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Report of a Technical Committee meeting held in Vienna, 8–12 May 2000

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FOREWORD

The nuclear fuel cycle consists of a broad range of installations including mining and milling, conversion, enrichment, fuel fabrication (including mixed oxide fuel), reactor, interim spent fuel storage, reprocessing, vitrification and waste disposal facilities.

Although some similar safety hazards may be posed at reactor and non-reactor fuel cycle facilities, the differences between them give rise to specific safety concerns at the non-reactor fuel cycle facilities that must be especially taken into consideration in the design and operation of these facilities.

In 1999 the IAEA initiated the compilation of information on the status of national regulations and safety issues for nuclear fuel cycle facilities other than NPPs. It was found that more than 250 facilities of different types and capacities are operating and some 60 others are under construction worldwide. The IAEA's incident reporting records show that over the last eight years there were more than 25 events in these facilities, of varying significance, including the criticality incident which occurred at Tokai Mura in Japan in September 1999. To reflect the importance of the lessons learned from past experience, some countries are currently revising their relevant national legislation.

In order to compile information on the nature of the safety concerns and current status of the regulations concerning nuclear fuel cycle facilities in Member States an IAEA Technical Committee meeting on this topic was convened from 8 to 12 May 2000 in Vienna. The present publication contains the results of this meeting. The contributions of the participants in Annex 3 exemplify the work done in some Member States to develop an adequate regulatory framework to oversee the safe operation of these facilities.

The contributions of the participants of this meeting and their help in the drafting and review of this report are greatly appreciated. The IAEA officers responsible for this publication were V. Ranguelova and F. Niehaus of the Division of Nuclear Installation Safety.

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1. INTRODUCTION

The nuclear fuel cycle consists of a broad range of installations including mining and milling, conversion, enrichment, fuel fabrication (including mixed oxide fuel), reactor, interim spent fuel storage, reprocessing, vitrification and waste disposal facilities.

In 1999 the IAEA initiated the compilation of information on the status of national regulations and safety issues concerning nuclear fuel cycle facilities other than NPPs. It was found that more than 250 facilities of different types and capacities are operating and some 60 others are under construction worldwide. The IAEA's incident reporting records show that over the last eight years there have been more than 25 events in these facilities, of varying significance, including the criticality incident which occurred at Tokai Mura in Japan in September 1999. To reflect the importance of the lessons learned from past experience, some countries are currently revising their relevant national legislation.

The major safety issues with the fuel cycle facilities are largely determined by the great variety and diversity of technologies and processes being employed. In addition, there is an extensive reliance on operators and administrative controls. Thus operators' 'hands-on' involvement is common, frequent changes in operations are made and there are often chemical hazards associated with the nuclear hazard. Although some similar safety risks may be posed at reactor and fuel cycle facilities, the differences between them give rise to specific safety issues at the fuel cycle facilities that must be taken into account when these facilities are designed and operated.

Against this background the IAEA convened a Technical Committee meeting from 8 to 12 May 2000, to prepare a report on safety aspects and national regulatory practices with respect to nuclear fuel cycle facilities other than NPPs. The need for the IAEA to develop a limited number of safety standards to address specific safety issues for the non-reactor fuel cycle facilities was also discussed and the TCM recommendations on this subject are included in the last section of the present report.

Section 2 gives some general information on the technological processes utilized at different type of facilities, while Section 3 provides information on different safety aspects, such as criticality, radiation, chemical toxicity, fire and explosion hazards recognizing that the hazards vary from facility to facility depending upon the process employed, age, throughput, inventory, and material condition. Safety relevant experience gained from the operation of the nuclear fuel cycle facilities; the number and types of such facilities under operation worldwide and different regulatory systems are discussed in Sections 4, 5 and 6 respectively. The IAEA safety standards documentation relevant for these facilities is outlined in Section 7.

The information presented in Annex 3 on various regulatory systems established in Member States to oversee the safe operation of nuclear fuel cycle facilities might be of interest for a wide range of experts from the regulatory bodies and industry when deciding on the type and nature of the national safety regulations to be used for such facilities.

Throughout this report "fuel cycle facilities" is taken to refer generally to nuclear installations other than nuclear power plants or research reactors. Transportation, interim storage facilities and waste treatment facilities are also generally excluded

2. THE FUEL CYCLE

The nuclear fuel cycle consists of a broad range of installations that employ a variety of technologies to process and utilize uranium and plutonium. These facilities include mining and milling, conversion, enrichment, fuel fabrication, reactor, interim spent fuel storage, reprocessing, mixed oxide (MOX) fuel fabrication, waste disposal, and vitrification facilities. Transportation systems are also recognized as an integral link between the fuel cycle installations.

2.1. URANIUM/THORIUM MINING, MILLING AND REFINING

Conventional mines include both open pit and underground mines. Solution mining is sometimes used to extract uranium from ores. Surface or open pit mining is used for ores that lie near the surface. The topsoil and overburden are removed to expose the ore, which is then mined. In underground mining, shafts and tunnels are used to gain access to the ore. The ore is moved to the surface and stored for transport to a uranium mill.

Some commonly used underground mining techniques for low grade ore deposits include: the modified room and pillar method, vein structure mining, and breccia-pipe mining. In the modified room and pillar method, a large diameter entry shaft is sunk to a level below the ore body. A haulage way is excavated below the ore body, and vertical raises are driven from the haulage way up into the ore body. Development drifts are then driven along the base of the ore body connecting the vertical raises. Mined ore is hauled along the development drifts and gravity fed to the haulage way for removal to the surface. In vein structure mining, the ore is broken by drilling and blasting and is gravity fed through draw cones to the haulage level. It is removed from the mine through the vertical shaft or horizontal adit. Most of the mined-out stopes are interconnected, but bulkheading and air doors are used extensively throughout the mine to control air flow. Breccia-pipe mining is used to remove breccia-pipe deposits containing uranium ore. The breccia-pipes are generally long, ovate, tubular deposits which were formed by vertical magmatic intrusions into the host rock. The breccia-pipes are separate and discrete, and each one is mined as an individual unit. A single, large shaft is constructed vertically outside the breccia-pipe to a point below the deposit. The breccia-pipe is broken by drilling and blasting. The ore falls into the haulage drift and is removed to the surface through the entry shaft.

The mining of higher grade ores has necessitated the development and modification of mining practices to protect the health and safety of workers. The basic principles of radiation protection of ‘time, distance and shielding’ are used to enable the mining of ore grades up to 20% uranium. Higher grade ores are mined from several hundred metres below the surface and are accessed by shafts and utilize raise boring through the ore from drifts. The extraction of the ore is via a remote scooptram beneath the borehole. Mining methods are constantly being refined to increase the protection of the health and safety of workers.

Solution mining (in situ leaching) may be used to recover uranium from low grade ores which may not be economically recoverable by open pit or underground mining. In this process a leaching agent, such as acid, is injected through wells into the ore body to dissolve the uranium from the ore. The leach solution is pumped from the formation and treated for recovery of the uranium by ion exchange or solvent extraction. Use of in situ solution mining eliminates the problem of dust generation and control in the mines and the disposal of tailings, which contain the majority of the uranium decay products. In situ mining does however, introduce the need for a proper assessment of the environmental impact of injecting the chemical leaching agents into the ore body and any resulting impact on the groundwater.

