
Regulatory Guide

Radiation Protection for Nuclear Power Plants (FANR-RG-033)

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Basic Principle of Regulatory Guides

Regulatory guides are issued to describe methods and/ or criteria acceptable to the Federal Authority for Nuclear Regulation (FANR) for meeting and implementing specific requirements in FANR's regulations. Regulatory guides are not substitutes for regulations and compliance with them is not required. Methods of complying with the requirements in regulations different from the guidance set forth by regulatory guides can be acceptable if the alternatives provide assurance that the requirements in the regulations are met.

Definitions

Article (1)

For the purpose of this regulatory guide, the following terms shall have the meaning set forth below. Other capitalised terms used but not defined herein shall have the meaning ascribed to them in Article 1 of the Federal Law by Decree No 6 of 2009, Concerning the Peaceful Uses of Nuclear Energy, in Article 1 of FANR Regulation for Radiation Dose Limits and Optimisation of Radiation Protection for Nuclear Facilities (FANR-REG-04), and Article 1 of FANR Regulation for Radiation Protection and Predisposal Radioactive Waste Management in Nuclear Facilities (FANR-REG-11).

Accreditation	Third-party attestation issued by an authoritative body that performs Accreditation (for example Emirates National Accreditation System (ENAS) in the UAE), related to a conformity assessment body (e.g. laboratories), conveying formal demonstration of its competence to carry out specific conformity assessment tasks.
Anticipated Operational Occurrences	An operational process deviating from Normal Operation, which is expected to occur at least once during the operating lifetime of a Nuclear Facility but in view of appropriate Design provisions does not cause any significant damage to items important to Safety or lead to Accident Conditions.
Investigation Level	The value of a quantity such as the Effective Dose, intake or contamination per unit area or volume at or above which an investigation should be conducted.
Normal Operation	Operation within specified operational limits and conditions. For a Nuclear Power Plant this includes start-up, power Operation (including low power), shutting down and shutdown, Maintenance, testing and re-fuelling.

- Nuclear Power Plant** An electricity generating facility using a Nuclear Reactor as its heat source to provide steam to a turbine generator.
- Radiation Generator** A device capable of generating Ionising Radiation such as X-rays, neutrons, electrons or other charged particles that may be used for scientific, industrial or medical purposes.
- Supervised Area** A defined area not already designated as a Controlled Area but where occupational exposure conditions need to be kept under review even though specific protective measures and Safety provisions are not normally needed.

Purpose

Article (2)

1. The purpose of this regulatory guide is to provide guidance to FANR's Licensees who conduct Regulated Activities involving Ionising Radiation during the Commissioning with Nuclear Fuel present, Operation and Decommissioning of a Nuclear Power Plant. This regulatory guide complements the following FANR regulations:
 - a) FANR Regulation for Radiation Dose Limits and Optimisation of Radiation Protection for Nuclear Facilities (FANR-REG-04).
 - b) FANR Regulation for Radiation Protection and Predisposal Radioactive Waste Management in Nuclear Facilities (FANR-REG-11).
 - c) FANR Regulation for Emergency Preparedness for Nuclear Facilities (FANR-REG-12).
 - d) FANR Regulation for Requirements for Off-site Emergency Plans for Nuclear Facilities (FANR-REG-15).
2. This regulatory guide addresses the following requirements in FANR's regulations:
 - a) The Optimisation of Radiation Protection for Workers and the public in Articles (5) and (6) of FANR-REG-04.
 - b) The development of a Radiation Protection Programme in accordance with Articles (3) to (13) of FANR-REG-11.
 - c) Recording and reporting of Occupational Exposure data consistent with the requirements of Article (12) of FANR-REG-11, and the establishment of a register of occupational Doses as per Article (5) of Federal Law by Decree No 6 of 2009, Concerning the Peaceful Uses of Nuclear Energy.

- d) Radiation Protection training in accordance with Article (25) of FANR-REG-11.
 - e) Monitoring to determine the existence and extent of any abnormal radiation levels as a result of an Accident in accordance with Article (10) of FANR-REG-12.
3. The following documents [the revisions are the most current as of date of this regulatory guide where a date has not been provided] serve as the primary sources for this regulatory guide:
- a) US Nuclear Regulatory Commission, Title 10, Code of Federal Regulations, Part 20 - Standards for Protection Against Radiation.
 - b) IAEA Safety Standards, General Safety Guide, No. GSG-7, Occupational Radiation Protection, 2018.
 - c) US Nuclear Regulatory Commission, Regulatory Guide 8.2, Administrative Practices in Radiation Surveys and Monitoring, 2011.
 - d) US Nuclear Regulatory Commission, Regulatory Guide 8.8, Information relevant to ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is reasonably achievable, 1978.
 - e) US Nuclear Regulatory Commission, Regulatory Guide 8.15, Acceptable Programs for Respiratory Protection, 1976.
 - f) US Nuclear Regulatory Commission, Regulatory Guide 8.27, Radiation Protection Training for Personnel at Light-Water-Cooled Nuclear Power Plants, 1981.
 - g) US Nuclear Regulatory Commission, NEI 07-08A, Generic FSAR Template Guidance for ensuring that Occupational Radiation Exposures are as Low as is Reasonably Achievable (ALARA), 2009.

Radiation Protection Programme

Article (3)

1. All Licensees must develop, document and implement a Radiation Protection Programme commensurate with the scope and extent of licensed activities, and sufficient to ensure compliance with applicable FANR regulations. The general objective of a Radiation Protection Programme is to ensure that the responsibility for Radiation Protection and Safety is documented in the Licensee's Management System, policies, procedures and organisational arrangements commensurate with the nature and extent of the risks.
2. The Licensee should use to the extent practical procedures and engineering controls to ensure occupational Doses and Doses to members of the public are justified and Optimised.

3. The radiological evaluation should include the following in all aspects of Operation:
 - a) The sources of routine Exposure and reasonably foreseeable potential Exposure such as surface contamination, airborne contamination and sources of external Ionising Radiation.
 - b) The nature and magnitude of Exposures in Normal Operation.
 - c) The nature, likelihood and magnitude of potential Exposures. This should include the ways in which structures, systems and components, and procedures relating to Radiation Protection or Safety might fail singly or in combination with something else, or otherwise lead to potential Exposures, and the consequences of such failures.
 - d) The measures for Radiation Protection and Safety that are necessary to implement the Optimisation process.
 - e) Appropriate monitoring systems.
 - f) An Assessment of potential Public Exposure due to radioactive effluents from the Nuclear Power Plant.
4. The Assessment of Exposures in the radiological evaluation should be made by one or more of the following methods:
 - a) Use of Workplace Monitoring. This method can give a good Assessment of the Doses that Workers will receive provided that the radiological conditions in the workplace are reasonably predictable over a long period (at least for several months). Workplace Monitoring should be repeated at appropriate intervals and when the working conditions change significantly.
 - b) Use of data from the scientific literature and information from comparable facilities. Some Dose values are given in the literature for various workplace situations. In principle, these can be used to judge whether monitoring is needed.
 - c) Use of simulation. Numerical simulation can be powerful and can provide information instantly on the parameters that influence Doses that would be received in given Exposure situations. Simulation results should be verified by measurement.
 - d) Use of confirmatory measurements. Taking confirmatory measurements with personal dosimeters can help to determine whether individual monitoring is needed.
5. The radiological evaluation will help to determine what can be achieved at the Design stage to establish adequate working conditions through the use of engineered features.

Examples would be the provision of shielding, containment, ventilation or interlocks. These considerations should aim to minimise the need for relying on administrative controls and personal protective equipment for Radiation Protection and Safety during Normal Operation. Consideration should then be given to additional operational procedures and restrictions that might be implemented to further control Worker Exposure. Only if these measures are not sufficient to adequately restrict the Doses received by Workers will the evaluation need to take into consideration the use of special tools, personal protective equipment and specific task related training.

6. The Radiation Protection Programme should document the following with an appropriate level of detail:
- a) The assignment of responsibility for the Radiation Protection and Safety of Workers of different management levels including corresponding organisational arrangements.
 - b) The designation and functions of Qualified Experts.
 - c) The integration of occupational Radiation Protection with other areas of health Safety and environment such as industrial hygiene, industrial Safety and fire Safety.
 - d) The system of accountability for Radiation Generators and Radioactive Sources.
 - e) The designation of Controlled Areas and Supervised Areas.
 - f) The local rules for Workers to follow and the supervision of work.
 - g) The provision of personal protective equipment.
 - h) The arrangements for monitoring Workers and the Workplace Monitoring including the acquisition and Maintenance of suitable instruments.
 - i) The system for recording and reporting all the relevant information relating to the control of Exposures, the decisions regarding measures for occupational Radiation Protection and Safety, and the monitoring of individuals.
 - j) The education and training programme on the nature of the hazards and on measures for Radiation Protection and Safety.
 - k) The methods for periodically reviewing and auditing the performance of the Radiation Protection Programme.
 - l) The Radiation Protection organisation's functions necessary to support the on-site Emergency Plan and where necessary the off-site Emergency Plan.
 - m) The programme for Workers' health surveillance.

- n) The requirements to ensure the improvement of quality and process.
7. The organisational structures should reflect the assignment of responsibility and the commitment of the organisation to Radiation Protection and Safety. The Management System should facilitate cooperation between the various individuals involved. The Radiation Protection Programme should be designed in such a way that the relevant information is provided to the individuals in charge of the various aspects of the work.

Radiation Protection Organisation

Article (4)

1. Management should allocate to staff the responsibility for the implementation of the Radiation Protection Programme within the organisation. The Radiation Protection Programme should delineate each responsibility for both managerial and non-managerial staff members, and it should be documented in written policy statements to ensure that all staff members are aware of their responsibility.
2. The organisational structure should reflect the assignment of responsibility, and the commitment of the organisation to Radiation Protection and Safety. The Management System should facilitate cooperation between the various individuals involved. It should also include the roles of any Qualified Experts that the Licensee has identified. The Radiation Protection Programme should be designed in such a way that the relevant information is provided to the individuals in charge of the various aspects of the work.
3. In order to coordinate decision-making concerning the choice of Radiation Protection measures, it may be appropriate (depending on the size of the organisation) to create a specific committee with representatives of the departments concerned with Occupational Exposure. The main role of this committee would be to advise senior management on the Radiation Protection Programme. Its members should include, therefore, managerial staff from the relevant departments and Workers with field experience. The committee should delineate the main objectives of the Radiation Protection Programme, and operational objectives of Radiation Protection. The committee should also make proposals on the choice of Radiation Protection measures, and give recommendations to management on the resources, methods and tools, which will be assigned to allow the objectives to be met of the Radiation Protection Programme.
4. Qualified Experts should be available to provide advice on FANR's requirements. Qualified Experts in Radiation Protection in particular should provide advice on a range of issues including the Optimisation of Radiation Protection and Safety.
5. A direct reporting chain should be established from the head of Radiation Safety to the plant manager that is independent of the reporting chains for operations and Maintenance.

