5. RADIOLOGICAL PROTECTION ARRANGEMENTS

5.1 Introduction

This Section addresses the radiological protection arrangements that have been established for the plant and plans for their future development. Attention is focused on workplace control procedures, environmental and public protection, as well as emergency planning arrangements.

Effects in exposed tissues and individuals from exposure to ionising radiation depend on the severity of the dose received and the time over which it is delivered. This leads to a distinction between "deterministic" and "stochastic" effects as follows.

- "Deterministic effects" occur at very high doses and/or dose-rates; they are of concern only for on-site personnel and in major accident situations.
- "Stochastic effects" are of concern in case of exposures to low doses. Their probability of occurrence - which is a function of the dose delivered - can be calculated. Moreover, it is assumed that the relationship (dose/possible induction of cancers or inheritable defects) is linear - with no threshold below which stochastic effects do not occur and hence the results can be extrapolated to very low doses at which such effects cannot be distinguished from doses arising from other causes.

The three main principles which have been adopted at an international level are as follows.

- All exposures to radiation must be justified.
- All exposures must be as low as reasonably achievable (ALARA), social and economic factors being taken into account.
- Dose limits must be set up and imposed, both to prevent the occurrence of deterministic effects and to minimise probabilistic effects.

The primary source of recommendations on radiological protection is the International Commission on Radiological Protection (ICRP). ICRP recommendations are used for international standards (including the basic safety standards of the European Union and those of the International Atomic Energy Agency (IAEA)) and national statutory requirements.

5.2 International standards

5.2.1 ICRP

The original ICRP recommendations published in 1959 recognised the need to set limits on annual and lifetime doses, in order to limit the incidence of radiation-induced cancers. In addition, limits were placed on exposure to airborne activity.

In further recommendations published in 1965, ICRP introduced the concept of risk for exposure to radiation [5.1]. In 1976, a system was developed for weighting the dose from relative effects of different types of incident radiation (dose equivalent) on different organs of the body.

Subsequent basic recommendations of ICRP (of which the latest is ICRP 60 [5.2] dated 1991) have established the three aforementioned principles for radiological protection i.e.

- Justification.
- Optimisation (ALARA).
- Limitation.

A comparison of dose limits applied in different ICRP publications is shown in Tables 5.1 and 5.2.

Table 5.1
Comparison of annual dose limits for occupational exposure in ICRP publications

Organ or Tissue	ICRP2	ICRP9	ICRP26	ICRP60(1)
Effective Dose(2)			50 mSv	20 mSv(3)
Tissue Dose	300 mSv (skin, thyroid) 150 mSv (other single organs except gonads and bone marrow)(4)	50 mSv (gonads, red bone marrow) 300 mSv (skin, bone, thyroid) 150 mSv (other single organs)(5)	500 mSv (individual organs or tissues)	500 mSv (skin)(6)
Lens of eye			300 mSv	150 mSv
Hands and Feet	750 mSv	750 mSv		500 mSv

(1) Dose limits in ICRP 60 apply to the sum of relevant doses from external exposure in the specified period and the 50 year committed dose (to age 70 for children) from intakes in the same period.

(2) The concept of effective dose, obtained by summing over weighted tissue doses, was introduced in ICRP26.

(3) The annual effective dose limit in ICRP60 represents the average over a defined 5 year period, subject to the provision that the effective dose should not exceed 50 mSv in any single year, additional restrictions apply to the occupational exposure of pregnant women.

(4) Limits are also placed on weekly and quarterly exposures. A lifetime limit is specified for the whole body dose from intakes of mixtures of radionuclides and the dose to gonads, blood forming organs and the lens of the eye for which the quarterly limit is given as 30 mSv.

(5) Up to one half of the annual dose limit in any quarter. The quarterly quota may be repeated in each quarter of the year provided that the local dose accumulated at any age, N, over 18 years does not exceed 50(N-18) mSv.

(6) The limitation on effective dose provides sufficient protection for the skin against stochastic effects. An additional limit is needed for localised exposures in order to protect against deterministic effect.

Table 5.2
Comparison of annual dose limits for members of the public in ICRP publications

Organ or Tissue	ICRP2	ICRP9	ICRP26	ICRP60(1)

Effective Dose(2)			5 mSv	1 mSv(3)
Tissue Dose	5 mSv (skin, blood-forming organs and lens of the eye, or whole body dose from intake)	5 mSv (gonads, red bone marrow) 30 mSv (skin, bone, thyroid)(4) 15 mSv (other single organs)	50 mSv (individual organs or tissues)	50 mSv (skin)(5)
Lens of eye			50 mSv	15 mSv
Hands and Feet		75 mSv		

(1) Dose limits in ICRP 60 apply to the sum of relevant doses from external exposure in the specified period and the 50 year committed dose (to age 70 for children) from intakes in the same period.

(2) The concept of effective dose, obtained by summing over weighted tissue doses, was introduced in ICPR26.

(3) In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over five years dose not exceed 1 mSv per year.

(4) Special limit of 15 mSv in a year to the thyroid of children up to 16 years of age.

(5) The limitation on effective dose provides sufficient protection for the skin against stochastic effects. An additional limit is needed for localised exposures in order to protect against deterministic effects.

5.2.2 IAEA

Basic safety standards for radiation protection are set out in IAEA Safety Series No. 9 [5.3]. Other relevant publications include:

- Radiation Protection During Operation of NPPs (IAEA Nuclear Safety Standards Programme No.50-SG-O5) [5.4].
- Provision of Operational Radiation Protection Services at NPPs (IAEA Safety Series No.103) [5.5].
- Operational Radiation Protection: A Guide to Optimisation (IAEA Safety Series No. 101) [5.6].

5.2.3 European directives

The recommendations in ICRP publications 26 [5.7] and 30 [5.8] were used as the basis for European Council Directives on Basic Radiological Protection Standards (80/836/Euratom and 84/836/Euratom) [5.9].

A new European Council Directive has been adopted recently, based on the 1990 recommendation of the ICRP. The national legislation of Member States will require compliance with this directive by May 2000, but working practices already serve to ensure that the new requirements are largely respected.

5.3 Ukrainian legislation

There are a number of Ukrainian standards on the protection of the environment against radioactive contamination and on radiological protection and radiation safety of personnel and the population [5.10 – 5.24].

Under Article 54 "Protection of the environment against acoustic, electromagnetic, ionising and other hazardous effects of physical factors and radioactive contamination" of the Law on Environmental Protection [5.25], enterprises engaged in activities associated with the use of radioactive substances in any form or for any purpose shall ensure ecological safety of the said activities ruling out the possibility of radioactive contamination of the environment or that of negative health effects in the course of extraction, enrichment, transportation, reprocessing, utilisation and disposal of radioactive substances.

Article 23 of the Law on ensuring sanitary and epidemiological safety of the population [5.10] sets requirements on ensuring radiation safety. This Law, establishes the priority of human and environmental safety, stipulates rights and duties of citizens in the area of nuclear energy use; regulates activities associated with use of nuclear facilities and sources of ionising radiation; and lays down the legal basis of Ukraine's international liabilities with regard to nuclear energy use.

5.3.1 Siting

According to the law of Ukraine "on Nuclear Energy Utilisation and Radiation Safety" [5.11], siting for an NPP is carried out in the following way. First, State power and local government institutions or separate legal entities and natural persons submit a proposal for NPP siting to the Cabinet of Ministers. For consideration of the question of siting, the applicant must present justification to construct the NPP as well as at least three siting options. The document must include:

- natural environment characteristics in the region of the possible NPP sites;
- an assessment of the impacts of NPP construction, operation, and decommissioning on the human and natural environment; and
- design measures to prevent and attenuate negative impacts on the environment.