Thorium is extracted from monazite or is produced as a by-product from processing of monazite for rare earth. Monazite typically contains 3 to 10% thorium. Mining of monazite in placer deposits is usually done by using earth moving equipment or suction dredges. Separation of monazite from other minerals is done by a combination of magnetic, electrostatic and gravity separation techniques. Thorium is extracted from monazite by using either sulphuric acid or a caustic treatment. The remaining rare earths are then removed by partial precipitation or leaching.

Mills extract uranium and thorium from ores and recover them in a concentrated form. Generally, 90 to 95% of the uranium and thorium is extracted from the ore. The resulting purified form of uranium concentrate is called yellowcake. Crushing or milling is conducted for the purpose of creating a greater surface area to improve the extraction of uranium from the ore. Crushing reduces the ore size. The crushed ore is graded to determine the appropriate leaching process. Low grade ores are frequently heap leached after grinding. Higher-grade ores are blended to produce a more uniform feed to the batching process. The crushed ore is then ground to a finer size, using ball, rod, or hammer mills. A high temperature roasting or calcining operation prior to leaching is frequently desirable and may be useful for several purposes. The characteristics of many ores are improved by roasting.

Conventional mills use one of a number of extraction processes, three of which are: acid leach — solvent extraction, acid leach — ion exchange, and alkaline leach. The leaching process removes the uranium from crushed ore. Whereas the acid leach process uses sulphuric acid, the alkaline leach process uses a mixed solution of sodium carbonate and sodium bicarbonate. The acid leaching process is the most common extraction process followed by solvent extraction, but the choice of the process depends largely on the chemical and mineralogical nature of the ore.

2.2. CONVERSION AND ENRICHMENT

After the yellowcake is produced at the mill, the next step for the light water reactor fuel process is conversion into pure uranium hexafluoride (UF_6) suitable for use in enrichment operations. Uranium hexafluoride is the only uranium compound that exists as a gas at a suitable low temperature. Uranium in a gaseous form is required for enrichment at existing facilities. For historical reasons and material accountability, yellowcake is often denoted as U_3O_8 but is often actually ammonium diuranate [$(NH_4)_2U_2O_7$]. Two approaches for yellowcake conversion to UF_6 are commonly used. They involve the same basic chemistry, but are applied in critically different procedures. One uses a dry fluoride volatility process, also called the hydrofluor process. The other depends on wet acid digestion processing.

In the dry fluoride volatility conversion process, the yellowcake is uniformly sized and then reacted with hydrogen at a high temperature to form uranium dioxide in the reduction stage. The uranium dioxide (UO_2) is reacted with anhydrous hydrofluoric acid in fluidized bed reactors during hydrofluorination to yield uranium tetrafluoride (UF_4). The UF_4 reacts with gaseous fluorine to produce crude gaseous UF_6 in the fluorination stage before entering the final distillation stage. Here light fraction gases and impurities are removed to produce a purified liquid UF_6.

The wet process for the production of UF_6 involves yellowcake (65 to 85% U_3O_8) digestion with nitric acid, selective solvent extraction with tributyl phosphate (TBP)-kerosene, or TBP-hexane, evaporation to concentrate the uranyl nitrate solution, denitration/calcination, reduction, hydrofluorination, and fluorination. Unlike the dry process, the wet process does not require fractional distillation to purify the UF_6 from other contaminants since it uses extensive front end treatment (e.g., digestion, selective extraction, and evaporation) to produce a high-purity uranium compound for subsequent conversion to UF_6. The chemistry and concept for reduction, hydrofluorination, and fluorination in the wet conversion process are very similar to those of the dry conversion process.

Uranium enrichment is an essential stage in the nuclear fuel cycle to prepare uranium fuel for use in light water reactor (LWR) nuclear power plants. Enrichment separates uranium-235 and uranium-238. Because it can fission (split) to produce heat, ^{235}U is the most efficient isotope of uranium that can be used to fuel power plants. Uranium-235 makes up less than 1% of natural uranium, but most commercial (LWR) nuclear power plants require 3% to 5% concentrations of ^{235}U for a usable fuel.

Two methods are commercially used to enrich uranium. The gaseous-diffusion method makes use of the phenomenon of molecular diffusion to effect separation. In a vessel containing a mixture of two gases, molecules of the gas with lower molecular weight travel faster and strike the walls of the vessel more frequently, relative to their concentration, than do the molecules of the gas with higher molecular weight. If the wall of the vessel has holes just large enough to allow passage of the individual molecules without permitting bulk flow of the gas as a whole, more of the lighter molecules flow through the wall, relative to their concentration, than the heavier molecules. The gas centrifuge process consists of a long, narrow, vertical cylinder rotating about its axis with high angular velocity. A mixture of two gases contained in the cylinder will tend to separate, with the component of higher molecular weight concentrating toward the outer wall of the cylinder and the component of lower molecular weight concentrating toward the axis. Mathematical correlation illustrates that significantly more ^{235}U enrichment can be obtained from a single unit gas centrifuge than from a single unit gaseous diffusion barrier. The separation factor available from a single centrifuge is about 0.07 as compared to 0.004 for a gaseous diffusion stage. However, the amount of UF_6 that can be processed by a single centrifuge is very small compared to a gaseous diffusion stage.

2.3. FUEL FABRICATION — URANIUM

The uranium fuel for light water reactors is made using enriched uranium while natural uranium is used for heavy water moderated reactors. The commercial light water reactor fuel fabrication process starts with the conversion of enriched uranium hexafluoride (UF_6), containing uranium-235 (^{235}U) concentrations from natural uranium to enriched uranium (2 to 6%), into a form suitable for use in a power reactor. The fuel forms for both reactor types must be capable of maintaining their chemical and physical properties under the extreme heat and radiation levels inside the reactor vessel. Typically light water reactor uranium fuel fabrication consists of three basic steps: a chemical process to convert UF_6 to UO_2 powder, a ceramic process to convert UO_2 powder to pellets, and a mechanical process to load UO_2 pellets into zircaloy tubes and construct fuel assemblies. Fuel fabrication from natural uranium for use in heavy water reactors is similar except that no enrichment and conversion are required.

In addition to these processes, a scrap recovery and recycle programme is very important to the efficient operation of a fuel fabrication facility. These operations recover valuable scrap materials generated during the various fuel fabrication processes and return the materials back into the production process. These facilities using enriched uranium must be carefully designed to prevent any possibility of a criticality occurrence.

2.4. FUEL FABRICATION — MIXED OXIDE

Plutonium is obtained by exposure of uranium-238 to neutrons in a reactor. When the fuel or breeder element is reprocessed, the plutonium is obtained as a solution of nitrate in nitric acid. This nitrate is then converted to plutonium oxide, which is used as a reactor fuel material. The plutonium oxide is then typically blended with uranium oxide to produce a fuel, which can be fabricated into a reactor fuel assembly. In addition, similar to the uranium fuel fabrication process, a scrap recovery and recycle programme may be utilized. These facilities must be carefully designed to prevent any possibility of a criticality occurrence.