Classification of Areas and Access Control

Article (5)

1. Consideration should be given to classifying working areas whenever there is Occupational Exposure to Ionising Radiation. These areas should be clearly defined in the Radiation Protection Programme, and their classification should result from a radiological evaluation. Two types of area can be defined: Controlled Areas and Supervised Areas.
2. The Licensee should designate as a Controlled Area any area in which specific measures for Radiation Protection and Safety are (or could be) required for the following purposes:
 - a) To control Exposures or prevent the spread of contamination in Normal Operation.
 - b) To prevent or limit the likelihood and magnitude of Exposures in Anticipated Operational Occurrences and Accident conditions.
3. When defining the boundaries of any Controlled Area, the Licensee should take into account the magnitude of the Exposures expected in Normal Operation, the likelihood and magnitude of Exposures in Anticipated Operational Occurrences and in Accident conditions, and the type and extent of the procedures required for Radiation Protection and Safety.
4. For Controlled Areas the Licensee should:
 - a) Delineate Controlled Areas by physical means or, where this is not reasonably practicable, by some other suitable means.
 - b) Delineate an appropriate Controlled Area by means that are appropriate under the prevailing circumstances and specify Exposure times where a Radioactive Source is only intermittently brought into operation or energised, or is moved from place to place.
 - c) Display the symbol for Ionising Radiation recommended by the International Organisation for Standardization, and the instructions at access points to the Controlled Area and at appropriate locations within the Controlled Area.
 - d) Establish rules and procedures for Controlled Areas including measures for Radiation Protection and Safety to control the spread of contamination.
 - e) Restrict access to Controlled Areas by means of administrative procedures such as the use of Ionising Radiation work permits, and by installing physical barriers, which could include locks or interlocks - the degree of restriction being commensurate with the likelihood and magnitude of Exposure.
 - f) Provide the following, as appropriate, at the entrance of a Controlled Area:

- i. Personal protective equipment;
 - ii. Equipment for individual monitoring and Workplace Monitoring; and
 - iii. Suitable storage for personal clothing.
 - g) Provide the following, as appropriate, at the exit from a Controlled Area:
 - i. Equipment for checking skin and clothing for contamination;
 - ii. Equipment for monitoring any objects or material being removed from the area due to contamination;
 - iii. Washing or showering facilities and other personal decontamination facilities; and
 - iv. Suitable storage for contaminated personal protective equipment.
 - h) Periodically review conditions to assess whether there is any need to modify the measures for Radiation Protection and Safety or the boundaries of Controlled Areas.
 - i) Provide appropriate information, instruction and training for Workers working in Controlled Areas.
5. Work with unsealed radioactive substances can result in contamination of the air and surfaces, and in turn this can lead to intakes of radionuclides by Workers. Such contamination will be generally of an intermittent nature, and it will not be normally possible to control intakes by relying solely on Design features particularly in the event of an incident. Operational procedures will be, therefore, necessary to prevent or reduce the possibility of intake.
6. Controlled Areas may not need to be set up where only small quantities of unsealed radioactive substances are used (e.g. for tracer studies in a research laboratory). They may be also unnecessary when only materials with low radioactivity concentrations are handled.
7. The Ionising Radiation warning signs at the entrance to a Controlled Area should be used to indicate to Workers, especially Maintenance staff, that special procedures apply in the area and that Radioactive Material is likely to be present.
8. When setting up a Controlled Area, the Licensee may find it useful to make use of existing physical boundaries such as the walls of rooms or buildings. This might mean that the areas will be larger than would be strictly necessary on the basis of Radiation Protection considerations alone.

9. The Licensee should designate as a Supervised Area any area not already designated as a Controlled Area but for which Occupational Exposure conditions need to be kept under review even if specific measures for Radiation Protection and Safety are not normally needed.
10. Taking into account the nature, likelihood and magnitude of Exposures or contamination in the Supervised Areas, the Licensee should do the following:
 - a) Delineate the Supervised Areas by an appropriate means.
 - b) Display approved Ionising Radiation warning signs, as appropriate, at access points to Supervised Areas.
 - c) Periodically review conditions to assess whether there is any need for further measures for Radiation Protection and Safety or any need for changes to the boundaries of Supervised Areas.
11. The essential purpose of a Supervised Area is to identify those parts of the workplace that should be subject to regular review of the radiological conditions. Such review would determine whether the status of the area should be changed as a result, for example, of circumstances that were not foreseen in the radiological evaluation, or whether there has been some breakdown of control either in the Design features or in the procedures that apply in any adjacent Controlled Area. Usually, the review of the radiological conditions would include a programme of regular monitoring of the area and, in some cases, of the individuals who work in it. It should not be automatically necessary to set up a Supervised Area around every Controlled Area as the requirements that apply within a designated Controlled Area may well be sufficient.
12. As with the Controlled Area, the definition of a Supervised Area is best based on operational experience and judgement, but again, use may be made of a Dose rate to define the boundary. A reasonable objective would be to ensure that those Workers exposed outside designated areas receive the same level of protection as if they were members of the public. The conditions in a Supervised Area should be such that Workers are able to enter the area with a minimum number of formalities for Radiation Protection. Furthermore, it may be appropriate to make use of existing physical boundaries when defining Supervised Areas.

Local Rules, Planning and Supervision of Work

Article (6)

1. In Controlled Areas where it is possible that levels of Ionising Radiation or contamination may be significant, consideration should be given to the planning of work. Advanced planning of work is an important means of keeping Ionising Radiation Doses Optimised.

2. The Radiation Protection organisation should take part in planning any Regulated Activities that might entail significant Doses, and should advise on the conditions under which work can be undertaken in areas of Ionising Radiation and contamination.
3. Such work planning should include the provision of written procedures or a work permit for Ionising Radiation as appropriate. Matters that should be considered in planning work include:
 - a) Information on similar work completed previously.
 - b) Intended start time, the expected duration and the Worker's resources necessary.
 - c) Anticipated Dose rates, the need for supplemental dosimetry, dosimetry with an alarm.
 - d) The Nuclear Power Plant's operational state (cold or hot shutdown, Operation at full power or reduced power).
 - e) Other activities in the same area or in a remote area of the Nuclear Power Plant that may interfere with the work or may require the work to be conducted in a particular manner.
 - f) The need for the preparation for and assistance in operations (such as the isolation of the process, construction of scaffolding or insulation work).
 - g) The need for protective clothing and a list of tools to be used.
 - h) Communication procedures to ensure supervisory control and co-ordination.
 - i) The handling of Radioactive Waste.
 - j) Requirements and recommendations for industrial Safety in general.
4. Responsibilities with regard to the interface between different working teams should be clearly identified. A responsible work supervisor should be designated who should ensure that all participants have received training including training in Radiation Protection as needed for the type of work and the conditions in which the work will be undertaken.
5. Work planning should ensure that Workers' tools, equipment and material are available when needed, that a check for completeness is carried out before the work has started, and that standard instructions are established for measures to be taken in the event of abnormal situations. Training on mock-ups or simulations should be considered when the work is non-routine or complex.
6. Preparation of the work area may be necessary for example by: cordoning it off and posting warning signs; laying down temporary coverings to retain contamination; providing local

changing areas for protective clothing; solid waste bins; additional Ionising Radiation monitors; and temporary Ionising Radiation shielding or ventilation.

7. For tasks needing radiological precautions, a radiation work permit should be prepared. A copy of the radiation work permit should be submitted to the supervisor of the work and it should be retained with the work team (as necessary) throughout the performance of the work. Information and instructions that should be given in the radiation work permit (in addition to a description of the work) include:
 - a) Details of average Dose rates and possible areas of elevated radioactivity in the working area on the basis of a survey carried out prior to the work or calculated based on other information such as radioactivity sample results.
 - b) Estimates of contamination levels and how they might change in the course of the work.
 - c) Additional dosimeters to be used by the Workers.
 - d) Protective equipment to be used in different phases of the work.
 - e) Possible restrictions on working time and Doses.
 - f) Instructions on when to contact members of the Radiation Protection organisation.
8. The person in charge of planning the work activity should request an Ionising Radiation work permit for the person who is to supervise or carry out the work. A Radiation protection staff member should sign the Ionising Radiation work permit to confirm that the workplace is in the condition specified in the permit. The Ionising Radiation work permit should be amended, if necessary, to take into account changing conditions as the work proceeds.
9. On completion of the task or the work period, a Radiation Protection staff member should revoke the Ionising Radiation work permit to certify that the work has been finished.
10. Appropriate criteria should be established and implemented to evaluate estimated Exposure to actual Exposure for tasks and/ or parts of tasks defined within the Ionising Radiation work permits.

Facilities and Equipment

Article (7)

1. There should be facilities provided for the effective radiological control in the Operation and Maintenance of the Nuclear Power Plant, and to respond to an Emergency. The facilities should include:

- a) An operations office for Radiation Protection, an accredited facility for instrument calibration (or adequate arrangements using accredited external vendors), and rooms for the preparation of samples and measurement of radioactivity.
 - b) A changing room for protective clothing with washing and shower facilities, a laundry room for protective clothing, a Worker decontamination room, and a first aid room.
 - c) An equipment decontamination facility, a Storage area for contaminated items and tools, a special workshop for Maintenance of radioactive components, and a Storage area for Radioactive Material.
 - d) Appropriate facilities and instruments for the management, conditioning and Storage of Radioactive Waste, and equipment for the handling and transport of Radioactive Waste of different types.
2. The Nuclear Power Plant should be equipped with Ionising Radiation shielding materials of different types for temporary use in special jobs. Examples of such shielding materials are tungsten shielding, water shields, polyethylene shields, moulded shield wraps, magnetic shields and blocks of concrete.
 3. For the on-site transport of activated objects (such as in-core detectors or loose parts that have become activated in the Nuclear Reactor core, or other highly Radioactive Waste or objects), appropriate packaging for transport should be used. The packaging should have appropriate shielding and it should be clearly marked for use only for the on-site transport of activated objects.
 4. In addition to the equipment for Workplace Monitoring and individual monitoring listed in Article (13) of this regulatory guide, equipment for radiological control should include:
 - a) Miscellaneous supplies such as movable shielding, signs, ropes, stands, sampling equipment and documents.
 - b) Emergency equipment including self-powered air samplers and additional protective clothing (consideration should be given to providing Emergency vehicles, boats, radios and other proven specialised equipment for use in an Emergency).
 - c) Personal protective equipment including protective clothing and respiratory protective equipment and a fresh supply of breathing air from a compressor.
 - d) Meteorological instruments.
 5. Measures should be taken to ensure that the equipment is properly maintained.

Protective Clothing and Protective Equipment

Article (8)

1. Protective clothing should be worn in contaminated areas where levels of removable contamination exceed specified values. The type of protective clothing required should be determined on the basis of considerations of contamination levels, the chemical and physical form of the contaminant, the activities to be performed and the accessibility of the area.
2. For certain tasks, additional overalls worn over the normal overalls should be provided. For work in highly contaminated areas involving direct contact with body parts other than hands and feet, or wet work in contaminated areas, stronger plastic suits, ventilated if necessary, should be made available. The suit may be pressurised by means of a supply of breathing quality air.
3. In areas where airborne contamination or loose surface contamination is present or may be produced during work, use of respiratory protective equipment may be necessary and should be considered. The protective equipment should meet the specifications in the Ionising Radiation work permit, and there should compliance with administrative procedures.
4. Respiratory protective equipment issued to an individual should protect adequately against the specific radionuclides of concern. The equipment should be especially selected to provide the degree of Radiation Protection necessary with the objective of minimising the total Dose by using a pre-determined set of protection factors as a guide. These pre-determined protection factors should be justified based on best international practice or manufacturers values.
5. Respirators should only be used by Workers who have been medically screened, trained, and (for face-sealing devices) fit-tested within the period prescribed. Workers should only be issued face-sealing respirators for which they have been fit-tested (i.e. same make, model, style, and size).
6. The Licensee should be cautious of the use of supplied air respirators and self-contained breathing apparatus that operate in the demand mode. Since these devices operate in a negative-pressure mode, any face-to-face piece seal leakage will permit contaminants to enter the respiratory inlet covering where they could be inhaled.
7. The use of certain items of protective equipment may prolong the working time and thus increase the external Dose received during the work. In deciding on the type of protective equipment to be used, it should be taken into account that in some cases protective equipment may thus cause the Worker to receive an additional external Dose that is greater than the internal Dose averted by its use.

8. After use, protective clothing and respiratory equipment should be considered contaminated and should be handled accordingly.
9. Work in areas of Ionising Radiation and contamination may also require the use of other types of special equipment to reduce Doses such as: portable shields; portable ventilation equipment with filters for local exhaust; remote handling tools; special monitoring and communication equipment; special temporary containers for solid Radioactive Waste; and containers for radioactive liquids.
10. Site Workers including contractor Workers should be specifically trained and qualified in the use of protective clothing and special protective equipment, as appropriate. Those Workers handling, issuing or decontaminating protective clothing and respiratory protective equipment should also be appropriately qualified.
11. Respiratory protective equipment and its use should conform to the following:
 - a) The use of respiratory protective equipment should be carefully supervised to ensure that the expected protection is provided.
 - b) The Licensee should ensure that respiratory protective equipment fits properly and is used correctly.
 - c) The protection factors to be used in assessing the actual intake of the Worker should be specified.
 - d) The periods of use of respiratory protective equipment should not be so long as to discourage its proper use.
 - e) Filter respirators should have a low breathing resistance and should be efficient for the dust size concerned.
 - f) When equipment for supplied air is used, the air supplied should be of breathable quality and of sufficient quantity to ensure leak-free operation in the conditions of use.
 - g) Powered air respirators or helmets with face shields are preferred to other types of respiratory protective equipment for the comfort of the Workers using them provided that they ensure effective respiratory protection.
 - h) When choosing equipment for a particular operation, factors affecting the comfort of Workers (e.g. the weight of the equipment, its restriction of vision, and effects on temperature and mobility) should be considered as well as the required protection factor.