The decision on construction is taken by the Cabinet of Ministers of Ukraine, together with local government institutions of the region where the NPP is planned for construction. The decision is made on the basis of the State expert's opinion on the safety of the installation and of other expert examinations in accordance with legislation.

In Ukraine, several normative documents regulate NPP siting. According to regulatory documents in force in Ukraine in 1996, a site for an NPP must meet "Requirements for siting of Nuclear Power Plant" [5.26] and sanitary norms for industrial planning [5.27].

On siting, calculations must be presented on minimal acceptable distances from an NPP to cities in accordance with [5.26]. Local factors which could adversely affect NPP radiation safety must also be taken into account. Among these factors are both natural characteristics and hazards caused by human activities.

The average density of the population within a 25 km radius around an NPP, calculated for the whole operating period, must not exceed 100 persons per km^2. Provision must be made for a road network and for vehicles to evacuate the population from contaminated areas of the above-mentioned zone within 4 hours.

The distance from an NPP to conglomerations, culture and health establishments is defined in each particular case for technical and economic reasons; minimum permissible distances correspond to Table 5.3.

Table 5.3
Minimum permissible distances from NPPs to conglomerates and culture and health establishments [5.26]

Nature of site concerned	Distance from NPP (km)	
	P<4 GW	4 GW<P<8 GW
Conglomeration population (thousands)		
100-500	25	25
500-1000	30	30
1000-1500	35	40
1500-2000	40	50
Over 2000	100	100
Recreation areas of significance, biosphere and historical preserves, State national parks	25	25

Other criteria for NPP siting are given in Table 5.4.

Table 5.4
Additional NPP siting criteria [5.27]

Criteria	NPP siting is not allowed:
Flooding	On territories which could be flooded accidentally.
Hazardous installation operation	In areas where operation of the installation could lead to an accident involving fire and explosion with release into environment of toxic substances and ejection of heavy objects.
Seismicity	Within zones of maximum estimated seismicity greater than 8 according to MSK-64 scale.
Water resources	In areas where there are no water resources sufficient to supply 97% of the requirement for making up losses in NPP cooling systems and where there are no reliable sources for making up water losses in safety related reactor cooling systems.

5.3.2 Area classification

In accordance with regulatory provisions in Ukraine, areas within NPP sites shall be classified. The criterion for defining such areas is not the surface potential contamination but the level of gamma-radiation equivalent dose rate at the working place.

All NPP buildings and structures must be classified as follows.

- Controlled Area, where radiation exposure of workers is possible.
- Free Access Area, where the action of radiation factors on workers is practically eliminated.

The area classification was proposed by the drafters of the SPAS-88 document [5.23], i.e. leading experts in the area of radiation hygiene of the Academy of Science of the USSR, Goskomatom and Gosatomenergonadzor. Such classification was based on previous works [5.24]. As for criteria used under NPP area classification, the critical ones were the levels of external exposure rate, levels of radionuclides in air, and radioactive contamination of surfaces.

Rooms in the controlled area must be separated into the following categories:

- unattended rooms with technological equipment and communication devices which, due to operating and radiation conditions when the NPP operates at power, rule out the presence of workers;
- periodically attended rooms in which operating and radiation conditions when the NPP operates, allow the possibility of presence of workers only for limited times; and
- attended rooms in which radiation conditions allow for the possibility of continuous stay during the whole working day.

It is required that, both during normal operation and in emergency, the containment of basic rooms of the controlled area shall be assured. Verification of room tightness and compliance of confining devices with design must be carried out before putting the NPP into operation and then periodically throughout operation.

All basic rooms in controlled areas where there are working places for personnel must be equipped with reliable two-way communication, including telephone, with monitoring and control boards. They must also be equipped with an alarm system.

5.3.3 Protection during routine operation

The following categories of exposed persons are set out in RSS-76/87 [5.16]:

Category A: personnel working in conditions where they are exposed to the effects of ionising radiation sources (IRS).

Category B: individuals who, due to condition of work or residence, could potentially be exposed to abnormal radiation conditions. This category concerns people working in organisations or enterprises where IRS are present but where people are not involved in activities directly associated with the use of IRS (e.g. employees of the administrative services of nuclear facilities, medical personnel). It also concerns people living in the vicinity of an NPP or other nuclear facilities ("observation zone").

Category C: the rest of the population.

5.3.3.1 Protection for workers and members of the public that can be exposed to radiation effects

The basic dose limits in force in Ukraine are given in Table 5.5.

Ukraine's current maximum permissible individual dose (MPD) from all kinds of ionising radiation sources is currently based on those specified in ICRP 26 [5.7] (given in Table 5.1 and Table 5.2). By the time that K2 is operational these dose limits will be based on ICRP 60 [5.2].

To not exceed the 50 mSv MPD value, the gamma-radiation equivalent dose rate in attended rooms which are continuously occupied (1700 h/year) shall not exceed 29 μSv/h and 58 μSv/h in rooms attended not more than half of the working time (850 h/year).

Table 5.5
Statutory annual dose limits in the Ukraine (external and internal exposure) [5.13]

Organ or tissue	A – Personnel	B – Resident population and other than category A personnel
1-Whole body, gonads and red marrow	50 mSv	5 mSv
2-Muscles, thyroid, adipose tissue, liver, kidneys, spleen, alimentary canal, lungs, crystalline lens and other organs (excluding first and third group)	150 mSv	15 mSv
3-Common integument, bone tissue, hands, forearms, skin and feet	300 mSv	30 mSv

According to standard BSR 72-87 [5.24], protection from external and internal exposure of personnel, organisation of technological process when operating, and at maintenance, must be designed with a safety margin of 2 for individual dose during the NPP life time. That is why the design limit levels of dose rates (shown in Table 5.6) in force in Ukraine are half the above mentioned values, so that the worst annual dose expected for workers should be 25 mSv instead of the statutory limit of 50 mSv.

In the near future, Ukrainian radiation safety norms that now comply with ICRP 26 [5.7] (50 mSv of MPD for category A personnel) will be changed to fully comply with the latest ICRP recommendation (ICRP 60 [5.2] with 20 mSv MPD).

Controlled exposure of personnel in responding to an accident is restricted by the following.

- In every particular case, it is only allowed to have twice the annual maximum permissible dose (AMPD) only once in the whole working life (in every such case, personnel must be notified beforehand about extra exposure).

- Exceeding the MPD is not allowed if a worker formerly has taken a dose five times the AMPD in the whole working life or if a worker is woman aged under 40.

Table 5.6
Design limit for dose rates in Ukraine

Exposed Iindividual Categories	Purpose of premises and areas	Period of exposure (hrs yr^{-1})	Maximum dose rate (μSv hr^{-1})	Implied annual dose (mSv)
A – Personnel	Premises permanently occupied by personnel	1700	14	25
	Premises occupied by personnel for no more than half of the working hours	850	29	25
B – Resident Population	Premises, offices and parts of the sanitary zone occupied by people included in category B	2000	1.2	2.5
	Any premises (including residential) and territories within the observation zone	8800	0.03	0.25

5.3.3.2 Protection of the public

Under current legislation [5.10], the annual external dose limit for the population residing near an NPP must not exceed 5% of the dose limit for population individuals (Category B), that is 0.25 mSv/year (Table 5.5). This dose limit is lower than the value recommended by IAEA, i.e. 1 mSv/year.

Dose limits for individuals established under CS NPP-88 [5.13] are given in Table 5.7.

Table 5.7
Acceptable/permissible annual exposure levels for a population residing near to an NPP in Ukraine (mSv) [5.13].