2.5. REPROCESSING

The spent fuel from a reactor can be shipped to a reprocessing plant to recover the remaining fissile materials: uranium-235 and various plutonium isotopes, or in the case of the thorium cycle, uranium-233. The principle of operation for a reprocessing plant is to dissolve the irradiated reactor fuel elements to extract the useful isotopes of uranium and plutonium. This is typically accomplished by removing fuel elements from the fuel assembly components using first a mechanical process and then a chemical dissolution process. The resulting hulls consisting of insoluble clad material are treated as waste while the uranium, plutonium enriched chemical slurry is subjected to a solvent extraction process where the desirable uranium and plutonium isotopes are removed and purified to be reintroduced back into the fuel cycle. Uranium-235 is typically reintroduced back into the enrichment cycle where it is used as feed for further enrichment while the plutonium is purified as plutonium nitrate and then converted to plutonium oxide for reintroduction back into mixed oxide fuel elements.

In the nuclear fuel cycle, the reprocessing stage has the potential hazard of contamination and release of radioactive materials to the environment. Stripping and dissolving reactor fuel elements liberates large inventories of volatile and gaseous fission products, which need to be collected. As a consequence, the radioactive waste management system for reprocessing facilities must be robust to prevent the routine or accidental release of radioactive materials. Because of the high radiation levels, reprocessing plants are designed for remote, automated operations. Reprocessing stages which involve uranium and plutonium concentrates must also be designed to prevent any possibility of a criticality occurrence.

3. SAFETY ASPECTS FOR FUEL CYCLE FACILITIES

The nuclear fuel cycle facilities differ from reactors in several important aspects. First, they employ a greater diversity of technologies and processes. Second, fissile material and wastes are handled, processed, treated, and stored throughout the nuclear installations. These treatment processes use large quantities of hazardous chemicals which can be toxic, corrosive or combustible. Consequently, the materials of interest to nuclear safety are more distributed throughout the nuclear installations, in contrast to reactors where the bulk of the nuclear material is located in the reactor core or fuel storage areas. For example, the nuclear materials in fuel cycle facilities are often present in solutions that are transferred between vessels used for different parts of the process, whereas at reactors the nuclear material is generally concentrated in the solid fuel. This greater distribution and transfer of material requires greater attention to accounting for the nuclear material throughout the installations, not just for safeguards purposes, but also to ensure nuclear safety. Third, the facilities are often characterized by more frequent changes in operations, equipment and processes, which are necessitated by treatment or production campaigns, new product development, research and development, and continuous improvement. Fourth, the fuel cycle facilities rely to a greater extent on operator and administrative controls to ensure safety, and less on active and passive engineered controls. Fifth, for these facilities, maintaining criticality is not a part of the operational process, thus usually there are systems designed to prevent the criticality occurrence, but not designed for fast 'shutdown' as such systems exist at nuclear research and power reactors. Finally, fuel cycle facilities have a greater requirement, inherent in the process, for operator 'hands-on' involvement. Comprehensive information on the safety of the nuclear fuel cycle can be found in [1].

It is important to recognize that the hazards vary from facility to facility depending upon the processes employed, age, throughput, inventory, and material condition. For example, the radiation hazards at a vitrification facility are generally greater than those at a uranium mill, although both types of facilities pose some risk to workers and members of the public. Hazards may also vary depending upon the specific conditions at the facilities. For example, processing and storage of UF_6 may pose criticality hazards if the uranium is enriched. However, if the uranium is natural, criticality is not credible. Similarly, criticality hazards may not be credible at a vitrification facility if the high activity waste stream has been sufficiently processed to remove significant quantities of fissile materials. However, criticality hazards may exist under abnormal operating conditions (for example leading to greater amount of fissile material in waste streams) or if fissile materials are intentionally immobilized using vitrification.

Although some similar safety hazards may be posed at reactor and fuel cycle facilities, such as radiation hazards, the differences between reactor and fuel cycle facilities spawn some different safety considerations at the fuel cycle facilities. These differences must be taken into consideration during design, construction, operation and decommissioning stages. Some of these safety issues encountered at fuel cycle facilities are described in the next sections and Annex 1.

3.1. CRITICALITY

Criticality safety is one of the dominant safety issues for the fuel cycle facilities. These facilities employ a great diversity of technologies and processes, thus the materials of interest to nuclear safety are more distributed throughout these nuclear fuel cycle facilities. They may be used not only in a bulk form (fuel pellets, fuel elements, fuel rods, fuel assemblies, and so on), but in the distributed and mobile forms as well (different kinds of solutions, slurries, gases, powders, and so on). This is in contrast to reactors where the bulk of the nuclear material is located in the reactor core or fuel storage areas. As a result the fissile materials may accumulate in some parts of the equipment and may also escape from the facility as a result of equipment leakage. The distribution and transfer of potentially critical nuclear material requires operator attention to account for this material throughout the installation and thus ensure that nuclear criticality safety is maintained and to prevent the potentially lethal effects of gamma and neutron radiation doses to workers and the subsequent release of fission products from an inadvertent nuclear criticality.

All areas of fuel cycle facilities, which process or contain fissile material, need to be evaluated for criticality hazards. The evaluation must show whether the presence of nuclear materials with greater than natural enrichment, presents a credible scenario for an inadvertent criticality during the processing being conducted at the facility. As regards nuclear criticality, fuel cycle facilities may be split into two groups: (1) facilities where a criticality hazard is not credible — mining, milling, and conversion of natural uranium facilities, and (2) those where the criticality hazards may be credible — enrichment, reprocessing, uranium fuel fabrication, mixed oxide fuel fabrication, fresh fuel storage (and transportation), spent fuel storage (and transportation), waste treatment and waste disposal facilities. Those facilities in group (2) need to be designed and operated in a manner that provides a high level of assurance that critical parameters and controls are followed. Designs of such facilities need to ensure subcriticality in all areas, first by engineering design, utilizing where possible 'criticality safe designed equipment'. Similarly for the operation of these facilities, critical parameters and controls have to be maintained. This includes assurance that excessive amounts of fissile material do not accumulate above the specified limits in vessels, transfer pipes and other parts of the facility. To prevent inadvertent nuclear criticality, process safety limits must not be violated, and safety limits must have enough margin to preclude criticality during postulated abnormal operating conditions. Particular attention should be paid to fissile material in waste streams; process changes or modifications which may be inadequate (from the point of view of criticality); nuclear materials accounting and control procedures which may lack the appropriate accuracy to ensure subcriticality; and controls which are used to prevent the accumulation of nuclear materials in zones which are not included within the design parameters of the installations (or equipment).

Fuel cycle facilities with credible criticality hazards should have in place a programme to ensure subcriticality. Provision should be made to cope with an accident and to alarm the facility personnel should an inadvertent criticality occur. Adequate emergency preparedness should be foreseen, where appropriate. A review of some criticality accidents that occurred during nuclear fuel process operation is provided in [2].

3.2. RADIATION

Radiation safety is an important consideration at nuclear fuel cycle facilities. Special attention is warranted to ensure worker safety because of their intimate contact with nuclear material in the process, which may include open handling and transfer of nuclear material in routine processing. Potential intakes of radioactive material require careful control to prevent and minimize contamination and to adhere to operational dose limits. In addition, releases of radioactive material into the facilities and through monitored and unmonitored pathways can result in significant exposures, particularly from long lived radiotoxic isotopes. Some facilities, such as MOX fuel fabrication, reprocessing, and vitrification facilities require careful attention to shielding design, containment, ventilation and maintenance procedures to reduce external exposures.