- i) Respiratory protective equipment should be cleaned and maintained regularly, and should be inspected at appropriate intervals by properly trained persons in suitably equipped facilities.
 - j) Respiratory protective equipment should be examined, fitted and tested as appropriate by a competent person before being issued for use and periodically during use, and the results of these tests and examinations plus details of any repairs should be recorded.
 - k) The frequency of testing of respiratory protective equipment should be determined on the basis of the type of equipment, the environment in which it is used and how it is handled.
 - l) Respiratory protective equipment should be checked by users before use and by the safety Maintenance staff after cleaning, and should be pressure-tested, as appropriate.
12. Where engineered controls and administrative controls are not sufficient to ensure that Radiation Protection for the lens of the eye is Optimised, consideration should be given to protecting the lens of the eye by use of appropriate protective glasses. Glasses made of Perspex may be sufficient when the Exposure is predominantly to beta Ionising Radiation. Account should be taken, however, of any bremsstrahlung generated by high energy beta Ionising Radiation. When the Exposure is predominantly to penetrating Ionising Radiation (gamma Radiation or X-rays), consideration should be given to the use of protective glasses with lenses containing lead.
13. If conventional industrial safety glasses are to be used to protect against Exposure to beta Ionising Radiation, they should be evaluated for their shielding properties beforehand. Similarly, protective glasses with lenses containing lead should also be evaluated before use. Records of such evaluations shall be maintained. Such glasses may well be adequate for protecting against low energy X-rays, but may be inadequate to protect against higher energy gamma Ionising Radiation.
14. The Ionising Radiation attenuation factor of the lenses of the glasses is not an adequate descriptor in itself of the effectiveness of the eyewear in reducing Ionising Radiation Exposure. The area covered by the lenses should also be taken into consideration. Well-fitting glasses containing a small percentage of lead (including side shields) should be adequate to give the required protection to the lens of the eye. For maximum effectiveness, protective glasses should intercept as much of any scattered Ionising Radiation as possible in particular in image guided interventional procedures. Workers should use such protective glasses in workplaces with a higher potential for Exposure of the lens of the eye.

Application of the Optimisation Principle

Article (9)

1. The Optimisation of Radiation Protection and Safety measures (i.e. to keep Doses as low as reasonably achievable, economic and social factors being taken into account), should be carried out at all stages during the lifetime of the equipment and installations including Decommissioning. In the Optimisation, all relevant factors should be taken into account such as:
 - a) The balance between present Doses due to discharges and future Doses due to confinement of the same radioactive substances solidified as Radioactive Waste.
 - b) Exposures arising from different tasks.
 - c) Options for Radioactive Waste Management and Decommissioning.

The trade-offs between the various factors should be considered.

2. In order to keep all Exposures within authorised Dose limits and Dose Constraints, and as low as reasonably achievable, economic and social factors being taken into account:
 - a) The Ionising Radiation Exposure should be reduced by means of Radiation Protection measures to values such that further expenditure for Design, Construction and Operation would not be warranted (i.e. for economic reasons) by the associated reduction in Radiation Exposure.
 - b) Issues such as reducing major disparities in the occupational Doses received by Workers of different types who work within the Controlled Area and avoiding arduous working conditions in Ionising Radiation areas should be taken into account.
3. It may also be difficult to balance individual and collective Doses (it may be desirable to use a roster system of duties in order to reduce individual Doses, but this should not be a substitute for good Radiation Protection practice), and to take into account the implications for occupational Doses of further reductions in public Doses as well as the broader social factors that such reduction might entail. For these situations, the use of qualitative decision aiding techniques such as multi-criteria analysis and expert judgement should be considered. For example, an analysis may not be able to justify on economic grounds the provision of remote equipment to eliminate the need for Workers to enter areas with high Ionising Radiation levels or contamination levels, but the decision may be taken to provide such equipment on social grounds.
4. The Licensee should develop an Optimisation programme that reflects the efforts to be taken to Optimise Ionising Radiation Exposure. This programme should be in written form

and should contain sections that cover the generally applicable guidance presented in this regulatory guide, as a minimum. This programme may be combined with the Radiation Protection programme or other documents; it need not be an independent document.

5. A Management System for (and commitment to) ensuring that Ionising Radiation Exposure will be Optimised should be established.
6. The Management System and commitment should be reflected in written procedures and instructions, and should be reflected in Design features. Instructions to designers, builders, vendors and personnel specifying or reviewing features, systems or equipment should reflect the goals and objectives to Optimise Occupational Exposures.
7. In view of the need for senior management support, responsibility and authority for implementing the programme to Optimise Occupational Exposures should be assigned to an individual (or committee) with organisational freedom to ensure development and implementation. Responsibilities should include:
 - a) Ensuring that a corporate programme that integrates management philosophy and regulatory requirements is established with specific goals and objectives for implementation included.
 - b) Ensuring that an effective measurement system is established and used to determine the degree of success achieved with regard to the programme's goals and specific objectives.
 - c) Ensuring that the measurement system results are reviewed on a periodic basis and that corrective actions are taken when attainment of the specific objectives appears to be jeopardised.
 - d) Ensuring that the resources needed to achieve goals and objectives to Optimise Occupational Exposures are made available.
8. In view of the responsibilities required to implement a programme to Optimise Occupational Exposures, the individual (or committee) selected for this function should also be chosen to coordinate the effort amongst the several functional groups such as operations, Maintenance, technical support, engineering, Safety ,and Radiation Protection.
9. Responsibilities of the plant manager with respect to a programme to Optimise Occupational Exposures should include:
 - a) Ensuring support from all personnel.
 - b) Participating in the selection of specific goals and objectives for the Nuclear Power Plant.

- c) Supporting the on-site head of Radiation Safety in formulating and implementing a programme to Optimise Occupational Exposures.
 - d) Expediting the collection and dissemination of data and information concerning the programme.
10. The head of Radiation Safety has a Safety function and responsibility to both Workers and management that can be best fulfilled if the head of Radiation Safety is independent of operations, Maintenance or technical support, and whose prime responsibility is continuity or improvement of operability. The head of Radiation Safety should have direct recourse to responsible management personnel in order to resolve questions related to the conduct of the Radiation Protection programme.
11. Responsibilities of the head of Radiation Safety with respect to a programme to Optimise Occupational Exposures should include the:
- a) Participation in Design reviews for facilities and equipment that can affect potential Ionising Radiation Exposures.
 - b) Identification of locations, operations and conditions that have the potential to cause significant Exposures to Ionising Radiation.
 - c) Initiation and implementation of an Exposure control programme.
 - d) Development of plans, procedures and methods to maintain the optimisation of Ionising Radiation Exposures.
 - e) Review, comments on and recommendation of changes in procedures to Optimise Ionising Radiation Exposures.
 - f) Participation in the development and approval of training programmes related to work in Ionising Radiation areas or involving Radioactive Material.
 - g) Supervision of the Ionising Radiation surveillance programme to maintain data on Exposures by specific job functions and type of work.
 - h) Supervision of the collection, analysis, and evaluation of data and information attained from radiological surveys and monitoring activities.
 - i) Supervision training and competence evaluation of Radiation Protection staff to ensure they are qualified.
 - j) Adequate Radiation Protection coverage for Workers during all working hours.
12. Since several functional groups (e.g. Maintenance, operations, Radiation Protection, technical support, engineering, and Safety groups) are interested in the Design and

selection of equipment, the Licensee should ensure that these groups are adequately represented in the review of the Design of the Nuclear Power Plant and the selection of equipment. A coordinated effort by the several functional groups is required to ensure that features will permit the goals and objectives of the Optimisation principle to be achieved.

13. Design concepts and features for any modifications should take into account the activities of Workers (such as Maintenance, refuelling, in-service inspections, processing of Radioactive Waste, decontamination, and Decommissioning) that might be anticipated and that might lead to Occupational Exposure to Radioactive Material. Radiation Protection aspects of Decommissioning should be factored into modification activities.
14. Specifications for replacement equipment should reflect the objectives of the Optimisation programme including the reliability, serviceability, limitations of internal accumulations of Radioactive Material, and other features addressed in this regulatory guide.
15. Radioactive Material within a Nuclear Power Plant differ appreciably with respect to location, intensity and characteristics. The magnitude of the Dose rates that results from these Radioactive Material is dependent on many factors including the facility and equipment design, layout, mode and length of Operation, and Radioactive Material concentration and characteristics. In order to provide a basis for Design modifications, there should be an estimate of the quantity and isotopic composition of the Radioactive Material that can be anticipated to be contained, deposited or accumulated in the modified or replaced equipment. In order to avoid the unnecessary and inadvertent Exposure of Workers to Ionising Radiation, the magnitude of the potential Dose rates at all affected locations should be estimated prior to performing any Design modifications.
16. Actual Dose rates should be measured periodically during Operation to determine the current Exposure potential. Areas associated with the higher Dose rates should be kept as low as reasonably achievable to carry out the services in those areas including equipment laydown requirements. Ionising Radiation areas where Workers spend substantial time should be designed such that the Dose rates will be as low as reasonably achievable.
17. Ionising Radiation shields should be designed using the shielding Design basis assumptions and conservative assumptions for geometries. Calculation methods known to provide reliable and accurate results (i.e. methods and modelling techniques that have been demonstrated to give acceptable accuracy in analyses similar to the problem of concern) should be used to determine appropriate shield thicknesses. Shield Design features should reflect the following to Optimise Occupational Exposures:
 - a) The Exposure of Workers servicing a specific component (such as a pump, filter or valve) to Ionising Radiation from other components containing Radioactive Material can be reduced by providing shielding between the Worker and the individual components that constitute substantial sources of Radioactive Material.

- b) Where it is impracticable to provide permanent shielding for individual components that contain a substantial quantity of Radioactive Material, the Exposure of Workers maintaining such components can be reduced (i) by providing as much distance as practicable between the serviceable components and the substantial sources of Radioactive Material in the area, (ii) by providing temporary shields around components that contribute substantially to the Dose rate, and (iii) reducing the Exposure duration.
- c) The potential Exposure of Workers to Ionising Radiation from certain systems containing Radioactive Material can be reduced by means of a layout that permits the use of distance and shielding between the Radioactive Material and work locations.
- d) Streaming or scattering Ionising Radiation from locally shielded components (such as cubicles) can be reduced by providing labyrinths for access. However, such labyrinths or other Design features of the cubicle should permit the components to be removed readily from the cubicle for repair or replacement where such work is expected or anticipated. Single-scatter labyrinths may be inadequate if the cubicle contains a substantial source of Radioactive Material.
- e) Streaming (collimated beams) of Ionising Radiation into accessible areas through penetrations for pipes, ducts and other shield discontinuities can be reduced (i) by layouts that prevent substantial sources of Radioactive Material within the shield from being aligned with the penetrations or (ii) by using shadow shields such as shields of limited size that attenuate the direct Ionising Radiation component. Streaming can occur also through roofs or floors unless adequate shielding encloses the sources of Radioactive Material from all directions.
- f) The Exposure of Workers to Ionising Radiation from pipes carrying Radioactive Material can be reduced by shielded pipe chases.
- g) Design features that permit the rapid removal and reassembly of shielding, insulation and other material from equipment that must be inspected or serviced periodically can reduce the Exposure of Workers carrying out these activities.
- h) Space within cubicles and other shielding to provide laydown space for special tools and ease of servicing activities can reduce potential Ionising Radiation Exposure by permitting the services to be accomplished expeditiously thus reducing Exposure time.
- i) The Exposure of Workers who service components associated with substantial quantities of Radioactive Material or are located in high Ionising Radiation fields can be minimised by removing the components and transporting them to low Ionising Radiation areas where shielding and special tools are available. Design

features that permit the prompt removal and installation of these components can reduce the Exposure time.

- j) Floor and equipment drains, piping and sumps that are provided to collect and route any contaminated liquids that might leak or be spilled from process equipment or sampling stations can become substantial sources of Radioactive Material. The drain lines can be shielded as appropriate. These systems can also become a source of airborne contamination because of the potential for gases to form in (and be released by) such systems.