Source	Group of critical organs(1)		
	1	2	3
Gas and aerosol releases	0.2	0.6	1.2
Radioactive substances in liquid discharges	0.05	0.15	0.30
Heat supply	0.01	-	-

(1) See categories in Table 5.5

According to General Safety Regulations 88 [5.14] in the case of an accident exceeding the maximum design basis accident, the NPP design shall ensure that the following dose limits (at a distance of 25 km from the NPP and in the worst weather categories) are not exceeded.

- External exposure dose for persons during the first year after an accident: less than 0.1 Sv.
- Internal exposure dose for a child's thyroid as a result of inhalation: less than 0.3 Sv.

According to NRA, this can be assured if the accidental release into atmosphere do not exceed 1.11 10^{15} Bq of I-131 and 1.1 10^{14} Bq of Cs-137.

A "buffer" area is established around any NPP where it is conceivable that levels of individual exposure during normal operation of the facility might exceed the stringent dose limit set for such purposes. The regime of dose limitations is established and radiation monitoring is conducted within the buffer area.

5.3.4 Radioactive effluent discharges

For each NPP, the limits of release for airborne and liquid discharges are specified such that the population exposure dose limit of 0.25 mSv/year (see Table 5.7) is not exceeded.

These limits are calculated by a procedure agreed upon by the State Committee on Hydrometeorology (Goskomhydromet) and the State Sanitary Inspectorate within the Ministry of Health Protection.

In the calculation procedure, it is assumed that the population exposure dose limit due to airborne releases does not exceed 0.2 mSv/year and that the population exposure dose limit due to liquid discharges does not exceed 0.05 mSv/year (Table 5.7).

Results of calculation of an NPP's average permissible emissions of radioactive gases and aerosols into the atmosphere are given in regulatory document: SRNPP-88 (Annex 1, Table 1) [5.13] as shown in Table 5.8. A daily value is given for radioactive noble gases, I-131, short-lived radionuclides mixture (Table 5.8 a). In the case of long-lived radionuclides, a more restrictive monthly value is also given (Table 5.8b).

Calculation of an NPP's average permissible liquid discharges depends on the particular conditions, such as river flow or water utilisation, which are specific to each NPP. As a consequence, the calculation is carried out each year by NRA taking into account the amount of water used by each NPP.

Table 5.8
NPP's average permissible emissions [5.13]

a) Daily permissible emissions of radioactive gases and aerosols into the atmosphere

Radionuclides	N = 1000-6000 Megawatt (e) Bq/24h 1000 Megawatt (e)	N>6000 Megawatt (e) Bq/24h for NPP
Radioactive noble gases (any mixture)	$1.85\ 10^{13}$	$1.11\ 10^{14}$
Iodine-131 (gaseous and aerosol phase)	$3.70\ 10^{8}$	$2.22\ 10^{9}$
Long-lived nuclides mixture (LLN)	$5.55\ 10^{8}$	$3.33\ 10^{9}$
Short-lived nuclides mixture (SLN)	$7.40\ 10^{9}$	$4.44\ 10^{10}$

b) Average monthly permissible emissions of radioactive aerosol

Radionuclide	N = 1000-6000 Megawatt (e) Bq/24h 1000 Megawatt (e)	N>6000 Megawatt (e) Bq/24h for NPP
Sr-90	$5.55\ 10^{10}$	$3.33\ 10^{11}$
Sr-89	$5.55\ 10^{11}$	$3.33\ 10^{12}$
Cs-137	$5.55\ 10^{11}$	$3.33\ 10^{12}$
Co-60	$5.55\ 10^{11}$	$3.33\ 10^{12}$
Mn-54	$5.55\ 10^{11}$	$3.33\ 10^{12}$
Cr-51	$5.55\ 10^{11}$	$3.33\ 10^{12}$

Footnote: N = Power capacity for the defined unit(s)

An example calculation is given in Table 5.9. The values of this Table are set using a 1.0 coefficient, corresponding to effective power at KNPP during 1995.

Table 5.9
Calculated maximum permissible release for airborne and liquid effluents for K1 in 1995

Effluent radionuclide	Airborne (Bq/year)
Noble gases	$6.67\ 10^{15}$
Long-lived nuclides	$2.03\ 10^{11}$
I – 131	$1.35\ 10^{11}$
Cr – 51	$6.67\ 10^{9}$
Mn – 54	$6.67\ 10^{9}$
Co – 60	$6.67\ 10^{9}$
Sr – 90	$6.67\ 10^{8}$
Cs – 137	$6.67\ 10^{9}$
Radionuclide	**Liquid (Bq/year)**

Co-60	$1.86\ 10^{6}$
Sr-90	$2.56\ 10^{6}$
Cs-134	$2.2\ 10^{9}$
Cs-137	$8.89\ 10^{7}$

Taking into account its technical options and safety level and in agreement with Goskomhydromet and Goskomsannadzor, each NPP specifies the permissible check release (PCR) that must not exceed 70% of the maximum permissible release. Beyond this percentage, authorities must be informed.

There is currently a lack of requirements concerning the release of tritium into the environment. A new regulation is in preparation that is expected to cover this issue.

5.3.5 Emergency planning preparedness and response

At present, a comprehensive well-structured and well defined legal basis for emergency preparedness and response does not appear to exist in Ukraine, but there are several laws and regulations with special articles dealing with emergency preparedness and response. These include.

- Law on Protection of Environment [5.25].
- Law on the Use of Nuclear Energy and Radiation Safety [5.11].
- Law on Civil Defence [5.28].
- Regulation on creation of the Permanent Governmental Commission for Technogenic Ecological Safety and Emergency Situations [5.29].
- Regulation on creation of the State Committee on Nuclear Power Utilisation (GOSKOMATOM) Enactment of the Cabinet of Ministers of Ukraine 386 [5.30].
- Regulation on Creation of Nuclear Regulatory Administration of the Ministry of Environmental Protection and Nuclear Safety (Ministerial Order 82) [5.31].
- Decision of Cabinet of Ministers of Ukraine number 22 [5.32].

Furthermore, a concept for the development of a unified State system was approved by the Cabinet of Ministers resolution number 501 [5.33].

5.3.5.1 Emergency planning and preparedness

According to the regulations summarised above, the institutions which have responsibilities in emergency planning and preparedness are as follows.

- Department of Normative Regulation and Accident and Emergency Management of the NRA.
- Goskomatom.
- Headquarters of Civil Defence.
- Parliament of Ukraine.

Furthermore a Permanent Governmental Commission for Technogenic Ecological Safety and Emergency Situations exists. The Head of this Commission is a deputy Prime Minister; the most important ministries and administrations are involved in this commission e.g. the Ministry of Health, Transport, Agriculture, Civil Defence and the State Hydrometeorological

Committee (Goskomidromet). On behalf of this Commission, an interministrial group OPAS will be created to assist the NPP in an emergency situation.

5.3.5.2 Emergency declaration and response

NPP site level

The emergency administration of the NPP is responsible for:

- declaring an emergency; and
- all on-site arrangements including emergency preparedness and response at site level.

Regional level

If the emergency exceeds the on-site level, the NPP administration informs the local Civil Defence structures (as well as accident and emergency dispatchers of NRA and Goskomatom), which is responsible for declaring an emergency - in parallel with the Regional and local Commission for Technogenic Ecological Safety and Emergency Situations. The latter is responsible - in co-operation with the local representative of Regional Civil Defence structures - for emergency preparedness and response including enforcement of counter-measures on a regional level.

National level

The Permanent Commission for Technogenic Ecological Safety and Emergency Situations is responsible, in co-operation with National Civil Defence structures for:

- declaring an emergency; and
- enforcing counter-measures.