A facility should have in place a radiation protection programme that is adequate to protect the radiological health and safety of workers and the public. To accomplish this, facilities evaluate and characterize the radiological risk and typically provide sufficient robust controls to minimize the radiological risks at the facility. Potential accident sequences are considered in assessing the adequacy of the controls, which aim to minimize radiological risk and contamination.

Good fuel cycle facility radiation practices include: (1) an effective documented programme to ensure that occupational radiological exposures are ALARA; (2) an organization with adequate qualification requirements for the radiation protection personnel; (3) approved written radiation procedures for conducting activities involving radioactive materials; (4) radiation protection training for all personnel who have access to restricted areas; (5) a programme to control airborne concentrations of radioactive material with engineering controls and respiratory protection; (6) a radiation survey and monitoring programme that includes requirements for control of radiological contamination within the facility, and monitoring of external and internal radiation exposures and (7) other programmes to maintain records, to report radiation exposures to the regulating authority and to reinstate an acceptable on-plant radiological environment in the event of an incident.

3.3. CHEMICAL HAZARDS

Fuel cycle facilities also pose hazards to workers and members of the public from releases of chemically toxic and corrosive materials. For purposes of classification, fuel cycle facilities may be considered as chemical plants, which handle and store large volumes of toxic products and corrosive materials. Major steps in the nuclear fuel cycle basically consist of chemical processing of fissile materials. This processing involves the use of strong reagents to dissolve the materials to allow the needed chemical reactions to take place. For example the production of uranium hexafluoride (UF_6) in the conversion fuel cycle facilities involves the use of significant quantities of hydrogen fluoride. Hydrogen fluoride is both a powerful reducing agent and chemotoxic. This poses a significant hazard to workers although the hydrogen fluoride is not in itself a radioactive material. Other examples include the use of strong chemical acids to dissolve uranium and other materials and to remove, in some cases, the fuel cladding. They are also used to chemically dissolve the spent fuel during reactor fuel element reprocessing enabling the separation of the plutonium and uranium from the residual fission products. In addition, the residual fission products, which comprise approximately 99% of the total radioactivity and toxicity in the spent fuel pose a significant radiological hazard in what is typically a complex chemical slurry. During the solvent extraction processes, strong acids and organic solvents are used to remove the plutonium and uranium from the slurries. These processes can generate toxic chemical by-products that must be sampled, monitored and controlled. Other chemicals encountered at fuel cycle facilities in industrial quantities include such chemicals as ammonia, nitric acid, sulphuric acid, phosphoric acid and hydrazine.

The chemical risks for fuel cycle facilities are integral to the nuclear processing. Consequently, assurance of safety requires control of both the chemical and nuclear hazards. In addition, unplanned releases of the chemicals may adversely affect safety controls. For example, a release of hydrogen fluoride could disable an operator who may be relied upon to ensure safe processing.

In order to reduce risks to workers of the fuel cycle facilities, the chemically reactive and toxic substances are typically classified and controlled. A robust chemical risk control process would include process descriptions with sufficient detail to support an understanding of the chemical process risks (including radiological risks caused by or involving chemical accidents) and would allow development and understanding of potential accident sequences involving chemical processes. Appropriate methods should be used to estimate the concentration or to predict the ‘toxic’ footprint of a release of hazardous chemicals from a plant utilizing hazardous chemicals to process radioactive materials. The tolerability of the toxicological consequences should be assessed against appropriate chemical exposure standards. Chemical exposure standards are available from a variety of national and international organizations, e.g. relevant ISO standards. Fuel cycle facilities should be designed and operated in a manner which ensures that the risks of hazardous chemical exposure and contamination are minimized.

3.4. FIRE AND EXPLOSION

Fire and explosive safety is also an important issue for non-reactor nuclear fuel cycle facilities. Many of the facilities use flammable, combustible and explosive materials in their process operations, such as a tributyl phosphate-kerosene mixture for solvent extraction, bitumen for conditioning radioactive wastes, hydrogen in calcining furnaces and chemical reactors for oxide reduction. Typically design of the facilities is conducted to minimize the inventories of combustible materials and ensure adequate control of thermal processes and ignition sources to reduce the potential for fire and explosions. For example extreme care is taken to prevent accumulation of radiolytic hydrogen which is generated in high activity waste tanks in fuel reprocessing plants. In addition, fire can become a motive force for significant releases of radioactive and toxic material from the facilities. Consequently, fire detection, suppression, and mitigation controls are usually necessary.

A fuel cycle facility typically considers the radiological and other consequences from fires and explosions. Suitable safety controls are instituted to protect the workers, the public and the environment from the potential consequences of fire and explosive hazards. These safety controls are designed to provide the requisite protection during the normal operations, anticipated operational occurrences and credible accidents at a facility.

3.5. EFFLUENTS

Some of the fuel cycle facilities may pose special safety hazards because they produce large quantities of effluents or they have the potential to produce highly hazardous effluents to the environment. For example, uranium milling and processing generate large quantities of radioactive and chemically toxic effluents that must be stored or disposed close to the point of generation to avoid large expenses. Similar effluents can be generated by fuel fabrication facilities. Other facilities, such as MOX fuel fabrication plants, reactors, and vitrification facilities have the potential to produce effluents to air and water with high concentrations of fission products and transuranic radionuclides that pose risks to members of the public and the environment.

Effluents in the forms of liquid and gases generated in the nuclear fuel cycle facilities must be treated in order to reduce the environmental and health impacts from release. Systems of effluent treatment could include a ventilation system with an appropriate filtration system to prevent unacceptable dispersion of aerosol substances within the plant, or to control the external release of hazardous substances. A liquid recovering system to recycle selected products with appropriate filtration in place could be incorporated into the design of the facility to minimize the generation of waste materials.

The fuel cycle facilities should have a suitable effluent monitoring programme that allows the fuel cycle facility to measure and monitor the concentrations of radioactive materials in airborne and liquid effluents and to establish that these concentrations are at or below regulatory limits as established by national authority. Airborne effluents from all routine and non-routine operations are usually continuously sampled. A sample collection and analysis process will be in place with analysis methods and frequencies appropriate for the effluent medium and radionuclide being sampled. Representative samples are usually taken at each release point. Normally a system is in place to limit to as low as reasonably practical potential leakage from onsite ponds, lagoons, and tanks to ensure that no unplanned releases to groundwater, surface water, or soil are occurring. Procedures and facilities are usually in place for solid and liquid waste handling, storage, and monitoring to ensure safe storage and timely disposition of the material.

3.6. MAINTENANCE

Maintenance of fuel cycle facilities may also pose special safety hazards. For example, although fuel cycle facilities all require some degree of maintenance for operations and safety, maintenance of some of these facilities requires special care during design and operation due to the expected high radiation or toxic hazards present and the required use of hot cells and glove boxes for some maintenance operations. These facilities include vitrification, reprocessing, and MOX fuel fabrication plants. In addition, maintenance may in itself pose special hazards because it may be an initiating event for accident sequences if it is not performed in an acceptable manner. However, other than for facility specific design considerations, these risks are not significantly different from those, which have to be taken into consideration for reactor maintenance.

