations in the atomic energy;
- General quality assurance program, QAP (G);
- NP-011-99, "Requirements for the quality assurance program of nuclear power plants"
- IAEA Safety Standards;
- ISO 9000 standards.

The QAP (ES) is included in the set of the documents justifying the site nuclear and radiation safety assurance to be submitted by the Customer to the regulatory body for obtaining the Akkuyu NPP siting license.

The QAP (ES) regulates the organizational and technical quality assurance activities of the divisions involved in the pro-project stage of the Akkuyu NPP siting, and determines the boundaries of responsibilities of these divisions.

The main goals of the QAP (ES) are as follows:

- to regulate the quality assurance activities to be performed by JSC Atomenergoproekt and its subcontractors involved in the survey and design activities and engineering services (hereinafter, the activities) for the implementation of the main criteria and principles of the Akkuyu NPP safety assurance;
- to provide for the quality procedures specified in the QAP (ES) with due consideration of the classification of equipment, systems and structures by the safety impact, as well as the differential approach to the quality assurance based on the quality categories of activities, systems and components in terms of safety and economic efficiency;
- further improvement of the applicable QMS of JSC Atomenergoproekt.

The QAP (ES) applies to the activities affecting the safety assurance and the personnel involved in those activities and services;

The QAP (ES) includes the requirements for the organizational and technical activities of JSC Atomenergoproekt business units and subcontractors involved in the Akkuyu NPP siting, and determines the boundaries of responsibilities between them.

The fulfillment of the QAP (ES) is reviewed in the course of the QMS internal audits. The QAP (ES) is periodically analyzed to assess the compliance with the requirements declared.

The QMS underlines the need for conformity of the personnel skill level with the performance standards. The personnel training, instructions, and examinations on the atomic energy safety are planned. The requirements for skills of the personnel involved in the examinations (audits) have been set forth.

REFERENCE LIST

12/1 Law of the Republic of Turkey on the atomic energy management No. 2690 of 09.07.1982

12/2 Resolutions of the Cabinet of Ministers of the Republic of Turkey on nuclear facility licensing, No. 83/7405 of 18.11.1983

12/3 Provisions on the fundamental quality management requirements for safety assurance of nuclear facilities (official newspaper No. 26642 of 13.09.2007)

12/4 IAEA safety requirements No. GS-R-3, Management system for facilities and activities

12/5 IAEA Safety Guide No GS-G-3.1, Application of the management system for facilities and activities

12/6 OPB-88/97 (PNAE G-01-011-97), General provisions for ensuring safety of nuclear power plants

12/7 NP-011-99, Requirements for quality assurance program in the operation of nuclear power plants

12/8 ISO 9000 International standards

13. ADDITIONAL INFORMATION

13.1 NUCLEAR SAFETY IN THE POST-FUKUSHIMA WORLD

Analysis of the event tree based on the Fukushima accident shows that a reason for the aggravated situation was a loss of all the safety systems provoked by power supply sources failure.

Nuclear Power Plants are equipped with emergency diesel-generators, which purpose is fast replacement of external power supply sources. At Fukushima NPP these sources turned out to be under the water. Moreover, if external power supply had been restored, electric power facilities would have failed to be connected (such as emergency diesel generators and mobile power plant) since switchboards also were flooded as a result of tsunami. It was the main reason for aggravation of the situation.

The real problem was unpreparedness for the situation of this type. More rigid safety measures could provide the other results. It would be worth to consider the worst scenario and contra-measures for this situation. For example, “if tsunami reaches the plant premises water can gush to buildings, and equipment important for safety including switchboards can be flooded. In view of the above it is reasonable to provide tightness of these systems preventing water leakage inside, or to place them in the water-proof sections. To strength systems and equipment in case of protection loss, and be ready to control situation if these strengthening measures seem to be insufficient”.

Power supply was also required to ensure cooling functions. As a result of Act of God the Fukushima NPP lost components cooling system (technical water system) since sea water pumps stopped operating. In view of the above the technical measures for power supply and cooling systems are considered in the NPP “Akkuyu” project.

13.2 CLASSIFICATION OF THE PROBLEMS.

The revealed problems are classified by 5 categories:

- Contra-measures against earthquake/tsunami impacts (threats of nature);
- Ensuring (reservation) of power supply;
- Measures against the loss of ultimate heat sink systems;
- Measures against generation of explosive hydrogen concentration;
- Preparedness for emergency situations control.

Table 13/1. Category of the Problems

Category	Problems/requirements
Contra-measures against earthquake/tsunami impacts	– Seismic correspondence of external power sources; – Corresponding measures for open switchgears; – Corresponding measures for sea water systems; – Protection of sea water pumps against flooding; – Corresponding measures for emergency diesel-generators; – Water – tightness of the buildings.
Ensuring (reservation) of power supply	– Reservation of inlet boards to receive power; – Provide the required capacity of the accumulator batteries; – Receive energy from external additional sources (e.g. mobile power plants); – Lay down cables for alternative power supplies.
Measures against the loss of ultimate heat sink systems	– Provide system/equipment integrity in case of the initial single event provided by the design; – Available ultimate heat sink provided by the design that excludes possibility to be out of service in case of tsunami; – Exclude loss of fresh water sources.
Measures against generation of explosive hydrogen	– Reveal hydrogen; – Available systems for decrease in hydrogen

concentration	concentration in the reactor buildings.
Preparedness for emergency situations control	– Provide sufficient number of the personnel for radiation measurements/monitoring – Protection of radiation control systems against damage – Communication methods in case of power supply loss – Mechanisms/equipment to provide access road – Provide safety of more than one transportation way within the building – Putting in force emergency and personnel training procedures – Seismic protection and contra-measures against tsunami for the pipelines of fire-protection system

Measures targeted at elimination of possible reasons triggered to emergency situations at Fukushima NPP will be provided for NPP “Akkuyu” at the stage of Technical Design.

Moreover, there has been prepared a Report on “stress-tests” for NPP “Akkuyu”, which provides the measures for comprehensive assessment of safety and risks in the after-Fukushima conditions according to ENSREG (European Group of Nuclear Safety Control Bodies) requirements.

REFERENCES LIST

13/1 InterRAO-Warley Parsons' Report – Inter RAO "Consulting services for NPP Akkuyu, Turkey (TNPP). Reports of stress-tests of NPP Akkuyu. 07 February 2012