5.4 <u>Occupational radiological protection</u>

5.4.1 <u>Historical experience</u>

In order to determine whether the plant design and occupational exposure control systems are likely to result in doses meeting the ALARA principle and maintained within regulatory dose limits, the records of similar Ukrainian VVER plants have been considered.

The number of workers receiving doses within defined intervals for 1995 and 1996 are shown in Figure 5.1 and Table 5.10 [5.33] and are understood to have been derived from the KNPP radiation safety report for 1996.

Figure 5.1
Individual exposure dose distribution (mSv/year) for Ukrainian NPPs in 1995

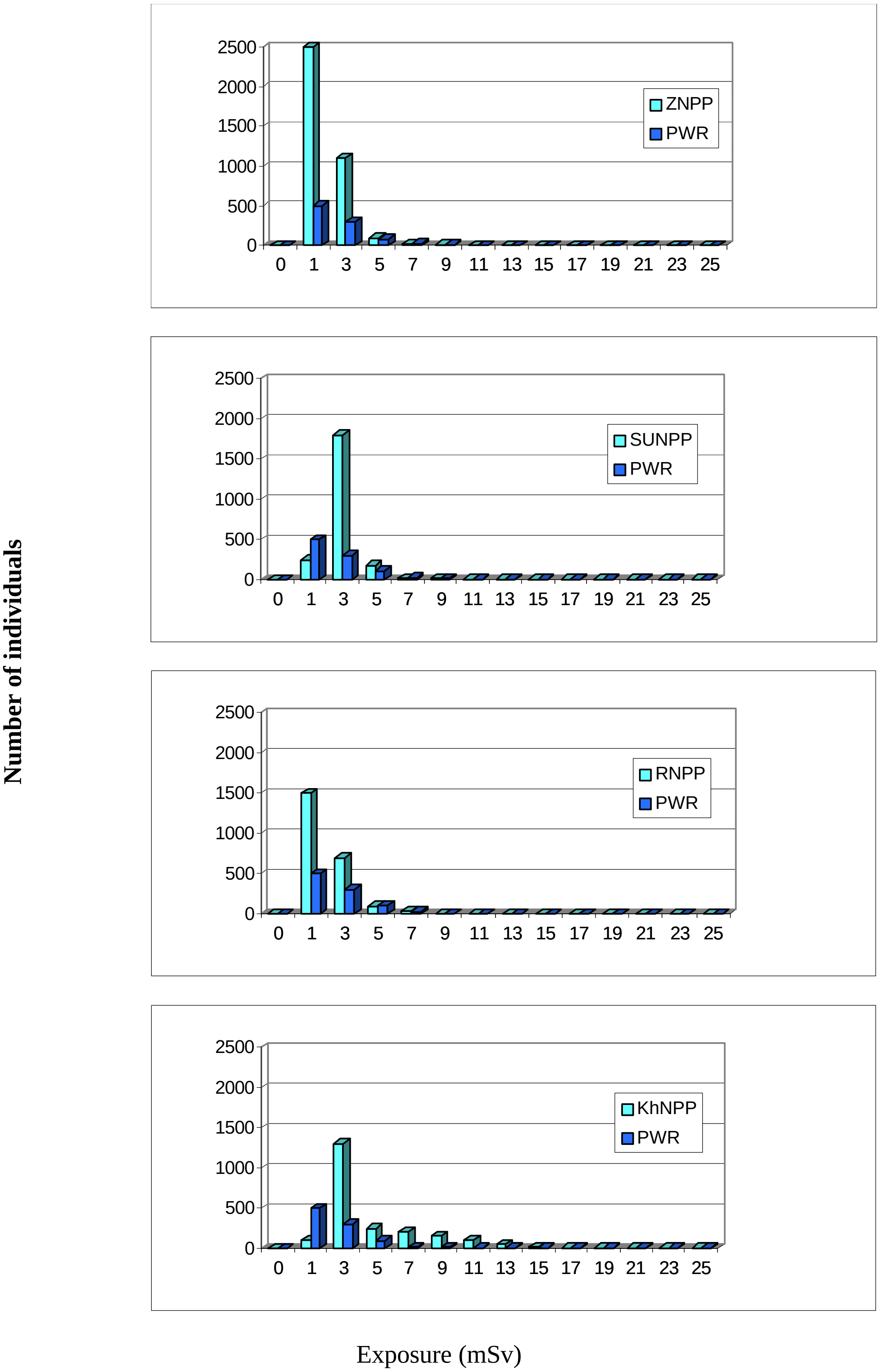

Table 5.10
Individual dose distributions for Ukraine NPPs (a) and for Khmelnitsky NPP (b) in 1996

(a)

Average individual dose (mSv/year)	Collective dose (man.mSv/MWe)
2.22	3.21

(b)

<5 mSv	5 – 15 mSv	15-50 mSv	>50 mSv
1331	105	12	-

These records show that individual annual doses for the large majority of operators at VVER type NPP's do not exceed 20 mSv in any one year.

25% of the mean annual total dose of workers at Ukrainian VVER NPPs is taken by external workers. The equivalent value for western NPPs is higher given the fact they use more external workers than Ukrainian NPPs. Radiological monitoring of external workers is the responsibility of the company which employs them. Though radiological supervision by NPPs appears to be done well, the annual maximum permissible dose, and more generally the workers' radiological background, are under the company's control. It is recommended that a system complying with Council Directive 90/641/EURATOM [5.35] should be set up and supervised by relevant national authorities.

The average annual dose and station collective doses are not very different from those for Western PWRs. For example, the average annual dose for all EDF PWRs during 1995 was 4.34 mSv for external workers and 1.55 for EDF workers. The collective dose for all EDF PWRs was 1.6 man-mSv/MWe [5.36].

5.4.2 Local rules

The local rules concerning radiological protection of workers are defined in the radioprotection instructions, in full compliance with national standard RSS-76/87 [5.16]. They specify the responsibilities of all the staff from the NPP Director and the Chief Engineer to all workers.

The basic goals of these local operating procedures are defined as:

- to maintain radiation exposure, the number of workers exposed to radiation and the probability of unexpected exposures in conformity with the principle of "As Low As Reasonably Achievable" (ALARA principle);
- to keep radiation doses below prescribed limits by fixing local dosimetry goals;
- to keep the impact of release into the environment of radioactive and non-radioactive wastes and effluents ALARA; and
- to ensure a high level of industrial safety.

The commitment to keeping doses ALARA is placed on all senior management. This is in line with recommended practice in IAEA Safety Series No. 103 [5.5], and generally accepted best practices for ensuring the health and safety of NPP staff.

The phases of implementation of the ALARA principle are:

- design and development of technical solutions for:
    - shielding; and
    - ventilation and filtration;

- emergency planning: justification of measures for the protection of workers;

- assembling and testing of plant and facilities:
    - parameters for purification systems;
    - fuel specification and inspection; and
    - control of corrosion in the primary circuit, control of the chemical composition of the coolant and surface treatment of the primary circuit.

Implementation of the ALARA principle for doses to individuals is based on:

- the use of a personal dosimetry database to monitor trends in exposure levels;
- the use of real-time monitoring; and
- the establishment of rules for operation of the radiation work permit system, and the use of the ALARA procedure in pre-planning operations and maintenance.

5.4.3 Classification of workers

Radiation workers or "classified workers" are medically examined for fitness to work in radiation areas once or twice a year, depending on the proportion of their time spent in the controlled area.

Access to the controlled area is limited to workers over 18 years of age. Women cannot enter the controlled area if they are pregnant or have given birth in the previous nine months.