Maintenance measures are normally performed at a facility on a continuing basis, with emphasis on equipment relied on for safety, to ensure the equipment is available and able to perform its functions, including those functions required to prevent accidents or mitigate the consequences of accidents, when needed. Most facilities have commitments relative to how equipment relied upon for safety is inspected, calibrated, tested and maintained, to the level commensurate with the equipment’s importance to safety, to ensure its ability to perform its safety functions when required.

A facility maintenance programme should generally address the following maintenance activities: corrective maintenance; preventive maintenance; surveillance and monitoring; and functional testing. Corrective maintenance includes a commitment to promptly perform corrective actions to remediate safety equipment failures and a description of the approach and methods for planning and implementing repairs to safety equipment with the objective of eliminating or minimizing the recurrence of failures. Preventive maintenance includes a commitment to conduct preplanning and scheduled periodic refurbishing of safety equipment and a description of the necessary activities required for preventative maintenance such as instrumentation calibration, and testing, and the methods used to establish the frequency of preventative maintenance activities. Surveillance monitoring includes a commitment to design and implement a programme to survey and monitor the performance of the safety equipment and provides for a description of the components of the surveillance and monitoring programme along with the methods used to establish the frequency of required inspections for safety equipment. Functional testing includes a commitment to perform the appropriate post maintenance functional testing to provide a reasonable assurance that the maintenance activity did not adversely affect the reliability of the safety equipment and a general description of functional testing and the documentation of the test results.

3.7. MANAGEMENT OF MODIFICATIONS

Nuclear fuel cycle facilities may be modified many times during their life cycle. Changes in design or operation are implemented for many reasons including the need to increase production, improve product quality, allow handling of a different feed material, adjust plant facilities to accommodate new regulatory requirements or to reduce or alter the resulting waste or by-product stream.

It is well known from experience in many facilities that incorporating design or operational modifications can result in unforeseen outcomes with complicating adverse effects on health and safety. Such effects may be due to the introduction of new hazards, to variations in existing hazards or because of changes in risks or consequences from existing hazardous conditions. In some cases a change to one part of a facility can result in a corresponding hazard increase in another part of the facility which may not be adequately analysed or constrained. In light of these possibilities, to ensure safe operation of fuel cycle facilities it is important that a good management system is in place to control the planning and implementation of any design or operational modifications.

Modifications at fuel cycle facilities are typically controlled to assure consistency amongst the facility design and operational requirements, the physical configuration, and the facility documentation. Many fuel cycle facilities have in place a formal documentation process which governs the design and continued modification of the site structures, processes, systems, equipment, components, computer programmes, personnel activities and other supporting management oversight activities. These documentation processes typically provide reasonable assurance for the disciplined documentation of: engineering, installation, and commissioning of modifications; the training and qualification of affected staff; the revision and distribution of operating, test, calibration, surveillance, and maintenance procedures and drawings; post-modification testing; and readiness review.

3.8. HUMAN FACTORS

Human factors need to be considered for fuel cycle facilities to alleviate potential safety issues. Human factors should be considered during the design, operation and maintenance of fuel cycle facilities. Most of the technological processes at fuel cycle facilities include essential safety operations that utilize a man/machine interface. Since most of the inadvertent condition upsets at fuel cycle facilities are a result of human error, human factors considerations are of paramount importance during fuel cycle facility operation. This is particularly true when technology changes are introduced or when equipment modifications are performed.

A central aspect of human factors is the training and qualification of the personnel who operate fuel cycle facilities. The rigour and formality of the training programme for a fuel cycle facility is really a function of the safety issues encountered at the facility and the resulting complexity of the training needed. In general, fuel facilities provide assurance that only properly trained and qualified personnel perform activities relied on for safety at fuel cycle facilities. Human factors should be taken into account when developing operational and safety procedures. Establishment of good safety culture is considered as an important factor contributing to the safe operation of all type of fuel cycle facilities.

3.9. ENVIRONMENTAL CONSIDERATIONS

It is recognized that the siting, construction, operation, modification and decommissioning of nuclear facilities has the potential to adversely affect the environment, either directly or indirectly. Direct effects can occur during the preparation or use of the site, as when existing features are altered to make the site suitable for the facility, e.g., vegetation is removed or wetlands are drained so that foundations can be installed or an uranium ore body can be accessed by open pit mining. Other direct effects include damage to vegetation resulting from the release of toxic substances from a nuclear facility, such as metals contained in effluents and tailings from uranium mining and nitrogen oxides and fluoride compounds from uranium processing. The effects may arise indirectly, for example, due to the construction of a new road to provide access to a facility or a dam to provide a source of water, or even by eliminating the habitat of some species which is important to the ecology of the region in which the facility is located. In certain cases, there is also the potential for significant socio-economic effects from the installation, operation or decommissioning of nuclear facilities, due to such factors as the influx of new populations or changes to employment patterns which result from commissioning or closing down the nuclear facility.

In many countries governments have prescribed requirements, typically referred to as environmental assessments, to identify at the planning stage what effects may be produced and on the basis of those findings, whether a project should be allowed to proceed or what measures should be used to mitigate adverse effects. The legislation and processes which apply to environmental assessments in certain Member States are outlined later in Annex 3 to this report.

4. OPERATIONAL SAFETY EXPERIENCE

Safety hazards associated with nuclear fuel cycle facilities have been demonstrated by operating experience with these facilities during the last fifty years. Review of the list of events from 1991 to the present from the IAEA's International Nuclear Event Scale (INES) [3] indicated in the order of 30 events at non-reactor nuclear fuel cycle facilities. The recent criticality accident at Tokai Mura was the highest level event reported during this period. The hazards associated with nuclear criticality at these facilities were reviewed at a recent conference in France [4] sponsored by the French nuclear safety advisory body (IPSN). The conference reported that nearly 60 criticality accidents have occurred since 1945, about a third of which occurred at nuclear fuel cycle facilities. Of these, 21 accidents killed seven people and resulted in significant radiation exposure to another 40 individuals. Although most of the accidents occurred before the early 1980s, two occurred as recently as 1997 and 1999. Twenty of these accidents involved processing liquid solutions of fissile materials, while none involved failure of safety equipment or faulty calculations. The conference identified the main cause of criticality accidents as the failure to identify the range of possible accident scenarios, particularly those involving potential human error. This finding is especially significant for non-reactor fuel cycle facilities given their extensive reliance on operator and administrative controls to ensure safety.

Similar hazards have been demonstrated by other operational problems and accidents. For example, chemical toxicity hazards associated with UF_6 processing were evident in two accidents in 1986 in the United States and Germany. Fire and explosion hazards have also been evident in the safety record at fuel cycle facilities. In 1990, for example, there was an ammonium-nitrate reaction in an offgas scrubber at a low enriched uranium scrap recovery plant in Germany, which injured two workers and destroyed the scrubber. Fire is an especially significant accident scenario because it can be both an initiating event for the accident sequence and a disrupter of safety systems as well as an energy source to transport radiological and chemical contaminants into uncontrolled areas where they may pose risks to members of the public. An example of this is the fire and explosion at the Tokai Mura reprocessing plant in March 1997, which contaminated 37 workers with radioactive material.