18. For modifications, appropriate layout and Design features should be provided to reduce the potential Doses to Workers who must operate, service or inspect instrumentation and controls. The following considerations should be reflected in selecting the features:

- a) The Exposure of Workers who must manually operate valves or controls can be reduced through the use of reach rods or remotely operated valves or controls. However, these devices can require lubrication and Maintenance that can be the source of additional Exposure, and these factors should be taken into consideration.
- b) The Exposure of Workers who must view or operate instrumentation, monitors and controls can be reduced by locating the readouts or control points in low Ionising Radiation areas.
- c) Instrumentation must satisfy functional requirements, but the Exposure of Workers can be reduced if the instruments are designed, selected, specified and located with consideration for long-service life, ease and low frequency of Maintenance and calibration, and low radioactive particulate accumulation. Operating experience should be recorded, evaluated and reflected in the selection of replacement instrumentation.
- d) The use of instrumentation that contains minimal quantities of contaminated working fluid (e.g. pressure transducers rather than bellows-type pressure gauges) can reduce the potential for Exposure at the readout locations.

19. For modifications, Design features should be considered to limit the average concentrations of Radioactive Material in air. Effective Design features can minimise the occurrence of occasional increases in air contamination and the concentrations and amounts of contaminants associated with any such occasional increases. Modifications that permit repeated, identified releases of large amounts of Radioactive Material into the air spaces occupied by Workers are contrary to a programme to Optimise Occupational Exposures.

20. For modifications, Design features should provide for Radiation Protection against airborne Radioactive Material by means of engineering controls such as process,

containment and ventilation equipment. The routine provision of respiratory protection by use of individually worn respirators rather than engineered Design features is generally unacceptable.

21. Auxiliary ventilation systems that augment the permanent system can provide local control of airborne contaminants when equipment containing potential airborne Radioactive Material is opened into the atmosphere. In areas where contaminated equipment must be opened infrequently, portable auxiliary ventilation systems featuring blowers, high efficiency particulate air (HEPA) filters, and activated charcoal filters (where radioiodine might be anticipated) on carts can be used effectively. Portable auxiliary ventilation systems should be tested frequently to verify the efficiency of the filter elements in their mountings.
22. Machining of contaminated surfaces (e.g. welding, grinding, sanding, or scaling) or the plugging of a leaking steam generator or condenser tubes can be substantial sources of airborne contamination. This can be controlled by using auxiliary ventilation systems.
23. Sampling stations for primary coolant or other fluids containing high levels of Radioactive Material can constitute substantial sources of airborne contamination. Such sources can be controlled by using auxiliary ventilation systems.
24. For modifications affecting the primary coolant system, the selection of Construction materials that will be in contact with the primary coolant, and features of equipment that treat the primary coolant should take into account anything that will reduce the production and accumulation of corrosion particles that may become activated in a Nuclear Power Plant where it can cause high Exposure levels. The following items should be considered in the radioactive particle control effort:
 - a) The production of Cobalt-58 and Cobalt-60, which constitute substantial sources of Radioactive Material in primary coolant radioactive particles, can be reduced by specifying to the extent practicable low-nickel and low-cobalt bearing materials for primary coolant pipe, tubing, vessel internal surfaces, heat exchangers, wear materials, and other components that are in contact with the primary coolant. Alternative materials for hard facings of wear materials of high-cobalt content should be considered where it is shown that these high-cobalt materials contribute to the overall Exposure levels. The potential increased service or repair requirements, and the overall reliability of the new material in relation to the old should be also taken into account. Alternative materials for high-nickel alloy materials (e.g. Inconel 600) should be considered where it is shown that these materials contribute to overall Exposure levels. The potential increased service or repair requirements, and the overall reliability of the new material in relation to the old should be also taken into account.

- b) Loss of material by erosion of load-bearing hard facings can be reduced by using favourable geometrics and lubricants where practicable, and by using controlled leakage purge across journal sleeves to avoid entry of particles into the primary coolant.
- c) Loss of material by corrosion can be reduced by continuously monitoring and adjusting the oxygen concentration and pH in the primary coolant, and by using bright hydrogen-annealed tubing and piping in the primary coolant and feedwater systems.
- d) Consideration should be given to clean-up systems (e.g. using graphite or magnetic filters) for removal of radioactive particles from the primary coolant during Operation.
- e) A deposition of radioactive particles within the primary coolant system can be reduced by providing laminar flow and smooth surfaces for coolant and by minimising particulate traps in the system to the extent practicable.

25. Potential Doses to Workers who must service equipment containing Radioactive Material can be reduced by removing such Radioactive Material from the equipment (decontamination) to the extent practicable prior to servicing. Serviceable systems and components that constitute a substantial source of Radioactive Material should be designed to the extent practicable with features that permit isolation and decontamination. For modifications, Design features should consider to the extent practicable the ultimate Decommissioning of the facility and the following concerns:

- a) The necessity for decontamination can be reduced by limiting to the extent practicable the deposition of Radioactive Material within the processing equipment particularly in the dead spaces or traps in components where substantial accumulations can occur. The deposition of Radioactive Material in piping can be reduced and decontamination efforts enhanced by avoiding stagnant legs by locating connections above the pipe centreline by using sloping rather than horizontal runs, and by providing drains at low points in the system.
- b) The need to decontaminate equipment and areas can be reduced by taking measures that will reduce the probability of release of Radioactive Material, reduce the amount released, and reduce the spread of the contaminant from the source e.g. from systems or components that must be opened for service or replacement. Such measures can include auxiliary ventilation systems, treatment of the exhaust from vents and overflows, drainage control such as curbing and floors sloping to local drains, or sumps to limit the spread of contamination from leakage of liquid systems.
- c) Accumulations of radioactive particulates or other Radioactive Material that cannot be avoided within components or systems can be reduced by providing features

that will permit the re-circulation or flushing of fluids with the capacity to remove the Radioactive Material through chemical or physical action. The fluids containing the contaminants will require treatment, and this source should be considered in sizing Radioactive Waste treatment systems.

- d) The potential for contamination of clean services (such as service air, nitrogen or water supply) from leakage from adjacent systems containing contaminants can be reduced by separating piping for these services from piping that contains Radioactive Material.
- e) Surfaces can be decontaminated more expeditiously if they are smooth, non-porous, and free of cracks, crevices and sharp corners. These desirable features can be realised by specifying appropriate Design instructions for modifications, by giving attention to finishing work during Construction or manufacture, and by using sealers (such as special paints) on surfaces where contamination can be anticipated.

26. Systems used to transport, store or process resins or slurries of filter sludge present a special Ionising Radiation hazard because of the concentrated nature of the Radioactive Material. Any Design modifications for resin and sludge handling systems should reflect this concern and the specific considerations listed below.

- a) The accumulation of Radioactive Material in components of systems used to process resin and sludge can be reduced by:
 - i. Reducing the length of piping runs.
 - ii. Using larger diameter piping (to minimise plugging).
 - iii. Reducing the number of pipe-fittings.
 - iv. Avoiding low points and dead-legs in piping.
 - v. Using gravitational flow to the extent practicable.
 - vi. Minimising flow restrictions of processed material.
- b) The need for Maintenance and the presence of intense local sources of Ionising Radiation can be reduced by:
 - i. Using full-ported valves constructed such that the slurry will not interfere with the opening or closing of the valve, and avoid cavities in valves.
 - ii. The deposition of resin and sludge that would occur if elbow fittings were used can be reduced by using pipe bends of at least five pipe

diameters in radius. Where pipe bends cannot be used, long radius elbows are preferred.

- iii. Smoother interior pipe surfaces at connections (with attendant reductions in friction losses, deposition of material, and tendencies to plug) can be achieved by using butt welds rather than socket welds, and by using consumable inserts rather than backing rings.
- iv. Where the use of tees cannot be avoided, line losses can be reduced if the flow is through the run (straight section) of the tee, and accumulations of material in the branch of the tee can be reduced by orienting the branch horizontally or (preferably) above the run.
- v. Slurry piping is subject to plugging that may require back-flushing from the tank and equipment isolation valves and pressurising with water, nitrogen, or air to blow out plugged lines. However, the use of pressurised gas for blowing out lines can present a potential contamination source and may not be effective in relieving plugged lines.
- vi. Water, air or nitrogen for sparging can be used to turn resin or sludge into fluid in Storage tanks. The use of gases, however, presents a potential source of airborne contamination and tank rupture from overpressure.
- vii. The spread of contamination by the loss of resin or sludge through overflows and vents can be reduced by using screens, filters or other features that will collect and retain solids. However, such features generally require cleaning by remote flushing by rapid replacement, or by other means to reduce Exposures during servicing.

27. Before entering Ionising Radiation areas where significant Doses could be received, Workers should have plans and preparations (described in the radiation work permit), which can ensure that the Exposures are Optimised while the Workers are carrying out the services. Plans and preparations should reflect the following:

- a) A staff member who is a specialist in Radiation Protection can be assigned the responsibility for contributing to and coordinating Optimisation efforts in support of operations that could result in substantial individual and collective Exposure.
- b) In order to provide the bases for planning the activity, surveys can be carried out to ascertain information with respect to Ionising Radiation, contamination, airborne Radioactive Material, and mechanical difficulties that might be encountered while carrying out services.

- c) Ionising Radiation surveys provided in conjunction with Inspections or other activities can define the nature of the Ionising Radiation fields and identify favourable locations where Workers may take advantage of available shielding, distance, geometry and other factors that affect the magnitude of the Dose rate or the parts of the body exposed to the Ionising Radiation.
- d) Photographs of equipment or components as installed can be invaluable for planning purposes, and can be augmented by additional photos taken during the surveys. The use of portable TV cameras with recording features has considerable merit as both an operational aid and a teaching aid. Models in 3D (i.e. three-dimensional) may also help.
- e) The existing Ionising Radiation levels can be reduced often by draining, flushing or other decontamination methods, or by removing and transporting the component to an area with lower Ionising Radiation. An estimate of the potential Doses to Workers expected to result from these procedures is germane in selecting amongst alternative actions.
- f) A pre-operational briefing for Workers who will carry out services in a high Ionising Radiation area can ensure that service Workers understand the tasks about to be carried out, the information to be disseminated, and the special instructions to be presented.
- g) An Ionising Radiation work permit with an appropriate format can be useful for recording pertinent information concerning tasks to be carried out in high Ionising Radiation areas so that the information is amenable to cross-referencing and statistical analysis.
- h) Consideration of potential Accident situations or unusual occurrences (such as gross contamination leakage, pressure surges, fires, cuts, punctures or wounds) and contingency planning can reduce the potential for such conditions and enhance the capability for coping with the situations expeditiously if they occur.
- i) Portable or temporary shielding can reduce Dose rate levels near hot spots and in the general area where the work is to be carried out.
- j) Portable or temporary ventilation systems or contamination enclosures and expendable floor coverings can control the spread of contamination and limit the intake by Workers through inhalation.
- k) Dry runs on mock equipment and 3D models can be useful for training Workers, identifying problems that can be encountered in the actual task, and selecting and qualifying special tools and procedures to reduce the potential Exposures of Workers.

- l) Adequate auxiliary lighting and a comfortable environment can increase the efficiency of the work and thus reduce the time spent in the higher Ionising Radiation areas.
 - m) Ionising Radiation monitoring instruments selected and made available in adequate quantities can permit accurate measurements and rapid evaluations of the Ionising Radiation and contamination levels, and changes in levels when they occur.
 - n) Carrying out work on some components inside disposable tents or (for less complicated jobs) inside commercially available disposable clear plastic glove bags can limit the spread of contamination. Such measures can also avoid unnecessary Doses resulting from the need to decontaminate areas to permit Workers access or to allow for entry with less restrictive protective clothing and equipment requirements.
 - o) Careful scheduling of Inspections and other tasks in high Ionising Radiation areas can reduce Exposures by permitting decay of Radioactive Material during the Nuclear Reactor shutdown period and by eliminating some repetitive surveys. Data from surveys and experience attained in previous operations and current survey data can be factored into the scheduling of specific tasks.
28. During Operation in Ionising Radiation areas, adequate supervision and Radiation Protection surveillance should be provided to ensure that the appropriate procedures are followed, that planned precautions are observed, and that all potential Ionising Radiation hazards that might develop or that might be recognised during Operation are addressed in a timely and appropriate manner. Important aspects to consider whilst working in high Dose rate environments include:
- a) Assigning a technician in health physics (i.e. Radiation Safety or Radiation Protection) the responsibility for providing Radiation Protection surveillance for each shift operating crew can help ensure adequate Radiation Protection surveillance.
 - b) Worker monitoring equipment such as direct-reading dosimeters, dosimeters with alarms, and personal Dose rate meters can be used to provide the early evaluation of Doses to individuals and the assignment of those Doses to specific operations.
 - c) Communication systems between Workers in high Ionising Radiation areas and Workers who are monitoring Operation in other locations can permit the timely exchanges of information and avoid unnecessary Exposures to monitoring Workers.
29. Observations, experience and data obtained during non-routine operations in high Ionising Radiation areas should be ascertained, recorded and analysed to identify deficiencies in

the programme, and to provide the bases for revising procedures, modifying features, or making other adjustments that may reduce Exposures during subsequent similar operations. Important aspects include:

- a) Formal or informal post-Operation debriefings of Workers carrying out the services can provide valuable information concerning shortcomings in pre-operational briefings, planning, procedures, special tools and other factors that contributed to the cause of Doses received during the Operation.
- b) The Dose data obtained during or subsequent to an Operation can be recorded in a pre-selected manner as part of a radiation work permit so that the data are amenable to statistical analyses.
- c) Information concerning the cause of component failures that resulted in the need for servicing in high Ionising Radiation areas can provide a basis for revising specifications on replacement equipment or for other modifications that can improve the component reliability. Such improvements can reduce the frequency of servicing and thus reduce attendant Exposures.
- d) Summaries of Doses received by each category of Maintenance activity can be reviewed periodically by senior management to compare the incremental reduction of Doses with the cost of modifications that could be made.