These arrangements for classifying workers as fit for work with radiation are more stringent than those required by Euratom Directive 80/836 and 84/836 [5.9].

5.4.4 Training

Senior personnel in the dosimetry section have professional qualifications in radiation protection obtained by six months theoretical training and six months practical experience at a nuclear plant.

All personnel working in controlled areas must undergo training in the rules of the controlled area. This training is repeated at least once a year.

5.4.5 Personal dosimetry

Regulatory requirements with regard to the compulsory wearing of personal dosimeters are defined in BSS-72/87 [5.17]. For those working under such conditions, the total external and internal exposure can exceed 6 mSv/year, individual dose control is compulsory. If working conditions do not exceed this value, individual dose control is not compulsory. Exposure in this case is assessed on the basis of monitoring data on the external exposure dose rate and radionuclide concentration in the air of the working area.

5.4.5.1 External dose

External dose control of personnel is carried out using various types of personal dosimeters (including thermoluminescent dosimeters).

Some dosimeters are designed for routine daily monitoring, mainly used by shift personnel but also when performing maintenance work. They are read by dosimetry personnel using a localised readout instrument. Others are used for accounting of dose monitoring (monthly or once in three months).

Personal dosimeters are assigned to each worker and are stored in special cupboards at special controlled area points. Dosimeters are read and recorded in the personal dose control laboratory located in the special purpose building of the NPP.

5.4.5.2 Internal dose from intakes

According to item 15.1 of SPAS-88 [5.23] document, persons involved with specifically hazardous activities at NPPs must pass a pre-shift medical examination. Also, they are subject to periodic examination by a psychiatrist.

The monitoring of internal exposure of NPP employees is performed periodically by the on-site health service with the use of measurement devices or calculation methods.

Although intake of radionuclides by inhalation is theoretically possible, it is considered unlikely. Nevertheless, arrangements exist at K2 to allow the assessment of these intake routes both routinely and following a suspected incident.

Hands and working clothes are monitored for signs of contamination and in case of doubt, a whole body count is made for meeting the radiation safety standards.

Gamma emitting radionuclides within the body are monitored through the use of various types of spectrometers to obtain a whole body count.

All detection devices are tested periodically by the use of phantoms (of lungs and the whole body) and are calibrated annually by the Centre for Standardisation and Metrology (located in the town of Bila Tserkva).

Each individual who wishes to enter laboratories or zones in the controlled area is required to check their work authorisation. Monitoring is carried out at these control points for entry or leaving laboratories and zones of the controlled area.

Personnel operating under normal conditions (i.e. non category A personnel) have a medical examination once every two years.

5.4.5.3 Dose record-keeping

The KNPP has a personal dosimetry record-keeping system on the internal computer network developed by the NPP Individual Dosimetry Laboratory.

The database provides both internal and external doses for all workers of the NPP. The records are automatically filled out from the personal dosimeter readers and internal dose assessment devices. Information provided from whole body counters and urine analysis is manually entered into the database.

The dose limits in the database are set at the levels recommended in ICRP 60. An internal investigation will be triggered when the annual dose exceeds a value above the 20 mSv limit. For K2, this local triggering limit has not yet been defined however, the corresponding limit for Khmelnitsky NPP unit 1 is about 15 mSv/year. The latter is lower than the limit of 20 mSv implied by ICRP 60.

5.4.6 Implementation of occupational dose control

The radiation work permit forms a major part of dose control in normal operation and at shutdown or refuelling. Only the personnel approved by the Head of the Health Department may issue radiation work permits.

Use of the radiation work permit for all work involving significant exposure clearly defines responsibilities and protective measures and provides an auditable system for investigating any abnormal exposure.

The radiation work permit contains:

- working task definition:
    - task definition and description of work;
    - estimated duration;
    - permit number, date, location, system involved, department;
    - number of workers, the number of the operation in the maintenance scheme; and
    - maximal permissible dose and estimated dose.

- radiation protection measures:
    - protective clothing requirements;
    - specific dosimetric equipment requirement if necessary;
    - specific protection requirements: working location with shielding wall, for example; and
    - name of each worker, individual dosimeter number.

The work permit is applied for by the department in charge of the work involved and signed by the relevant manager. It is then submitted to the dosimetry department, which evaluates the radiological situation in the working place, and predicts the doses likely to be received by workers. This department also provides requirements for radiological protection and dosimetry control.

After approval by the dosimetry department, the work permit is submitted to the Chief Engineer of the plant for final approval.

At the end of the work, the work permit is completed with remarks about execution of the work, signed again by the manager responsible for the work involved, then submitted to the dosimetry department, which assesses the actual work duration and doses with regard to predictions.

5.4.7 Control of access

The control of access when entering restricted areas is carried out as follows.

- Access is permitted to radiation workers only via a change room where workers take off their personal clothes.
- Workers then enter the second section of the change room via a one-way turnstile gate.
- In that second section, they:
  - put on special clothes;
  - receive individual protection devices; and
  - receive their work permits.

- In that section they are monitored for external contamination before they can reach their working area.

The control of access when exiting is carried out as follows.

- Workers enter the dirty section of the sanitary zone, where they take off their "dirty clothes".
- There they are monitored for external contamination via a special monitoring gate that prevents exit if the contamination limit is exceeded.
- If the contamination limit is exceeded, special personnel carry out more monitoring with portable devices for the identification of the specific location of contamination. After that, decontamination can either be carried out there (using showers) or, if necessary, the worker is taken to a special decontamination room.
- If not contaminated, the workers pass the monitoring gate and enter the clean section of the sanitary zone where they put on their personal clothes and exit the controlled area.

5.4.8 Dosimetry control room

In addition to the main control room for reactor operations, a dosimetry control room is located in the effluent treatment building. This control room is equipped with a data processing system to assess the radiological situation of the main rooms of the NPP site.

5.4.9 Shielding

The purpose of shielding in NPPs is to reduce neutron and gamma radiation fluxes to levels that ensure that dose rates conform to set standards. Radiation shielding is designed not only to protect the workforce but also to reduce irradiation and radiation-induced heating of structural and shielding materials to acceptable levels. Three types of concrete are used for shielding purposes in VVERs: ordinary (or heavy), superheavy and serpentinite. Ordinary concrete accounts for 95% of the concrete inventory in the VVER-1000.

5.5 Environmental radiation monitoring

5.5.1 Environmental radiation monitoring system (ERM)

Radiological monitoring of the 30 km area around the plant is carried out on the basis of measurements of regular samples, by a system entitled "Environmental Radiation Monitoring System (ERM)". The aim of this system is the acquisition of information on the radiation situation over the NPP location and exposure of the population, as well as the forecasting of the radiation situation over the area, under all NPP's operation conditions.

ERM includes:

- monitoring of barriers aimed at protecting against radionuclide releases to the atmosphere; and
- monitoring of the radiation situation throughout the area.

An NPP's radioactive releases and effluent data are the reporting parameters for supervisory bodies of the NPP and the initial data for forecasting the NPP's environmental impact. They characterise the condition of operation of an NPP's process equipment, operating, efficiency of equipment, and any malfunctions.

Radiation conditions are monitored at the unit, plantwide, and in the 30 km zone.

The unit level includes monitoring of:

- activity of gaseous and aerosol releases to the atmosphere through ventilation ducts;
- activity of discharges with service water;
- activity of discharges with circulation water; and
- activity of discharges with waste water.

Plantwide level monitoring includes:

- activity of discharges with all plant waste water; and
- activity of discharges with industrial and rainfall effluent.

Monitoring at the 30 km level includes monitoring of all environment components and monitoring of the gamma background over the area.