5. ANALYSIS OF THE NUMBER AND TYPES OF FUEL CYCLE FACILITIES

The IAEA maintains a database of nuclear fuel cycle facilities in Member States in the Nuclear Fuel Cycle Information System [5]. This system reasonably represents the approximate number and worldwide distribution of nuclear fuel cycle facilities. The system may not necessarily be up to date in all respects as the IAEA relies on Member States to refresh the information periodically; however, the information is sufficiently representative to be used in assessing the relative magnitude and diversity of existing and projected fuel cycle facilities in Member States.

The IAEA database identifies a total of 504 facilities in the nuclear fuel cycle other than reactors and waste disposal facilities that have been reported by Member States (as of 4 October 1999). The numbers of facilities are listed in Annex 2 by facility type and operating status. The table excludes some facilities included in the database, but not considered for this report to be nuclear facilities, such as zirconium processing plants, zircaloy tube manufacturing plants, and heavy water separation plants.

No attempt was made to distinguish between facilities on the basis of size or throughput. On first analysis, it may make sense to focus on the larger facilities because they may apparently have a larger number of safety issues. However, the smaller facilities may pose equal or greater challenges than the larger facilities for several reasons. First, it is recognized that small facilities include pilot, experimental or research facilities and involve new or complex technologies, for which safety procedures and controls may not be fully developed. Second, these facilities may not have the same infrastructure support as the larger facilities. Accidents have even occurred at large facilities when they depart from routine operations for special processing campaigns and projects of limited duration. For these reasons, Table 2 includes all nuclear fuel cycle facilities included in the Nuclear Fuel Cycle Information System regardless of size.

Approximately one third of all of the facilities are located in developing States. About half of all facilities (250) are reported to be operating, of which approximately 30% (71) facilities are operating in developing States. The system also lists 64 planned nuclear fuel cycle facilities, other than reactors, of which one fourth (17 out of 64) are in developing States. About one fifth of all the facilities are either in a shutdown, standby, or decommissioning mode, and about 15% have already been decommissioned.

A small number of the facilities are listed in the table in a ‘not relevant or unknown’ status. This designation is used for facilities that are included in the database, but are not strictly nuclear facilities. For example, the one zirconium conversion facility ($ZrSiO_4$ -> ZrO_2) is included in this category. In addition, facilities are included in this category if they are listed in a ‘deferred’ status or if no operating status has been entered in the database.

From this analysis, it can be seen that worldwide there is a large and diverse assembly of fuel cycle facilities. Relatively few facilities (about 10%) are currently being planned compared with the total number of facilities and those that are currently operating. As was previously pointed out in Section 3, fuel cycle facilities rely extensively on operator and administrative controls to ensure nuclear safety. Because of this reliance and the relatively large number of facilities in an operating status, it may be desirable to ensure that the IAEA safety standards also provide adequate guidance regarding the safety of operations of nuclear fuel cycle facilities other than reactors. It may also be prudent to ensure that design and siting matters are adequately documented, bearing in mind that guidelines and documents in this area might be used not only for new facilities, but also for existing facilities undergoing periodic safety reviews.

6. REGULATORY SYSTEMS FOR FUEL CYCLE FACILITIES

Regulatory systems used by Member States for nuclear fuel cycle facilities vary from State to State. In general, it would appear that agreement with the requirements of the IAEA Safety Series documents provides an adequate basis on which to regulate the whole of the nuclear fuel cycle. Many of the Member States are currently evolving their regulatory programmes to response to lessons learnt from the operation of fuel cycle facilities. Examples of how some Member States have implemented their regulatory system are given in Annex 3, showing a range of prescriptive, partially prescriptive and non-prescriptive systems. These examples demonstrate that there are many different methods for adequately exercising a regulatory regime for fuel cycle facilities and might be of interest when deciding on the type and nature of the safety requirements and guides to be applied in the regulation of cycle facilities other than reactors.

7. IAEA SAFETY SERIES DOCUMENTATION

Over a number of years, the IAEA has developed a comprehensive set of safety series documentation, which addresses, in a structured manner, many of the various nuclear fuel cycle safety needs identified by Member States.

Since 1996 the IAEA Safety Standards series of documents has been subject to a process of planned change from its original structure of Safety Fundamentals, Safety Standards, Safety Guides and Safety Practices, to a new structure with a single Safety Fundamentals document supported by Safety Requirements and Safety Guides.

The existing IAEA documents cover the safety of nuclear installations (predominantly, but not exclusively, nuclear power plants), radioactive waste management, radiation protection and transport safety.

Within the safety requirements structure the IAEA has identified the need for 14 documents in the five areas of:

General safety	(Emergency preparedness & response; legal & governmental; QA),
Nuclear safety	(Siting; design; operation; research reactors),
Radiation safety	(BSS),
Waste safety	(Discharges; predisposal management; geological disposal; near surface disposal; rehabilitation), and
Transport	(Transport regulations).

These requirements contain advice, which Member States shall implement if modern standards are to be achieved.

Each of these requirements will be supported by a suitable number of guides containing recommendations on how to satisfy the requirements.

The TCM reviewed the IAEA's current Safety Series documentation structure and formed the view that to address non-reactor fuel cycle facilities it would be appropriate to include one additional Requirement within the Nuclear Safety Requirements structure.

It was also considered that five subsidiary guides would be needed to support the requirement, in order to cover all of the major non-reactor fuel cycle facilities, addressing:

- Mining, milling and refining
- Conversion and enrichment
- Fuel fabrication — uranium
- Fuel fabrication — MOX
- Reprocessing.

8. CONCLUSIONS AND RECOMMENDATIONS

Nuclear fuel cycle facilities pose a range of safety challenges, including criticality, radiation, chemical toxicity, fire and explosions. These challenges can pose hazards to workers, members of the public, and the environment if they are not properly controlled. Taking these hazards into account, national regulatory authorities have established a variety of regulatory frameworks, including prescriptive and performance-based standards to reduce potential risks from the hazards. Regulatory authorities are evolving these standards to reflect experience from the operation of the fuel cycle facilities.

The major safety issues associated with the fuel cycle facilities are determined by the large diversity of technologies employed, the extensive reliance on the use of operators and administrative controls to provide safety, and the inherent attendant risk of many of the chemical processes utilized. There are a large number (about 500) of nuclear fuel cycle facilities world wide that employ this diverse range of technologies.

Recognizing the characteristics of fuel cycle facilities, a review of the IAEA's existing framework of safety standards concluded that some of the existing framework can be applied to these facilities. however other topics do warrant additional development or modification to address specific safety issues for the fuel cycle facilities.

On the basis of discussions during the Technical Committee meeting, the Committee made the following conclusions:

(1) It is important to facilitate continued international exchange on the regulatory and safety concerns for fuel cycle facilities.

(2) A work is underway by operators and regulators in several countries with the aim of securing improvements to the safety of fuel cycle facilities. However, there is no consensus at an international level of what standards should be applied to the significant number and broad range of facilities being designed and operated in the world. For NPPs the IAEA's safety standards series represents the only international nuclear safety standards, developed with consensus, no such standards exist for non reactor fuel cycle facilities. Therefor there is a need for development of a small number of international

standards to address the safety concerns specific to these fuel cycle facilities. The standards should be facility rather than theme or subject oriented and should cover at least the following facilities:

- MOX and uranium fuel fabrication
- Reprocessing
- Conversion and enrichment
- Uranium/thorium mining, milling and refining.