Control of Exposures

Article (10)

1. The Optimisation of the measures for Radiation Protection and Safety associated with any Regulated Activity should be subject to Dose Constraints.
2. A Dose Constraint is a Radioactive Material related value of individual Dose used to restrict the range of options considered in the process of Optimisation. A Dose Constraint is not a limit but a ceiling on the values of individual Dose that should be considered acceptable in the Optimisation process. It is used prospectively for the planning and execution of tasks as well as for Design purposes.
3. In order to apply the principle of Optimisation, individual Doses should be assessed at the operational planning stage, and the predicted individual Doses for the various options should be compared with the appropriate Dose Constraint. Options predicted to give estimated Doses that would exceed the Dose Constraint should be rejected.
4. For Occupational Exposure in a Nuclear Power Plant, the Dose Constraint should be related to a particular task or full Operation. It should be therefore set by the Licensee on

a case by case basis according to the specific circumstances of the Exposure as required by Article (5) of FANR-REG-04, Version 1.

5. The process of deriving the value of a Dose Constraint for Doses due to Occupational Exposure for any specific circumstances should include a review of operating experience and of experience derived from similar circumstances, if possible, together with consideration of economic, social and technical factors. For Occupational Exposure, experience from previous well-managed Operations should be considered of particular importance in setting Dose Constraints. International databases with data on the Doses associated with specific tasks should be used in setting Dose Constraints.
6. For Public Exposure, the Dose Constraint should be used to restrict the annual Doses that members of the public could receive from the planned Operation of the particular Nuclear Power Plant. In setting the Dose Constraint for a particular Nuclear Power Plant, an appropriate margin for unknown future Exposures should be included. Improvements in the effluent control process at the Nuclear Power Plant in question may well lead to lower levels of discharges than the authorised discharge limits. The use of a lower level of discharges as a reference level should not compromise operational flexibility, nor should operators be discouraged from making improvements in the effluent control process in order to reduce discharges.
7. As required by Article (6) of FANR-REG-04, Version1, the public Dose Constraint determined by the Licensee shall be subject to the agreement of the Authority. The Authority has established the following guidance for Licensees who propose public Dose Constraints:

Public Dose Constraint (mSv/ year)	Authority's Position
Up to 0.1	Acceptable without further basis
0.1 to 0.3	Acceptable if the Licensee provides a reason for why a Dose Constraint of 0.1 mSv/ year is impractical
Greater than 0.3	Unacceptable

8. Experience with a particular situation sometimes indicates a need to review procedures and performance. This experience can be qualitative (e.g. the observation that the frequency of occurrence of minor contamination may have increased) or quantitative (e.g. a trend in the results of a monitoring programme). The use of quantitative experience can be helped by the application of Investigation Levels to the monitoring results for individuals and workplaces.

9. Investigation Levels play an important role in a monitoring programme as tools for use by the management. Investigation Levels should be defined at the planning stage of activities and may be revised on the basis of operational experience. They should be defined by the Licensee in the Radiation Protection programme; their purpose being to facilitate the control of operations and Exposures.
10. Investigation Levels should be used in a retrospective sense only and should not be confused with Dose Constraints. If an Investigation Level is exceeded, a review should be initiated to determine the causes and to consider the arrangements for Radiation Protection and Safety, and the reasons for the value being exceeded. Such a review may lead to the introduction of additional measures for Radiation Protection and Safety. The review should have the objective of learning lessons that may be appropriate for any future operations and determining whether additional measures are necessary to improve the current arrangements for Radiation Protection and Safety.
11. Investigation Levels should be set by the Licensee on the basis of knowledge of the conditions in the workplace, the expected levels and variability of the quantities being determined (e.g. effective Dose and intake), and the type and frequency of monitoring. The value of the Investigation Level should also be consistent with the objectives of the monitoring programme and with the type of investigation that will be initiated. The value of an Investigation Level may be based on a selected fraction of the Dose limit, and it should correspond to the period of time to which the individual monitoring result refers. For instance, an Investigation Level for a routine Operation with routine monitoring may be set on the basis of a committed effective Dose of 5 mSv from intakes over the course of a year.
12. An Investigation Level may be set for individuals involved in a particular Operation or may be derived specifically for individuals within a place of work without reference to a particular Operation. The latter situation is particularly relevant when Workers are exposed to a number of different sources in a workplace or are involved in a number of different tasks at work.
13. The Licensee should identify those persons responsible for initiating investigations when they are required. The purpose of (and the actions associated with) each Investigation Level should be clearly defined in advance. The investigation should address:
 - a) The circumstances leading to the suspected Exposure.
 - b) Verification of the dosimetric results.
 - c) The probability that Dose limits or levels will be exceeded under current working conditions.
 - d) Corrective actions to be taken.

14. Workplace Monitoring may involve the measurement of Dose rates, contamination levels, airborne radioactivity concentrations or a combination thereof. Investigation Levels for Workplace Monitoring should be set by the Licensee on the basis of the expected levels and operational experience. A value of surface contamination (radioactivity per unit area) derived from a fraction of the relevant Dose limit may be useful in indicating the significance of particular measurements, and could be used therefore as an Investigation Level to indicate a deterioration in the radiological conditions in the workplace.
15. Occupational Dose performance, and performance of the Optimisation process should be benchmarked against other similar Nuclear Power Plants by comparing data using the Information System for Occupational Exposure (ISOE). Opportunities to improve Dose performance based on benchmarking should be considered.

Female Workers during and after Pregnancy

Article (11)

1. For the purposes of occupational Radiation Protection, there is no reason to make any general distinction between Workers on the basis of gender. However, additional Radiation Protection measures are required for a female Worker during and after pregnancy in order to protect the embryo or foetus or the breastfed infant.
2. The Exposure pathways to the embryo or foetus or the breastfed infant are of potential concern as described below.
 - a) In the uterus:
 - i. External Exposures due to Radioactive Material outside the body of the female Worker that irradiate not only maternal tissues but also the embryo or foetus.
 - ii. Internal Exposures due to the incorporation of radionuclides by the female Worker (or are present in maternal hollow organs such as the urinary bladder or bowel) that transfer to the foetus through the placenta; or Exposure of the foetus to penetrating Ionising Radiation from radionuclides deposited in maternal tissues (or that are present in maternal hollow organs).
 - b) Breastfed infant:
 - i. External Exposures due to penetrating Ionising Radiation from radionuclides in maternal tissues or present in maternal hollow organs such as the urinary bladder or bowel.

- ii. Internal Exposures from the intake of radionuclides by the breastfed infant via transfer from maternal tissues to breast milk and subsequent ingestion during breast-feeding.
3. The Licensee should provide female Workers who are liable to enter Controlled Areas or Supervised Areas with appropriate information on the risk to the embryo or foetus or the breastfed infant during and after pregnancy. Such a female Worker cannot be compelled to notify the Licensee if she is aware or suspects that she is pregnant or if she is breast-feeding. However, the Licensee is required to inform female Workers of the importance of notifying their employer as soon as possible so that the working conditions in respect of Occupational Exposure can be modified accordingly to protect the embryo or foetus or the breastfed infant.
4. Once a female Worker who is liable to enter Controlled Areas or Supervised Areas notifies the Licensee that she is aware or she suspects that she is pregnant or that she is breast-feeding, the Licensee is required to adapt the working conditions in respect of Occupational Exposure so as to ensure that the embryo or foetus or the breastfed infant is afforded the same broad level of Radiation Protection as is required for members of the public. It is required that such notification not be considered a reason to exclude the female Worker from work, but will require more stringent restrictions on the Occupational Exposures to which the female worker is subject. The Licensee should inform the female Worker of the decision to apply more stringent restrictions.
5. The more stringent restrictions should not necessarily prevent the female Worker from working with Ionising Radiation or Radioactive Material or from entering or working in designated Ionising Radiation areas. However, the restrictions should be such as to ensure that under Normal Operational conditions the requirements of FANR-REG-04 with regard to Dose limits for members of the public are met for the embryo or foetus during pregnancy and for the breastfed infant thereafter. Furthermore, the adapted working conditions should be such as to avoid any significant potential Exposure due to Accidents or other unforeseen events that could result in high Ionising Radiation Doses from external Exposure or Internal Exposure.
6. When determining more stringent Dose restrictions, account should be taken of any Doses that were received by the embryo or foetus as a result of the female Worker's Occupational Exposure to external Ionising Radiation in the period between conception and notification of pregnancy. Account should also be taken of any Doses that were (or that will be) received by the embryo or foetus or by the breastfed infant as a result of any intakes of radionuclides by the female Worker prior to the notification of pregnancy including intakes prior to conception.

7. Consideration should be given to whether the female Worker needs further information and training as a result of any change of working conditions to restrict Exposure of the embryo or foetus or of the breastfed infant.
8. Due to more stringent restrictions on Dose, female Workers should be monitored during and after pregnancy. Doses should be assessed with account taken of all relevant pathways of external Exposure and Internal Exposure.
9. Once the female Worker has notified her employer of her pregnancy, the monitoring programme should be redefined so as to be able to determine that the estimated Dose to the embryo or foetus or the breastfed infant (including the Dose from intakes by the female Worker prior to conception) that could be due to Occupational Exposure will not exceed 1mSv. Modification of the monitoring programme for Internal Exposure might be necessary because some radionuclides might be of more relevance for foetal Doses than for maternal Doses.
10. If there are indications that the Dose to the embryo or foetus or the breastfed infant might approach 1mSv/ year, individual monitoring of the female Worker and individual Assessment of the committed Dose to the embryo or foetus or the breastfed infant should be carried out. Dose reports should be available quickly to allow for prompt action to be taken if it is found that the Dose to the embryo or foetus or the breastfed infant might exceed 1 mSv/ year.
11. A shorter period (i.e. greater frequency) of monitoring may be advisable to keep a closer control over possible inadvertent Exposures. However, this frequency should be chosen in consideration of the recording level of the passive dosimeter or other techniques used. For dosimeters with a recording level of 0.1mSv, a monitoring period of less than one month might not be long enough to evaluate adequately the Dose to the foetus during the whole period after the notification of pregnancy. An active dosimeter might serve the purpose of maintaining alertness to any possible accidental Exposures. In all cases, the Dose recorded for the pregnant female Worker should be that of her regular dosimeter.
12. The calibration of dosimeters should be considered in assessing Doses to the embryo or foetus. For fields of penetrating Ionising Radiation, dosimeters that have been calibrated for the personal Dose equivalent $H_p(10)$ will give an overestimation of the Dose. However, this may not be the case for Ionising Radiation fields of high energy neutrons or of particles in accelerator facilities for which dosimeters calibrated for Doses at different depths below the surface are required.
13. Although it is not required to use an additional dosimeter on the abdomen, it can provide reassurance that attention is being given to any Exposure during pregnancy. The Licensee should consider the use of an appropriate dosimeter to monitor the Dose to the foetus. If the external Ionising Radiation is homogeneous, there is no preferred position on the abdomen for the dosimeter, but if the Ionising Radiation field is inhomogeneous, the

dosimeter should be positioned on that part of the abdomen that might be irradiated more significantly.