The following are monitored:

- atmospheric precipitation;
- concentration of radioactive aerosol in the lower atmosphere;
- gamma-background radiation over the area;
- radioactivity of water and sediments (rivers, lakes);
- radioactivity of soils and vegetation; and
- radioactivity of agricultural products and foodstuffs.

Monitoring is undertaken by the laboratory of external radiation control which is a structural division of the department of radiation safety of KNPP. The laboratory consists of three groups dealing with sampling, sample preparation and radiochemistry, and radiometric measurements.

As noted in Section 3, tritium has been measured in both surface and ground water samples for the last two years.

5.5.2 Automatic radiation situation control system (ASKRO)

At present an automatic radiation situation control systems (ASKRO) is planned at KNPP. The main components of this system include:

- automatic sampling;
- fast detection of accidental radioactive releases;
- determination of release rate and prediction of radiation situation over surroundings under prevailing weather conditions;
- preparation of recommendations for decision-making by officials; and
- collection of data for public information.

When achieved, this system would also be used as an on-line system for radiological monitoring of the 30 km zone when the NPP is operating normally.

ASKRO foresees control posts up to the site limits as well as control posts off-site (maximal distance from the NPP is 16 km).

Control posts at the site are aimed to control:

- the release of activity to atmosphere through vent stacks (e.g. inert radioactive gases, iodine, β-emitting aerosols, tritium);
- dose rates on site;
- site discharge line activities (to the reservoir, including tritium monitoring); and
- dose rate, inert radioactive gas, β-emitting aerosols.

Control posts at the NPP location area (up to 16 km) aim to control dose rate, inert radioactive gases, β-emitting aerosols).

Information from the control posts would be collected, processed and stored at the Central Control Post (CCP) which would be located at the edge of the sanitary 3 km zone. Meteorological parameters controlled by means of sodar set would also be performed at the CCP. This information would then be made available to the NPP administration and the radiation safety department.
In addition to ASKRO, possible systems to be provided by Euratom will need to be taken into account.

5.6 Emergency planning

5.6.1 Background

The design and operation of nuclear power plants ensures that the risk of an accident resulting in significant radiation exposure of workers and members of the public is very small. Nevertheless, it is still necessary to have suitable emergency arrangements for any level of accident. It is standard practice elsewhere to ensure that a suitable emergency plan is a prerequisite for licensing plant operation.

The Euratom Directive on protection from ionising radiation [5.9] incorporates a specific requirement on all users of ionising radiation to produce suitable emergency plans. In addition, there is a requirement for information on radiation emergencies to be given to the public who might be affected by an accident or incident.

There are also a number of IAEA recommendations on emergency planning of a more general nature that represent good practice. IAEA regulations on the transport of radioactive material [5.3] also require emergency plans should be developed and make detailed recommendations on the contents of such plans.

Basic standards for radiological protection which are based on the recommendations of the ICRP include principles for planning and for intervention to protect the public in the event of major radiation accidents.

Emergency planning at nuclear power plants in Ukraine is a requirement of Ukrainian legislation (Section 5.3.4.1). The management of the nuclear power plant is responsible for the preparation of emergency planning arrangements for the protection of on site personnel and to bring the plant under control. They must also provide for initial notification of and continuing supply of information to the CDA, who are responsible for carrying out measures to protect the public (off-site emergency plans).

Ukrainian regulations prescribe that an internal emergency plan (the on-site emergency plan) must be in place before fuel is loaded into the reactor. An external emergency plan (the off-site emergency plan), co-ordinated by the CDA and approved by the Head of the Civil Defence of Khmelnitsky region, must be in place before a nuclear plant goes into operation.

5.6.2 On-site emergency plan

The site emergency plan describes the overall emergency planning arrangements in terms of the Khmelnitsky site management response to emergency situations, including both on-site and off-site incidents. It covers:

- responsibilities for preparing the plan and overall responsibilities for protection of workers;
- external bodies and organisations involved in the emergency plan;
- methods and procedures for notification and warning;
- on-site countermeasures;
- key functional responsibilities;
- personnel involved in implementing the plan;
- training; and
- exercises.

Detailed implementation of the site emergency plan is defined in emergency planning procedures and instructions.

In addition to specifying the arrangements for on-site countermeasures and incident management, the site emergency plan describes the off-site responsibilities of the nuclear power plant i.e. operation of the off-site assessment centre (OFAC) relevant located at Khmelnitsky.

The response to an emergency or other incident will be controlled from two centres:

- the on-site emergency control centre (on-site ECC); and
- the off-site emergency control centre (off-site ECC).

The main role of the on-site ECC is to manage on-site operations to protect personnel and to mitigate the effects of an accident. It has been established in shelter No.l, below the main administration building. This shelter is provided with shielding and filtered air supply, and with a diesel-generator to provide energy.

Where accidents are likely to result in significant off-site release, the off-site ECC will be set up at Khmelnitsky. This off-site ECC is fully responsible for emergency activities. This main task is to co-ordinate implementation of counter-measures in emergency situations.

The construction of a second on-site ECC, as required by NRA, will form part of the K2 project. This second on-site ECC will be located at the edge of the 3 km sanitary zone and will have the same functions as the on-site ECC located in shelter No. 1.

5.6.2.1 Responsibilities

The site emergency plan defines the responsibilities of the following key posts with respect to emergency planning.

- Plant Director.
- Chief Engineer.
- Head of Nuclear Safety Department.
- Head of Emergency Situation Department.

In addition, the plan defines the specific responsibilities of senior managers with respect to protection of on-site staff and workers from other emergency response organisations who may come on site.

5.6.2.2 External organisations - communications

Implementation of the site emergency plan involves external organisations and bodies, which have been consulted in the preparation of the plan. These bodies are as follows:

- Ukrainian government.
- NRA.
- Headquarters of CDA in Khmelnitsky.
- Representative of CDA in Netishin.
- District Commission for Technogenic Ecological Safety and Emergency Situations.
- Hospitals and First Aid Centres.

The communication between KNPP and the above-mentioned organisations is mainly based on the public telephone network whose reliability and availability are not satisfactory in comparison with West European standards.

The on-site ECC is equipped with the following dedicated communications for contacting the above organisations:

- dedicated telephone lines (both fax and telephones) for connection with CDA only;
- teletype; and
- radio transmitters for connection with CDA.

The centre also has a network of 40 specific telephone lines that are independent of the NPP's normal network, allowing communication with strategic points of the plant in the event of failure of the normal network.

5.6.2.3 Notification and warning procedures

There are four levels of emergency:

1. Unusual Occurrence - an occurrence with the potential for degrading safety levels. (No release of radioactive materials requiring an off-site response is anticipated.)
2. Alert - an event involving either actual or potential significant degradation of safety levels. (No release of radioactive materials requiring an off-site response is anticipated.)
3. On-site Emergency - an event involving actual or likely major failure of operational system, potentially requiring public protection measures (implementation of relevant countermeasures as described in Section 5.6.2.4)
4. Off-site emergency - an event involving actual or imminent degradation of the reactor core (implementation of relevant countermeasures as described in Section 5.6.5.3)

The initial assessment of the level of emergency is made by the Shift Supervisor but must be kept under constant review with the Chief Engineer and the Director of the NPP, and may be changed. An algorithm has been defined that shows the decision path to classify the level of the emergency.

Notification and warning of on-site personnel and others in the immediate area including the town of Netishin is carried out by means of telephone, loudspeakers and sirens.

The emergency plan describes the arrangements for maintenance and testing of the sirens.