(3) During the time that these international standards are being developed, expert meetings should continue to be organized on a periodic basis to provide focus for the standards development.

(4) The use of integrated safety assessments should be examined for application to fuel cycle facilities.

Annex 1

SAFETY ASPECTS FOR FUEL CYCLE FACILITIES

	Criticality	Radiation	Chemical Toxicity	Fire/ Explosion	Product/ Residue Storage	Waste Storage	Ageing Facilities	Decommis-sioning	Effluents	Maintenance
Mining/ Milling		◎	◎	O	◎	◎	◎	◎	◎	
Conversion	O	◎	◎	◎	O	◎	◎	O		
Enrichment	O	◎	◎	◎	◎		O	◎		
Fuel Fabrication	◎	◎	◎	◎	◎	◎	O	◎	◎	O
Reactors	◎	◎		◎		◎	◎	◎	◎	◎
Interim Storage	◎	◎				◎	◎	O		
Reprocessing	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
MOX fuel fabrication	◎	◎		◎	◎	◎	◎	◎	◎	◎
Waste disposal	O	◎		◎			◎	O	◎	
Transportation	O	◎	O	◎				O		
Vitrification	O	◎		◎		◎		◎	◎	◎

O - may be a concern depending on specific conditions (enrichments, composition, etc.)
◎ - concern at most facilities

Annex 2

ANALYSIS OF THE NUMBER AND TYPE OF FUEL CYCLE FACILITIES

Facility	Total	Developing States	Operating (Number in Developing States)	Planned (Number in Developing States)	Shutdown/Standby/ Decommissioning	Decommissioned	Not Relevant & Unknown
Milling (incl. PO_4)	189	77	58 (31)	20 (6)	53	55	3
Conversion	45	11	31 (7)	4 (0)	8	1	1
Enrichment	39	14	22 (6)	4 (3)	6	2	5
Fuel Fabrication	72	19	49 (13)	4 (2)	10	9	0
Interim Storage	99	16	67 (10)	26 (4)	4	2	0
Reprocessing	38	9	13 (3)	3 (2)	11	7	4
MOX Fuel Fabrication	22	1	10 (1)	3 (0)	4	1	4
Total	504	147	250 (71)	64 (17)	96	77	17

Annex 3

VARIOUS REGULATORY SYSTEMS

BELGIUM

The Belgian Government regulates nuclear facilities through the Nuclear Act of 1958 and the subsequent Royal Decree 28.2.1963, which continues to be regularly updated. The Royal Decree concerns general regulation to protect both the public and the workers against ionizing regulation. Under the licensing process set forth by the Decree, all installations that use ionizing radiation are divided into four categories, according to the amount of fissile material and to the amount and type of radionuclides present.

The first three categories must each be licensed before operation in a manner described by the Royal Decree. For Class 1 installations, which include fuel cycle facilities and nuclear reactors, the competent Safety Authorities are within the Ministry of Public Health and the Ministry of Labour. To receive a license, an applicant must submit an application according to the specifics of the Royal Decree. For instance, the following information should be provided: nature and description of the installation, qualification of personnel, characteristics of the region (e.g. geological, topographic), a report describing the worst accidents and an evaluation of the radiological consequences, an environmental impact report and the measures concerning radioactive waste.

Through a process specified by the Royal Decree for Class 1, the Belgian Government assesses the safety aspects of an installation, and, if it meets requirements, grants a Royal Decree of Authorization. The licensee submits a Safety Analysis Report, which is the basis for a safety assessment by AVN, an authorized agency of Class 1, licensed by the competent Safety Authorities to carry out the surveillance of the Belgian Nuclear installations within the framework of the Belgian laws and regulations. The conclusions and recommendations of that assessment are presented by AVN to the Belgian Nuclear Safety Commission. Then, upon positive advice by this Commission, the Royal Decree of Authorization is written by the competent Safety Authorities and signed by the King.

Authorization to operate is contingent on an inspection report by an authorized body (AVN at present) that verifies compliance with the official license. AVN is also involved in the operating phase of the installations: permanent inspection during operation, follow up of modifications and periodic safety reviews

It is worth noting that the procedure for licensing may change, since the Royal Decree is presently under review as a Federal Agency for Nuclear Control has been created. As this Royal Decree also contains regulations on dose limits for the public and the workers, it is also under review in order to implement the European directive 96/29/Euratom.

BRAZIL

The Brazilian National Nuclear Energy Commission (CNEN) conducts the licensing process for nuclear fuel cycle facilities in Brazil. Through safety evaluation and financial review, the CNEN assures the safe construction, operation and decommissioning of installations in accordance with accepted international safety standards.

From its creation in 1962 (under Law no 4.118, 27.08.1962) to 1989, the CNEN was responsible for environmental evaluation and control of activities involving radioactive materials. However, the Federal Constitution of 1988 brought changes to Brazilian nuclear regulation.

Under the Federal Constitution, the Union, the highest level of government, has sole control over aspects of nuclear activities concerning politics, economics, labour and nuclear safety. Meanwhile, the Federation, which involves the Union, State, Federal District and County levels of government, controls the environmental and health aspects of nuclear activities.

One of the most important changes to come with the Federal Constitution was the introduction of the Brazilian Environmental Protection Agency (IBAMA) in 1989 under Law no. 7781, 27.07.89.

Today the IBAMA and the CNEN share responsibility for regulating nuclear facilities in Brazil. The CNEN, with its technical expertise, is responsible for establishing radiation protection guidelines, controls and surveys in nuclear safety according to Brazil's regulations and international recommendations. Both organizations consequently share the responsibility to assure the limitation of radiation exposure and the control over nuclear activities in the nuclear facilities.

As a result, a licensee must submit two applications, one to CNEN, regarding safety aspects related to the use of radioactive materials and another to IBAMA, regarding environmental aspects.

The licensee initiates the licensing process by submitting an application to the CNEN, complete with all the information required by the norms for the requested authorization.

The main licensing documents (norms), that give legal support for this application, and establish safety requirements and criteria (e.g. siting, accident analysis, radiation protection, criticality, fire protection, design and construction, quality assurance, operation, waste management, emergency measures and decommissioning) are:

- CNEN NE 1.04 (1984) Licensing of Nuclear Facilities;
- CNEN NE 1.13 (1989) Licensing of Facilities for Mining and Milling of Uranium and/or Thorium Ores;
- CNEN NE 6.02 (1984) Licensing of Radioactive Facilities
- CNEN NE 3.01 (1988) Basic Guidelines for Radiation Protection;
- CNEN NE 5.01 (1988) Transport of Radioactive Materials.