14. In the case of a suspected inadvertent intake, special monitoring should be carried out to ensure that the Dose limit for the embryo or foetus or for the breastfed infant will not be exceeded. Monitoring may be carried out by using whole body counting, individual organ counting (such as thyroid counting or lung counting) or in vitro analysis of the female Worker's excretions.
15. Information on the Dose to the embryo or foetus from maternal intakes of radionuclides has been published by the International Commission on Radiological Protection. This includes Dose coefficients based on biokinetic and dosimetric models that take into account the transfer of radionuclides from the pregnant female through the placenta, and photon Exposure due to radionuclides in the placenta and maternal tissues. The Dose coefficients expressed in units of sieverts per becquerel represent the committed effective Dose to the embryo or foetus per unit intake of radioactivity by the female Worker. Organ Dose coefficients for the foetus are also provided.
16. When there is an acute intake by a female Worker as a result of an Accident or other incident during or before pregnancy, the Dose coefficients of the International Commission on Radiological Protection can be used to calculate the committed organ Doses and effective Doses to the embryo or foetus. For chronic intakes, the Dose coefficients of the International Commission on Radiological Protection cover three scenarios: (i) chronic intake during pregnancy; (ii) chronic intake one year before pregnancy; and (iii) chronic intake five years before pregnancy.
17. In the Assessment of external Dose to the foetus, only penetrating Ionising Radiation should be considered. In the case of homogeneous Ionising Radiation fields for photons and beta Ionising Radiation, the Dose recorded by the female Worker's dosimeter will be a conservative estimate of the Dose to the foetus because by the time the female Worker has notified her employer of her pregnancy, the Dose at the depth of the foetus will be lower. In the case of inhomogeneous fields, a careful Assessment of the dosimeter results and the corresponding Dose to the foetus is necessary.

Health Surveillance

Article (12)

1. The Licensee should ensure that all Workers engaged in activities in which they could be subject to Occupational Exposure are provided with the necessary Workers' health surveillance and health services. For itinerant Workers who are subject to Exposure due to a source of Radioactive Material under the control of the Nuclear Power Plant at which they work, the management of that Nuclear Power Plant should make special

arrangements with the employer of the contracted Workers to ensure that they are provided with the necessary Workers' health surveillance.

2. The Licensee should make available (in the vicinity of the workplace) suitable facilities for medical examinations in connection with Workers' health surveillance.
3. The occupational health services should have the responsibilities listed below in relation to Workers' health surveillance.
 - a) Assessment of Workers' health.
 - b) Help to ensure initial and continuing compatibility between the health of Workers and the conditions of their work.
 - c) Establishment of a record that provides useful information in the case of:
 - i. Accidental Exposure or occupational disease.
 - ii. Statistical evaluation of the incidence of diseases that might relate to the working conditions.
 - iii. Assessment for public health purposes of management in relation to Radiation Protection and Safety in facilities in which Occupational Exposure can occur.
 - iv. Medical–legal enquiries.
 - d) Counselling for Workers on any Ionising Radiation risks to which they might be subjected, and the provision of an advisory and treatment service in the event of personal contamination or Exposure in excess of the Dose limits.
4. The occupational physician in charge of the programme for Workers' health surveillance should have the responsibilities listed below.
 - a) Carrying out medical examinations of Workers.
 - b) Advising management periodically on the fitness of Workers for their intended tasks on the Worker's health state and the employer's requirements for the job.
 - c) Granting clearance for the return of Workers to their normal working environment after being removed from that environment on medical grounds.
 - d) Giving advice on the arrangements for hygiene at work and the removal of contamination from wounds in consultation with the Qualified Expert, as appropriate.

5. The occupational physician should be knowledgeable through training, and retraining when necessary on the biological effects of Ionising Radiation Exposure, the means of control of Exposure, and the interpretation of Exposure data and dosimetric Assessments. With the support of specialists, as appropriate, the occupational physician should be in a position to use this knowledge in the programme for Workers' health surveillance and to provide counselling to the categories of Workers listed below on radiological health risks.
 - a) Occupationally exposed Workers who suspect that they are pregnant or who may become pregnant, or who are breast-feeding.
 - b) Individual Workers who have received, or who may have received, an Exposure substantially in excess of the Dose limits.
 - c) Workers who may be worried about their Ionising Radiation Exposure.
 - d) Workers who request such counselling.
6. In order to be able to make judgements about the Worker's fitness for duty, the occupational physician should be familiar with the tasks in the workplace and the conditions in the working environment.
7. The occupational physician should take responsibility for case management in the event of a suspected Exposure in excess of the Dose limits. This should include the submission of details of the case to relevant Qualified Experts, the counselling of the Worker, and the briefing of Workers' representatives and the Worker's family members if appropriate.
8. The main elements of the programme for Workers' health surveillance should be:
 - a) Assessment of the Workers' health for the purpose of ensuring that they are fit to undertake the tasks assigned to them.
 - b) Establishment and Maintenance of confidential medical records.
 - c) Arrangements for dealing with accidental Exposures, Exposures in excess of the Dose limits and subsequent follow-up.
 - d) Provision of medical advice to management and Workers.
9. Medical examinations of Workers should be carried out before the start of employment, periodically thereafter, and at the termination of employment.
10. A medical history and Assessment should be established for each Worker for the purposes listed below.
 - a) To determine fitness for the specific work for which the Worker is to be employed.

- b) To provide a baseline for use in the consideration of changes to specific work practices.
 - c) To provide a baseline for use in assessing an occupational illness or Exposure in excess of the Dose limits.
11. The initial medical examination should be aimed at assessing the Worker's health and fitness for the intended tasks and identifying whether the Worker has a condition that might necessitate special precautions during work. However, it should be rare for the Ionising Radiation component of the working environment to influence significantly the decision about the fitness of a Worker to undertake work with Ionising Radiation, or to influence the general conditions of service. The medical conditions that the occupational physician should look out for include those that would affect the ability to use and wear protective clothing and equipment, the ability to hear alarms and respond to Ionising Radiation hazards, and the ability to use specialised tools and equipment.
12. Fitness for work with Ionising Radiation depends on the Worker's health state and the type of work involved as illustrated by the examples listed below.
- a) If a Worker's duties are such that the use of respiratory protective equipment is required, the occupational physician should examine the fitness of the Worker to wear respiratory protective equipment including checks on the integrity of lung function.
 - b) If a Worker is engaged in the handling of unsealed Radioactive Sources, fitness for work could be influenced by the presence of skin conditions such as dermatitis, eczema or psoriasis. In such cases the decision regarding fitness should be based on the nature, extent and development of the skin condition, and the nature of the job. Workers with such conditions should not necessarily be excluded from work with unsealed radioactive substances if the levels of radioactivity are low and provided that appropriate precautions (such as covering the affected parts of the body) are taken.
 - c) If a Worker is required to work with Radioactive Material, fitness for work could be influenced by a neurological or psychological disorder. In such cases, the decision on fitness should take account of the Safety implications of symptomatic episodes of such a disorder. The primary concern is whether such Workers could represent a danger to themselves or to their co-Workers or the public.
13. There is no inherent reason why a Worker who has previously undergone radiotherapy should be excluded from work with Ionising Radiation. Each case should be evaluated individually by taking into account the outcome of the radiotherapy treatment, the general prognosis and other health considerations, the understanding and wishes of the Worker, and the nature of the work.

14. In the periodic medical examinations, the occupational physician should confirm that no clinical condition that could prejudice the health of the Worker has developed during work in areas involving occupational health hazards including hazards due to Ionising Radiation. The nature of a periodic medical examination should depend on factors such as the type of work that is undertaken, the age and health status, and possibly the habits of the Worker (e.g. smoking habits). For example:
- a) The skin should be examined where the nature of the work creates a potential for localised skin damage from Exposure particularly of the hands.
 - b) A Worker who has already received accumulated Doses to the lens of the eye of more than 0.5 Gy, or who could after a few more years accumulate Doses in excess of this level may need to be subject to regular ophthalmological examination. This relates to the risk of detectable opacities and visual impairment, which might affect the ability of the Worker to carry out the intended tasks e.g. carrying out image guided interventional procedures.
15. The frequency of periodic medical examinations should be based on the health state of the Worker and on the type of work involved. Exposure to Ionising Radiation should not in itself be a reason for carrying out periodic medical examinations more frequently than usual. A medical examination for visitors and visitors who assist with work activities for a limited duration (less than or equal to 7 days) is not required. Visitors who assist with work activities are subject to the FANR dose limits for the public, specified in Article (4) of FANR-REG-04. As such, additional controls should be in place to prevent exceedance of these limits.
16. On completing a medical examination, the occupational physician should communicate the conclusions in writing to both the Worker and the employer. These conclusions should not contain information of a medical nature, but should at least categorise the Worker as one of the following:
- a) Fit for work in a specific job or trade.
 - b) Fit for such work with certain restrictions e.g. no work necessitating respiratory protective equipment.
 - c) Unfit for the work in question.

With regard to point C above, the occupational physician should have the authority to declare Workers temporarily or permanently unfit on medical grounds for their regular work or to recommend the transfer of a Worker to other work. The occupational physician should also have the authority to advise the employer on reinstating such Workers in their normal duties on medical grounds.

17. In the case of an observed ailment likely to have been caused by prevailing working conditions, the occupational physician should advise the management of the need to investigate the working conditions. Where appropriate, the management should take corrective actions in consultation with the occupational physician.
18. Workers should be encouraged to report any significant ailment promptly to the occupational physician.
19. Workers should report any suspected inadvertent intake of radioactive substances to their supervisor and the Radiation Protection organisation. The occupational physician should be informed if it is suspected that an inadvertent intake exceeds a limit specified by FANR and should be advised of the outcome of any investigation to establish whether such an intake has actually occurred. The occupational physician may be made part of the proceedings for the investigation of the Exposure in excess of the Dose limits.
20. Health surveillance records should be stored according to national regulations on a time-scale similar to that for Dose records as defined in Article (12)7 of FANR-REG-11.
21. The exposed Worker should receive medical attention that is appropriate for the Doses that they may have received. Screening based on equivalent Doses to specific radiosensitive organs as a basis for medical follow-up and counselling should be provided if an exposed Worker has received an Effective Dose exceeding 100 mSv over a period of a month or if the Worker so requests. Although an Emergency Worker or an accidentally exposed employee who receives Doses in a nuclear or radiological Emergency should not be precluded from incurring further Occupational Exposure, qualified medical advice should be obtained before allowing further Occupational Exposure where a Person has received an Effective Dose exceeding 200 mSv. Such advice should also be made available at the request of the Worker. Such qualified medical advice is intended to assess the continued health and fitness of the Worker.

Workplace and Individual Monitoring

Article (13)

1. The workplace and individual monitoring programme, which is usually part of the Radiation Protection programme should be under management that is independent of the operations department and reports directly to the head of Radiation Safety.
2. Three types of Workplace Monitoring and individual monitoring should be conducted for Radiation Protection as listed below.
 - a) Routine monitoring should be conducted to demonstrate that the working environment is adequate for continued operations and that no change has taken place that would call for a reassessment of operational procedures.

- b) Task-related monitoring should be conducted to supply information about a particular task or operation, and to provide, if necessary, a basis for immediate decisions on the execution of the task.
 - c) Special monitoring should be undertaken following major modifications to either facilities or procedures, or when operations are being carried out under abnormal circumstances such as those following an incident or an Accident.
3. Investigation Levels for individual Doses and intakes should be set by the Licensee on the basis of expected levels of individual Dose. Investigation Levels for Workplace Monitoring should be set on the basis of the expected levels of Dose rate, contamination and operational experience.
4. An appropriate service for calibration and quality assurance should be provided for all monitoring instruments used in the Nuclear Power Plant and included in the Radiation Protection programme. The service should ensure traceability to national standards' laboratories. The instruments available should cover measuring ranges that extend from below any applicable reference level up to Ionising Radiation levels anticipated to prevail under Accident conditions.
5. All Ionising Radiation monitors and contamination monitors both permanently installed and hand-held as well as personal dosimetry systems should be periodically calibrated, tested and maintained according to a Quality Assurance programme in respect of:
- a) Quality of equipment and instruments.
 - b) Frequency of calibration, which should be in accordance with the manufacturers recommendations as a minimum.
 - c) Frequency of Maintenance.
 - d) Traceability of usage.
6. Dosimetry systems should be type tested according to the relevant standard (potential standards include but are not limited to European Standards, International Electrotechnical Commission, International Organization for Standardization, etc.). Failure of any part of the type testing should be clearly justified and documented.
7. Dosimeters in use should be fully tested and the results of these tests available. Fully tested means the determination of the dosimetric performance characteristics, including detection limit; tests of influence quantities; tests of the reliability of the complete system, including system software. For reusable dosimeters, the individual normalization/calibration factor should be checked periodically and adjusted if necessary.