5.6.2.4 On-site countermeasures

The main countermeasures for workers on site are as follows:

- The use of shelters with shielding and filtered ventilation. It is a statutory Civil Defence requirement that shielded shelters with filtered air supplies are provided for all personnel on-site during normal operation. This ensures the initial safety of all personnel.
- The use of respiratory protection and protective clothing when necessary, and protection against intake of radioactive substances.
- Evacuation of non-essential personnel.

In the case of an on-site emergency, evacuation will be to individuals' homes after exit monitoring. In the event of an off-site emergency, evacuation of site personnel will be to the relevant reception centre defined in the off-site emergency plan.

Sheltering

The NPP is presently equipped with two personnel shelters that can accommodate 1,100 and 165 persons, respectively. Radiological protection is ensured by the walls of these shelters and by a radiological filtration system. The shelters are equipped with:

- water supply and 5 days food supply;
- oxygen-generating capsules allowing personnel sheltering (in isolation mode) to survive for several tens of hours, if necessary;
- facilities for decontamination of personnel entering them (showers, decontaminating soap, surface contamination measuring equipment);
- a medical unit (provided with equipment transferred from the medical block if required); and
- a diesel generator set capable of keeping the shelter supplied with electricity for four days.

When unit 2 is in operation, the plant personnel will consist of 2,340 people. Although the accommodation capacity of shelter No. 1 could be temporarily expanded, construction of a second 900-place shelter with characteristics similar to the existing shelters is currently under study as part of the K2 completion project. This shelter will need to be fully operational when unit 2 is commissioned.

Protection against intake of radioactive substances

Other countermeasures exist when intake of radioactive substances may have occurred including iodine tablets to reduce uptake of radioactive iodine by thyroid blocking.

The plant currently has a stock of iodine tablets available at all work stations and allowing for 10 tablets per person per day. It also has an additional 10 day stock available at the plant medical centre. Each tablet contains 0.25g of potassium iodine. If preventive iodine treatment is necessary, the potassium iodine is taken once every 24 hours during 10 days.

Evacuation

If necessary, personnel would be evacuated in buses belonging to the NPP. There are currently 26 buses and their availability is ensured as they run every day to provide transport for the plant personnel.

The duration of an evacuation of all NPP staff in case of emergency has not been calculated. However, in comparison with Rivne NPP staff evacuation, it can be assumed that the duration of this kind of operation in KNPP would not exceed one hour.

5.6.2.5 Key functional responsibilities

There is a detailed description specified in the site emergency plan of key functional responsibilities on site associated with different levels of emergency. Initially, the Shift Supervisor is in overall control of the entire response. For more severe accidents, the Shift Supervisor retains overall responsibility for plant operations but responsibility for other arrangements devolves to the ECC Director.

The key personnel involved at each level of emergency are defined as follows.

- Unusual occurrence: Shift Supervisor and shift personnel.
- Alert: Shift Supervisor and shift personnel, communication department, ECC on standby.
- on-site emergency: Shift Supervisor, on-site ECC, off-site ECC, CDA and NRA.
- off-site emergency: Shift Supervisor, on-site ECC, off -site ECC, CDA, NRA and Government.

Emergency response personnel will be alerted by telephone and, in some circumstances, by radio. Check lists are used for all major actions to be carried out by emergency response personnel.

5.6.2.6 Training

The plant has an on-site Training Centre which has the full status of a Department, under an assistant to the Chief Engineer with responsibility for personnel training.

The training provided is both theoretical and practical and concerns all the operational personnel at the plant. These persons benefit from specific training once every three weeks and specific training in the implementation of emergency plans once every three months.

An annual training course on Civil Defence is also given at the plant.

The plant's specific organisations that are governed by an authority other than the plant itself (fire service, medical personnel) are also put through a specific continuous training cycle with a timetable that depends on the relevant supervisory authorities.

The following points are covered:

- informing and collecting of emergency works management centre and heads of departments in working and non-working hours;
- informing the personnel, shelter in special building, evacuation from the NPP;
- use of individual protection means;
- calculation of size of contaminated territory, level of acceptable contamination;
- reconnaissance actions; and
- emergency group actions on migration and localisation of accident consequences.

A description of training programs and responsibilities is given in Table 5.11.

Table 5.11
Emergency training and responsibilities [5.34]

Type of training	Persons to be trained	Responsible for the training	Periodicity	Who keeps protocol of the training

Theoretical and Practical training at KHNPP: • all staff • NPP's Administration and special Emergency Departments and Groups at Civil Defence courses	1. NPP's administration, heads of departments and sections - 15 hours 2. Special emergency groups and departments staff - 15 hours 3. Other KhNPP staff - 12 hours	1.For NPP's administration Director 2. For the heads of departments and groups - Chief Engineer 3. For section and department staff – their heads	Every year from January to July according to the plans	KhNPP Department of Emergency Situation

5.6.2.7 Exercises

Exercises of the emergency procedures will take place on a regular basis. Table 5.12 shows the type and frequency of emergency exercises to be undertaken by specific personnel. The main areas covered in exercises are warning and notification, fire fighting, radiation monitoring and personnel evacuation.

Table 5.12
Purpose and frequency of exercises in emergency procedures [5.34]

Purpose of exercise	Personnel involved	Frequency
Communication	Workers in charge of notification	Monthly
Fire fighting	On-site fire brigade	Monthly
Emergency situation response	Emergency Situation Department personnel	Quarterly
Medical	Rescue and first aid teams	-

It is a condition of the operational license for a nuclear plant that representatives from the NRA and Health Authorities should be invited as observers to emergency exercises on an annual basis. A formal exercise of the on-site emergency plan is required before fuelling of any reactor unit.

Large-scale exercises are conducted every three years. These exercises involve both the plant personnel and the neighbouring population in the context of a simulated external emergency plan.

5.6.3 <u>Monitoring equipment</u>

The monitoring systems for emergencies fall into five main categories:

- technical radiation monitoring at the plant to detect failures leading to the release of activity;
- specific plant parameters;
- off-site environmental monitoring;
- district monitoring; and
- nationwide monitoring.

In addition, meteorological data will be provided from nearby meteorological stations as identified in Section 5.6.3.6.

5.6.3.1 Technical radiation monitoring

Radioactivity levels in primary, secondary and intermediate cooling systems are continuously monitored to detect leakage.

Final discharged activities are also monitored by the ERM subsystem to detect possible increases in discharge levels. External dose rates, airborne particulate levels and noble gas activities are monitored in a number of areas of the plant, including the containment zone, which is normally unoccupied during operation.

5.6.3.2 Specific plant parameters

In addition to technical data on the plant itself, the temperature and pressure in the containment zone are monitored and relayed to the on-site ECC. The on-site ECC is occupied on a shift basis by the Safety Engineer, who provides technical backup to the Shift Supervisor under normal operation.

5.6.3.3 Off-site environmental monitoring

The plant's specialised services can assess the radiological situation around the plant on the basis of the following:

- calculations made on the activity levels of radionuclides discharged during an accident; and
- results of measurements carried out by the radiological monitoring department (measurements conducted using portable devices and the ERM system).

An on-line environmental radiation monitoring system is also foreseen (Section 5.5). This system (ASKRO) would carry out on-line radiological monitoring in the 30 km zone. It would transmit the results of measurements to a CCP located at the edge of the sanitary 3 km zone. From here, all ASKRO information would be available for:

- the existing on-site ECC (located in shelter No.1);
- the NPP Administration and Radiation Safety Department;
- the future 2nd on-site ECC (to be built in the same building as the one that will house the CCP); and
- the off-site ECC relevant to CDA.