8. The main objectives of radiological monitoring and surveying are: to provide information about the radiological conditions at the Nuclear Power Plant and in specific areas before and during a task; to ensure that the area designation remains valid; and to determine whether the levels of Ionising Radiation and contamination are suitable for continued work in the area.
9. This surveillance should be carried out by means of an appropriate combination of fixed monitors for Ionising Radiation and air contamination, and through periodic monitoring and sampling by trained Workers. Since radiological conditions are rarely uniform throughout an area, the location of fixed monitors for use in assessing ambient radiological conditions should be given careful consideration. Wherever fixed monitors are provided, they should be located where major or rapid changes in Ionising Radiation levels, Dose rates or levels of air contamination (caused by gases, iodine or particulates) may occur, and should incorporate alarms that indicate if a reference level has been exceeded. In areas where frequent occupancy is expected, consideration should be given to providing fixed monitors.
10. The frequency of monitoring and surveys as well as the types and locations of the measurements to be taken should be designated on radiological surveillance forms as part of the Radiation Protection programme and updated as necessary in accordance with the prevailing conditions.
11. Special surveys may be undertaken to meet specific problems e.g. if high levels of airborne contamination or loose surface contamination are suspected, or when routine monitoring reveals unusual or abnormal conditions such as the occurrence of an area of elevated radioactivity.
12. The Licensee should ensure that equipment necessary for the Radiation Protection programme is provided including various instruments for measuring Ionising Radiation and for sampling and analysis. The quantities and types of equipment provided should be adequate for anticipated needs in Normal Operation and Emergencies, and account should be taken of radiological conditions prevailing and suspected or expected to prevail in the local area.
13. The equipment to be provided for measuring Ionising Radiation and radioactivity and for sampling and analysis should include:
 - a) Counting instruments and shields for measuring radioactivity and for the analysis of Radioactive Material.
 - b) Instruments for Ionising Radiation surveying and monitoring including those for environmental monitoring.
 - c) Fixed instruments for monitoring external Ionising Radiation, airborne contamination and process radioactivity.

- d) A small items monitor for Ionising Radiation monitoring out of potentially contaminated areas.
 - e) Worker monitoring instruments including:
 - i. Worker monitoring dosimeters (some with Dose rate or Dose alarm devices).
 - ii. Contamination monitors such as portal monitors and hand and shoe monitors.
 - iii. Portable monitors.
 - f) Air samplers.
 - g) Radioactive Sources, instruments and other devices necessary for the calibration and/ or performance verification of Ionising Radiation measuring and Ionising Radiation analytical instruments and air samplers.
14. The reliability of the monitoring for the Assessment of internal and external Doses depends on many factors including: functional testing; periodic Maintenance and performance testing of the instruments used for these measurements; the calibration methods; and the qualification of the staff involved. Likewise, the traceability of these measurements and the retrievability of Dose Assessments should be given appropriate consideration. An adequate Quality Assurance system should be implemented so as to confirm the validity of the results of the assessment.
15. The Licensee should develop a preventive Maintenance schedule for all Ionising Radiation monitoring systems. The performance of monitoring systems should be tested. Performance testing should always include calibration of the instrument and verification of the calibration facilities. These steps will ensure that Doses are being assessed correctly, which in turn will enable the Nuclear Power Plant management to confirm the adequacy of controls exercised in the workplace.
16. For any Worker who is employed in a Controlled Area, or who occasionally works in a Controlled Area and may receive significant Occupational Exposure, individual monitoring should be carried out. The Authority also recommends individual monitoring for any Worker who is likely to receive more than 10% of the annual Dose limit of 20 mSv. For most cases individual monitoring means that Workers should wear personal dosimeters.
17. The Assessment of individual external Exposure is readily carried out by individual monitoring. For routine monitoring, an integrating personal dosimeter should be worn. These dosimeters should be processed, and the results evaluated at appropriate intervals by an accredited monitoring service. Task related and special individual monitoring is

normally carried out by real time self-reading dosimeters often with additional warning functions.

18. Whenever established procedures allow persons such as occasional visitors to enter a Controlled Area without individual monitoring dosimeters, provisions should be made to ensure that their Doses can be estimated either on the basis of the Dose rates and the time spent in the various areas or by referring to dosimeters worn by persons accompanying them. In some cases, there should also be individual monitoring of occasional visitors.
19. If a Worker is liable to receive an equivalent Dose to the extremities, skin or lens of the eye that is a sizeable fraction of the relevant Dose limit, the individual dosimetry employed should be capable of providing the information needed for an Assessment of the equivalent Dose to the tissue or organ concerned. In situations with non-homogeneous exposure conditions for which whole body monitoring does not provide an adequate estimate of the Dose to the skin, extremities or lens of the eye, these tissues and organs should be monitored separately. For example:
 - a) Monitoring of hands and fingers should be considered for workplaces where extremities are particularly close to the Ionising Radiation emitter or Ionising Radiation beam.
 - b) Monitoring of skin should be considered for workplaces where skin is close to the Ionising Radiation emitter or Ionising Radiation beam or can become contaminated for instance in the handling of unsealed Radiation Sources.
 - c) Monitoring of the lens of the eye should be considered in workplaces where the eyes are particularly close to the Ionising Radiation emitter (which can also be a source of stray Ionising Radiation) or the Ionising Radiation beam.
20. When extremity dosimeters are used, they should be worn in positions that will measure the Dose to the areas of the body expected to receive the highest Dose. Often, the location of the maximum Dose to the skin or to an extremity is not known in advance, or it is not practicable to wear a dosimeter at these extremities. In such cases, a correction factor should be used to estimate the maximum Dose.
21. When it is necessary to monitor the Dose to the lens of the eye, the personal Dose equivalent $H_p(3)$ should be ideally measured. However, suitable $H_p(3)$ dosimeters are not widely available and in certain circumstances the measurement of $H_p(0.07)$ or sometimes $H_p(10)$ can provide a sufficiently accurate estimate of $H_p(3)$. The need for a separate eye lens dosimeter and its positioning on the body depends on the type, energy, direction and homogeneity of the Ionising Radiation field as well as on the use of shielding:
 - a) For neutron Ionising Radiation where homogenous Ionising Radiation fields are usually present, separate eye lens dosimetry is not necessary because neutron

whole body monitoring usually gives a conservative estimate of the Dose to the lens of the eye irrespective of the energy and direction of incidence of the Ionising Radiation.

- b) For photon Ionising Radiation, separate dosimetry for the lens of the eye is usually the only suitable method for determining the Dose to the lens of the eye in the following circumstances:
- i. If the Ionising Radiation field is inhomogeneous, the dosimeter should always be located near the eyes, if possible, in contact with the skin and facing towards the Radiation Source.
 - ii. It is usually acceptable to measure $H_p(0.07)$ but not $H_p(10)$; however, the measurement of $H_p(10)$ may also be acceptable if the mean photon energy is greater than about 40 keV and if the Ionising Radiation is mainly from the front of the face, or the person is moving in the Ionising Radiation field.
 - iii. If eye shielding in the form of lead glasses is used, the dosimeter should preferably be located behind the eye shielding; where this is not practicable, the dosimeter should be worn above (or next to) the eyes and possibly covered by a filter that mimics the attenuation provided by the lead glasses.
 - iv. If shielding for the trunk (e.g. a lead apron) is used, monitoring near the eyes is necessary because monitoring behind the shielding does not give a true estimate of the Dose to the lens of the eye.
- c) For beta Ionising Radiation, monitoring is necessary only if the maximum beta energy exceeds 700 keV since beta Ionising Radiation of lower energy does not penetrate the lens of the eye in the following circumstances:
- i. If eye shields (e.g. glasses) are used that are thick enough to absorb the beta Ionising Radiation; only photon Ionising Radiation should be considered, but account should be taken of any bremsstrahlung contributions (both outside and behind the shielding) produced by high energy beta Ionising Radiation.
 - ii. If adequate eye shields are not used, separate dosimetry for the lens of the eye is necessary and $H_p(3)$ is the quantity that should be measured.

As beta Ionising Radiation fields are usually rather inhomogeneous, the dosimeter should be positioned near the eyes.

22. Workers who work under conditions in which Internal Exposures may occur should be appropriately monitored. This monitoring should be carried out on a routine or an occasional basis depending on the particular working conditions. Internal contamination should be assessed as far as possible by the use of indirect measurements such as the analysis of excreta or by whole or partial body counting. If, for the potential intake of Radioactive Material, it is not feasible to make any measurements immediately after the intake, other methods based on the calculation of intakes can be used to obtain an approximation. The results of Workplace Monitoring or special surveys as well as readings of personal air samplers may be useful.
23. The Licensee should maintain records showing the results of surveys and calibrations. These records should be retained for at least three years after the record is made.
24. The Licensee should retain each of the following records until the Authority terminates each pertinent Licence requiring the record:
- a) Records of the results of surveys to determine the Dose from external Radioactive Material and used in the absence of (or in combination with) individual monitoring data in the Assessment of individual Dose.
 - b) Records of the results of measurements and calculations used to determine the individual intake of Radioactive Material and used in the Assessment of internal Dose.
 - c) Records showing the results of air sampling, surveys and bioassays required according to the use of respiratory protection.
25. The Licensee is responsible for the Accreditation of the measurement of the following quantities (as a minimum):
- a) Measurement of individual monitoring personal Dose equivalent $H_p(10)$, and/ or $H_p(3)$, and/ or $H_p(0.07)$, and the parameters required for the National Dose Registry (see Annex A).
 - b) Measurement of ambient Dose equivalent $H^*(10)$ or ambient Dose equivalent rate $H^*(10)/t$.

Recording and reporting Occupational Exposure Data

Article (14)

1. The Licensee should report the Doses received by each Worker to the Authority during each half calendar year (1 January to 30 June and 1 July to 31 December) within two months of the end of each period.

2. The Licensee should provide the data to the Authority in a format agreed with the Authority using a method defined by the Authority for import into the UAE National Dose Registry.
3. The Licensee should (as a minimum) provide the data presented in Annex A in addition to any other data requested by the Authority.
4. For the purposes of compliance with 100 mSv over five years as defined in Article (3) of FANR-REG-04, the five-year period starts on 1 January 2018 and ends on 31 December 2022, and continues to repeat in fixed five-year calendar blocks of time.
5. The Licensee should maintain the records of Dose to an embryo/ foetus with the records of Dose to the declared pregnant Worker. The declaration of pregnancy should also be kept on file, but may be maintained separately from the Dose records.

Training

Article (15)

1. Qualifications needed for the head of Radiation Safety as well as those needed for other positions in the Radiation Protection organisation should be clearly established and implemented.
2. The Licensee should ensure that there are sufficient numbers of adequately trained and authorised staff working in accordance with approved and validated procedures. For Workers engaged in activities that involve or could involve Occupational Exposure, the Licensee should ensure that suitable and adequate human resources and appropriate training in Radiation Protection and Safety be provided as well as periodic retraining and updates as required in order to ensure the necessary level of competence.
3. The Licensee is responsible for the recruitment and training of all Workers and for the definition of levels of competence necessary to carry out various duties. Training should be provided so as to ensure that site Workers attain and maintain the necessary level of competence to carry out their duties and for their level of responsibility. Furthermore, skills should be acquired in training so as to help Workers to work efficiently and to respond effectively to changing circumstances, and thus to reduce their Exposure to Ionising Radiation.
4. The Licensee should make arrangements for all Nuclear Power Plant staff to be adequately trained and confirmed to be as proficient in measures for Radiation Protection as necessary for the duties that they will be expected to undertake and for the responsibilities allocated to them.

5. Training for Workers should cover all topics relevant to the Ionising Radiation task assignments and the potential risks. Those who need to work in areas of high Ionising Radiation levels should be trained in their specific work activities so as to enable them to carry out their duties in the minimum possible time to Optimise Exposure. This could include, for example, training on mock-ups, rehearsing the planned work and practising Emergency actions.
6. Training measures should cover the topics listed below to a level of detail commensurate with the assigned tasks and responsibilities of the respective Worker or supervisor.
 - a) Main types of Ionising Radiation and their effects.
 - b) Basic quantities and units in Radiation Protection.
 - c) Basic Radiation Protection and Safety procedures including the effects of time, distance and shielding on reducing Exposure.
 - d) Principles of Radiation Protection and Radioactive Waste Management (concerning Optimisation of Radiation Protection and Safety, Dose limits and the minimisation of Radioactive Waste).
 - e) Use of protective equipment such as shielding and protective clothing.
 - f) Use of survey meters and contamination monitors, and individual internal and external monitoring including Dose assessment.
 - g) Potential risks associated with the Operation of the Nuclear Power Plant.
 - h) Rules and procedures at the Nuclear Power Plant especially specific task related issues.
 - i) Warning signs, alarm signals and information on appropriate actions to be taken.
 - j) Contamination control, decontamination and reduction of sources of Radioactive Material.
 - k) Responsibility to inform designated persons immediately in the event of any unforeseen occurrence entailing increased risks in relation to Ionising Radiation.
 - l) Actions that should be taken in the event of a nuclear or radiological incident or an Accident, where appropriate.
 - m) Regulations for the safe transport of Radioactive Material on and off the site.
 - n) Safety criticality for Nuclear Fuel.
 - o) Behaviour in Controlled Areas and Supervised Areas.

7. Training should be provided so as to ensure that the required skills and knowledge are efficiently transferred. For example, this could be achieved by means of manuals and other written documents, lectures and discussions, demonstrations, instructions, exercises, training on mock-ups, on-the-job training and rehearsals of planned work.
8. Individuals whose assignments are incidental to the use of Ionising Radiation and who may spend only brief periods in areas where Exposure is possible should be provided with relevant basic information. Such information should cover issues such as: relevant and applicable local rules; the response to Ionising Radiation alarms; and basic Radiation Protection and Safety procedures including the effects of time, distance and shielding on reducing Exposure. The risks associated with such individuals' levels of Exposure, the potential hazards to which they may be subjected and the directives that apply in relation to prohibited actions should also be covered.
9. The Licensee should ensure that any Workers of other organisations who are employed on the site particularly Workers of the contractors have received training adequate to enable them to carry out their work so as to meet the required standards of Safety and quality. Special arrangements should be made so that temporary Workers whose normal place of work is elsewhere can become familiar with the relevant Safety rules relating to their task in the Nuclear Power Plant. In specific instances, a qualified individual may be provided as a full-time escort for temporary Workers in lieu of providing them with training.
10. Training should be repeated regularly, and particularly after changes in the task or significant changes or modifications to equipment, procedures or policies at the Nuclear Power Plant so as to ensure that the required level of competence is maintained and that the implications of the changes for Radiation Protection and Radioactive Waste Management are understood. For this purpose, records should be kept showing what type of training each person has undergone and when. Training programmes should be updated at regular intervals. In updating training procedures, the Licensee should take into account new recommendations and feedback from Inspections by the Authority, and operational feedback on events at the Nuclear Power Plant and from other relevant Nuclear Power Plants as well as any feedback from Workers on training needs.
11. Female Workers who work in Controlled Areas should be provided with appropriate information on the radiological risks to a foetus or embryo and the importance of notifying their employer of their pregnancy.
12. Adequate records of training should be maintained. Training records should include the following:
 - a) Worker's name, identification details, employee name, employee number, etc;

- b) Inclusive dates for each segment of training or for each different training programme.
- c) A specific description of all training completed adequately including references to pertinent lesson plans, course outlines, syllabuses, and other subject-specific descriptive information. Specific reference is usually made to such materials by date, edition and issue applicable to each Worker.
- d) A performance rating for each segment of training or each different training programme adequately completed by the Worker. This rating normally consists of a numerical or letter grade or a written evaluation.
- e) The source of the training i.e. the training facility and its location.

Dosimetry

Article (16)

1. Details of how and when to wear dosimeters are found below.

- a) Article (12) of FANR-REG-11 requires Licensees to provide individual monitoring for any Worker who is employed in a Controlled Area or who occasionally works in a Controlled Area and may receive significant Occupational Exposure. The Authority also recommends individual monitoring for any Worker who is likely to receive more than 10% of the annual Dose limit of 20 mSv in any one year. For most cases individual monitoring means that Workers must wear personal dosimeters.
- b) Licensees must also assess the Occupational Exposure of any Worker who is regularly employed in a Supervised Area or who enters a Controlled Area only occasionally. However, this may be done on the basis of workplace monitoring, so that personal dosimeters for these Workers are not required.
- c) In order to ensure that personal dosimeters are always worn in Controlled Areas and to avoid the risk of dosimeters being mislaid, the Authority recommends that Workers who are required to wear personal dosimeters simply wear them throughout the work day. Licensees should store the dosimeters of off-duty employees at a single location along with a control dosimeter.
- d) In most cases, a single dosimeter worn on the torso is adequate. The side of the dosimeter facing the body should be consistent with the provider's instructions so the body does not inadvertently shield the dosimeter. For strongly penetrating Ionising Radiation, the dosimeter should be placed in a position at which the highest Exposure on the surface of the trunk is expected. For Ionising Radiation coming primarily from the front, or when the Exposure to Ionising Radiation is

expected to be rotationally symmetrical or isotropic, the dosimeter should be worn on the front of the torso between the shoulders and the waist. Dosimeters to assess Doses to the lens of the eye should be worn near the eyes (e.g. on the forehead or a cap). In situations where there may be significantly varying fields of Ionising Radiation or the potential for inadvertent Exposure, alarming dosimeters should be worn in addition to ordinary dosimetry.

- e) In order to obtain a better measurement of the Effective Dose received in an inhomogeneous field of Ionising Radiation, it is useful for Workers to wear additional dosimeters on other parts of the body. In some special situations, where protective clothing such as personal shielding is used, the Authority recommends the use of one dosimeter under the personal shielding worn at waist level, and one outside the personal shielding on an unshielded part of the body, which could be on the torso, on the collar or at shoulder level. The purpose of the two dosimeters is to determine the Effective Dose received by the shielded and unshielded parts of the body. If only one dosimeter is available, it should be worn beneath the apron.
- f) For cases where the maximum Dose to extremities is expected to be at least ten times greater than the Dose to the surface of the whole body, one or more extremity dosimeters should be worn in positions that will measure the Dose to the area(s) expected to receive the highest Dose.

2. Details of the frequency of dosimeter readings are found below.

- a) In most cases dosimeters should be read monthly. For some low Dose situations, quarterly readings are acceptable.

3. Details of how to identify personal dosimeters are found below.

- a) The Authority recommends that Licensees assign personal dosimeters to individuals using both their full name and a unique identification number such as their passport number, and that they use the full names and the unique identification numbers when they send dosimeters to laboratories for reading. The use of full names reduces the likelihood that the Doses reported by a laboratory will be allocated incorrectly. The unique identification number prevents confusion if two persons have the same name.
- b) Licensees should keep Workers' Dose and health surveillance records by using their full names so that it will be easier for the Authority to construct the entire Dose record of a Person who has received Doses from more than one employer.

4. Details of approved dosimetry services are found below.

- a) Article (12) of FANR-REG-11 requires Licensees to use accredited licensed dosimetry services. The Licensees should use licensed dosimetry services

accredited by the Emirates National Accreditation System (ENAS). Licensees wishing to use other dosimetry services formally approved by other organisations should contact the Authority to learn whether it accepts approval by that organisation.

5. Details of how to estimate Doses when dosimeters are lost or damaged are found below.

- a) Dose estimation when dosimeters are lost or damaged may be done several ways. Acceptable methods are provided below. Licensees should use the method that best fits their circumstances, and include the reasons for using that method in the documentation of the estimate. If appropriate, more than one method may be used.
 - i. A Qualified Expert will review the dosimetry history and an official Dose should be assigned based on an average from previous monitoring periods or the highest Dose recorded during his or her employment.
 - ii. A Qualified Expert will assign to the individual who has lost or damaged his or her dosimeter a Dose based on the Dose received by a co-Worker who has performed similar tasks during the monitoring period in question.
 - iii. A Qualified Expert will assign a Dose based on known area Dose rates and estimate the time spent by the individual who has lost or damaged his or her dosimeter.
 - iv. The Dose assigned to the individual who has lost or damaged his or her dosimeter is equivalent to the highest Dose received by a co-Worker during the monitoring period in question.
 - v. The summed values for the work period from electronic personal dosimeters.
 - vi. Other method with an appropriate justification.
- b) Licensees should have a written procedure for estimating Doses where a dosimeter has been lost or damaged. If a dosimeter is lost or damaged, Licensees should document how they estimated the Dose and the actions they have taken to prevent dosimeters from being lost or damaged in the future.

Annex A – Minimum Parameters for Reporting Occupational Exposure Data

Licensee

Information	Required (yes/no)	Notes or Required Format
Licensee Name	Yes	
Licensee Number	Yes	
Licensee Address	Yes	
Licensee Phone Number	Yes	
Licensee e-mail	Yes	

Dosimetry Provider

Information	Required (yes/no)	Information
Approved Dosimetry Service (ADS) Provider's Name	Yes	N/A if Licensee processes own dosimetry
ADS Primary Identification Number	Yes	N/A if Licensee processes own dosimetry
ADS Address	Yes	N/A if Licensee processes own dosimetry
ADS Phone Number	Yes	N/A if Licensee processes own dosimetry
ADS e-mail	Yes	N/A if Licensee processes own dosimetry

Worker

Information	Required (yes/no)	Notes or Required Format
First Name	Yes	
Middle Name(s)/ Initial	Yes	
Last Name	Yes	
Birth Date	Yes	DD-MM-YYYY
Gender	Yes	Male, Female
Pregnant Worker	Yes	Yes, No, N/A
Declaration of Pregnancy	Yes	DD-MM-YYYY, N/A

Information	Required (yes/no)	Notes or Required Format
Revocation of the Declaration of Pregnancy	Yes	DD-MM-YYYY, N/A
Conclusion of Pregnancy	Yes	DD-MM-YYYY, N/A
Declaration of Declaration of Breast Feeding	Yes	DD-MM-YYYY, N/A
Revocation of the Declaration of Breast Feeding	Yes	DD-MM-YYYY, N/A
Nationality	Yes	
Identification Number (Emirates ID if available)	Yes	
Identification Type	Yes	Enter the type of ID: <ul style="list-style-type: none"> • Emirates ID • Passport Number • Work Permit Number • Other
Occupation/ Activity	Yes	Enter the type of occupation/ activity:

Dose

Information	Required (yes/no)	Notes or Required Format
Record/ Estimate	Yes	
Type of Exposure	Yes	Routine/ Planned Special Exposure/Emergency-Accident
Monitoring Period	Yes	DD-MM-YYYY to DD-MM-YYYY
External Dose Hp(0.07)	Yes	For the monitoring period in Sv/ mSv/ μ Sv

Information	Required (yes/no)	Notes or Required Format
External Dose Hp(10)	Yes	For the monitoring period in Sv/ mSv/ μ Sv
Internal Dose	Yes	For the monitoring period in Sv/ mSv/ μ Sv
Effective Dose	Yes	For the monitoring period in Sv/ mSv/ μ Sv
Effective Dose Annual Total	Yes	Total for the current year in Sv/ mSv/ μ Sv
Effective Dose Five Year Total	Yes	Total for the current five-year period in Sv/ mSv/ μ Sv
Organ Dose ¹	Yes	For the monitoring period in Sv/ mSv/ μ Sv
Lens (eye) Dose ¹	Yes	For the monitoring period in Sv/ mSv/ μ Sv
Lens (eye) Annual Dose ¹	Yes	Total for the current year in Sv/ mSv/ μ Sv
Lens (eye) Five-Year Total ¹	Yes	Total for the current five-year period in Sv/ mSv/ μ Sv
Extremity Dose ¹	Yes	For the monitoring period in Sv/ mSv/ μ Sv
Extremity Annual Dose ¹	Yes	Total for the current year in Sv/ mSv/ μ Sv
Dose Correction - Period	Yes	dd-mm-yyyy to dd-mm-yyyy
Dose Correction Dose value	Yes	Sv/ mSv/ μ Sv

¹ Dose will be provided if separate to whole body Dose.