Another system for control of the radiological situation in the 30 km zone of two other Ukrainian NPPs, called Gamma-l, already exists. This system is under the control of the Ministry of Environmental Protection and Nuclear Safety of Ukraine. It has been sponsored by the European Commission, and is partially in operation in Rivne and Zaporizhzha NPP 30 km zones. It consists of 47 gamma dose rate stations, one alpha and beta aerosol station, and two gamma aqueous measurement stations for both plants. There is currently no link between the Gamma-1 system and the NPP emergency control centre.

5.6.3.4 District monitoring

In the event of an emergency, an off-site monitoring team will be requested by the NPP to carry out monitoring around the plant. This team is responsible for providing information about the best way to evacuate the population in the 30 km zone.

The monitoring team is provided by CDA under the control of the regional authorities. It is equipped with vehicles suitable for use as mobile laboratories. These communicate the results of their monitoring to the civil authorities and to the NPP management directly by radio.

5.6.3.5 National monitoring

The nationwide non-automatic radiological monitoring system consists of 173 measurement stations. All these stations are equipped with gamma dose rate measurement devices, the essential part of them with devices for collecting deposited aerosols, and a few with filter-ventilation sets for the sampling of aerosols. The nationwide early warning system is operated on the basis of manual measurements in a daily working mode, but this daily mode could change to a short-term operating mode if the local average gamma ground level exceeded a given threshold.

5.6.3.6 Meteorological data

Three meteorological stations of the Ukrainian State Committee for Hydrometeorology are situated 40 to 50 km from the NPP site (Section 3), territorially making up an equilateral triangle with the NPP site in the centre.

These meteorological stations provide information on wind direction, wind speed, weather category, rainfall and depth of mixing layer in the event of an emergency. Such information would be supplemented by that which is intended to be provided by the ASKRO System (Section 5.5.2).

5.6.4 Emergency dose limits

Action levels for the implementation of countermeasures to protect members of the public are based on ICRP recommendations (Table 5.13). Table 5.14. shows the upper and lower dose intervention levels for the main countermeasures at the early stage of an accident.

Table 5.13
Intervention levels for doses to members of the public [5.38]

Countermeasure	Dose equivalent (mSv)	
	Whole body	Single organ preferentially irradiated
Sheltering and stable iodine administration:		
Upper dose level	50	500
Lower dose level	5	50
Evacuation:		
Upper dose level	500	5000
Lower dose level	50	50

Table 5.14
Intervention levels for doses to members of the public in Ukrainian legislation [5.34]

Countermeasure	Dose equivalent (mSv)

	Whole body	**Single organ preferentially irradiated**
Preventive iodine treatment:		
Adults:		
Upper dose level	-	500(1)
Lower dose level	-	50(1)
Children, pregnant women:		
Upper dose level	-	250(1)
Lower dose level	-	50(1)
Protection of respiratory organs and integument:		
Upper dose level	50	500
Lower dose level	5	50
Restrictions on the consumption of contaminated food products and drinking water:		
Upper dose level	50	500
Lower dose level	5	50
Resettlement or evacuation:		
Adults:		
Upper dose level	500	5000
Lower dose level	50	500
Children, pregnant women:		
Upper dose level	50	500
Lower dose level	10	200

(1) Thyroid only

The introduction of countermeasures is likely to be always justified above the upper intervention level and, according to circumstances, will often be justifiable at lower doses down to the lower intervention level, in accordance with ICRP recommendations and western standards.

The national authority is the only relevant authority to order implementation of countermeasures and it does so according to its knowledge of the situation in comparison with the thresholds shown in Table 5.14.

5.6.5 Off-site emergency plan

The off-site emergency plan describes the overall emergency planning arrangements in terms of the CDA's response to emergency situations. It covers:

- responsibilities for preparing the plan and overall responsibilities for protection of members of the public;
- bodies and organisations involved in the emergency plan;
- methods and procedures for notification and warning;
- off-site countermeasures;
- key functional responsibilities;
- personnel involved in implementing the plan;
- training; and
- exercises.

Detailed implementation of the off-site emergency plan is defined in the emergency planning procedures and instructions.

5.6.5.1 External organisations

Implementation of the site emergency plan involves organisations and bodies which have been consulted in the preparation of the plan, Section 5.6.2.2.

5.6.5.2 Notification and warning procedure

The initial assessment is made by the NPP management but must be kept under constant review with the authority responsible for the off-site emergency plans, and may be changed.

Notification to the main population centres around the NPP site is by sirens and radio information by the authority responsible for implementation of the off-site emergency plan.

Sirens are installed in local communities up to a radius of 30 km from the plant. These can be actuated from a central location, either individually or in groups, in order to notify and warn local residents.

5.6.5.3 Off-site countermeasures

The main countermeasures for the public are:

- protection of respiratory organs and integument;
- preventive iodine treatment;
- restriction of consumption of food products and drinking water; and
- evacuation.

Protection of respiratory organs, shelter

The town of Netishin, located in the immediate vicinity of the plant and the place of residence of most of the plant workers, is equipped with emergency shelters able to accommodate the whole population for several days. These shelters are provided with significant radiological protection facilities and with radiological ventilation systems. They are also equipped with sanitary facilities and several days' drinking water reserves.

For neighbouring populations within a wider radius, steps for sheltering and the protection of respiratory organs and skin will be announced by CDA.

Protection against intake of radioactive substances

CDA has several days' stock of iodine tablets for the whole population of Netishin, and the population has already been issued with iodine tablets on a preventive basis.

As for the population within a wider radius, CDA is in charge of the management of the stock of iodine tablets required for public protection.

Evacuation

Evacuation of the population within the 30 km zone is the responsibility of the CDA which can requisition all available means: buses, trucks, trains and, if necessary, facilities belonging to the army.

Two towns, Gritsiv and Biloghirya, located at distances of 60 and 40 km from the plant, have been chosen as reception points for the area's inhabitants in case of evacuation and, therefore, have the capacity to provide temporary accommodation for evacuated people. For evacuation, eight routes are available crossing the 30 km zone from the central point of the plant.

5.6.5.4 Key functional responsibilities

The local or regional Commissions for Emergency Situations are responsible for declaring an emergency and for enforcing countermeasures with Civil Defence structures.

5.6.5.5 Exercises

Major exercises on implementation of off-site emergency plans are carried out every three years. They involve a great part of the population of Netishin and part of the NPP staff.

The purpose of these exercises is to check on capabilities for:

- warning populations and giving notification of emergency plans;
- sheltering populations;
- evacuating populations; and
- distributing iodine tablets and food, etc.

The last exercise of such a type was conducted in 1995, and involved 20% of the staff of the Emergency Situation Department of the NPP and 1500 people among the population of Netishin.

The purpose of the exercise was to test the evacuation of the population of Netishin. No major problem was recorded during the exercise.

Apart from this dedicated exercise, all major Ukrainian companies and manufacturers also organise special exercises once a year for the implementation of specific measures against industrial accidents including radiological accidents. This can greatly reinforce the efficiency of forces involved in the management of emergency situations.

5.6.6 <u>Evaluation of off-site exposures</u>

The forecasting of off-site exposure in the case of an accident resulting in off-site radioactive releases is carried out through manual calculation and to a certain extent by NPP experts with the help of dedicated local software.

On a wider scale, there is no national computer system used to process radiological and meteorological data, and able to carry out prediction of atmospheric dispersion, dose estimates, and to provide decision-support in the case of an accident.

Ukraine plans to develop a modern forecasting and decision-support system, but because of the lack of financial resources, this project is delayed.

Installation of a comprehensive data handling and decision-support system is currently being undertaken with the assistance of the European Union (RODOS project). This system will meet requirements of western standards and practices.

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