The norm CNEN NE 1.04 establishes the guidelines and requirements for the licensing process, as well as the following:

- Site approval
- License for construction
- Authorization for nuclear material use
- Authorization for initial operation
- Authorization for permanent operation

To obtain approval to do any of the above, the licensee must submit an application to the CNEN with specific information in the form of a safety report. There are three reports: site report, necessary for the site approval; preliminary safety analysis report, for the construction; and final safety analysis report, for the authorization of operation, initial and final (revised report reflecting the experience of the initial operation). The CNEN staff evaluate the documentation and grants a license if the licensee has fulfilled the requirements established in the norms. All modifications in the facilities are subject to the approval of the CNEN prior to implementation, and require revised licensing documents.

The CNEN is divided in three directorates: radiological protection and nuclear safety (DRSN); research and development (DPD); and support and administration (DAL).

The superintendency of the licensing and control branch, which falls under the control of the radiation protection and nuclear safety directorate, is responsible for licensing of nuclear reactors, licensing of nuclear facilities, licensing of radioactive facilities, waste management and transport, and control of raw materials and minerals, that contain relevant amounts of uranium and /or thorium.

The responsibility for licensing the nuclear facilities falls under the Co-ordination of Nuclear Facilities (CODIN) and the Supervision of Nuclear Installations (SUNUC), within CODIN.

CANADA

Canada is a federation with two levels of government: federal and provincial, each with its own set of powers and jurisdictions. The different powers and jurisdictions are defined in the constitution and further defined by rulings made by the courts. The key considerations resulting from this are first, that the federal government alone is responsible for control of all aspects of nuclear fuel cycle technology and materials; second, that responsibility for environmental protection is shared between the federal and provincial levels; and third, that each province has control over the natural resources in its territory.

As a result, the regulatory regime, which applies to nuclear facilities, is based on legislation made by both the federal government and the government of the province in which the particular facility is, or is to be, located.

The primary federal legislation is the *Nuclear Safety and Control Act*. This act serves two functions — it establishes the legal framework for the control of nuclear technology in Canada, and concomitantly, it establishes the *Canadian Nuclear Safety Commission* (the CNSC) as the body to administer the regulatory regime provided for in the act. The basic element of this regulatory regime is the prohibition of specified activities, relating to nuclear technology, unless authorized by a CNSC licence. Operational details of the regulatory regime are expressed in the regulations made under the act and supplementary documents developed by the CNSC. The regulations comprise the following:

1. General nuclear safety and control regulations
2. Radiation protection regulations
3. Class I nuclear facilities regulations
4. Class II nuclear facilities regulations
5. Uranium mines and mills regulations

6. Nuclear substances and devices regulations
7. Packaging and transport regulations
8. Nuclear security regulations
9. Non-proliferation import and export control regulations

Of these, the general nuclear safety and control regulations, radiation protection regulations and either the Class I nuclear facilities regulations or the uranium mines and mills regulations (depending on the type of facility), plus, in certain cases, nuclear security regulations and the non-proliferation import and export control regulations, prescribe requirements applicable to nuclear reactors and non-reactor nuclear fuel cycle facilities. The packaging and transport regulations, of course, apply to the radioactive materials shipped into and from nuclear facilities.

The supplementary documents are intended to assist people in understanding the regulations and complying with the prescribed requirements. Their contents are not legally binding, however, and licensees may, if they wish, develop their own ways of achieving compliance.

In addition to the Nuclear Safety and Control Act and regulations, other federal legislation which applies to nuclear facilities includes: the Canadian Environmental Assessment Act, the Canadian Environmental Protection Act, the Fisheries Act, the Canada Labour Code (which covers the protection of workers' health and safety in general and the safety of pressure retaining equipment — i.e., piping and vessels), the National Building Code and the National Fire Code of Canada. The first of these laws, the Canadian Environmental Assessment Act, applies to the CNSC's decisions which permit licensees to carry out any project that may have environmental effects (unless it is a type of project specifically exempted from the CEA Act). This Act requires that an environmental assessment be made of non-exempt projects at the planning stage, to identify and characterize the potential adverse effects, including any socio-economic effects, and to define mitigative measures and follow-up programmes as may be warranted to minimize the adverse effects. At the choice of the CNSC, or the Minister of the Environment, the environmental assessments may be carried out by means of public hearings conducted by a panel of independent experts. This approach is usually reserved for large scale projects, where the effects are uncertain but potentially significant, and for projects which might be considered controversial for some reason, including public sensitivity to the project because of its nature — such as those involving nuclear facilities.

Any regulatory or licensing decision made by the CNSC may be challenged by any person who is dissatisfied with that decision, either by appealing to the CNSC for reconsideration of its decision, or by applying to the federal court for a judicial review. In such instances, the court's role is to determine whether the CNSC made the decision in accordance with all the procedural requirements of the applicable legislation. Judges have no power to reject a decision because of its content or substance, meaning because of the action it allows or prohibits.

Depending on the province in which a facility is (to be) located and the legislation in that province, certain projects may also be subject to an environmental assessment under provincial law. In such cases, the responsible federal and provincial authorities have co-operated and have arranged for public hearings by one, 'joint' panel of independent experts. Nuclear facilities are also subject to the requirements of provincial environmental protection legislation and for uranium mining facilities, requirements of provincial legislation, which applies, to natural resources.

The CNSC controls the installation, use and removal of any nuclear facility by a multi-stage decision making process, which allows for direct public participation at each stage. This process involves licensing the preparation of the site for any facility, its construction, operation, decommissioning and finally, its abandonment. Operating licences for nuclear facilities typically have a period of two years, after which they have to be renewed.

Generally speaking, the Regulations concerning licensing nuclear facilities constitute a hybrid of the so-called prescriptive and performance-based approaches. These requirements prescribe the subject matter of information applicants for licences have to submit to the CNSC in order to obtain the relevant licence, e.g., a safety analysis report, without setting specific details as to the content of the information. By policy and under administrative law interpretations, this approach provides the flexibility to tailor each requirement to fit the particular hazards and risks associated with the different types of facility. Thus, for example, a nuclear fuel fabrication facility is not expected to have quality assurance or radiation protection programmes identical to those expected for nuclear power plants. In other cases, certain requirements in the Radiation Protection Regulations and the Nuclear Security Regulations, for instance, no discretion or flexibility is permitted — such as the limits on maximum allowable radiation doses and the formulas used to combine internal and external radiation exposures.

CZECH REPUBLIC

The Czech Republic regulates nuclear facilities according to the Atomic Act of 1997 (Act no. 18/1997) which defined conditions for peaceful utilization of nuclear energy and ionizing radiation. The Atomic Act authorized the State Office for Nuclear Safety (SUJB), an independent regulatory body with a government appointed chairperson, to perform state supervision for nuclear safety and radiation protection.

The SUJB performs a myriad of duties vital to nuclear safety. It determines conditions, requirements, limits, and conditions for nuclear facilities, ensures emergency preparedness and physical protection, oversees decommissioning of nuclear facilities and other ionizing radiation sources. Additionally, the SUJB concerns itself with environmental and health aspects of nuclear energy. It authorizes the discharge of radionuclides into the environment, sets exposure limits, and appraises an exposure status.

The Atomic Act established a number of obligations in the Czech legal system that arose from the Vienna Convention on Civil Liability for Nuclear Damage and Joint Protocol relating to the Application of the Vienna and Paris Conventions, to which the Czech Republic has acceded.

According to the Atomic Act spent fuel is not considered waste, but both the operator and the State Office for Nuclear safety have the right to declare spent fuel as waste. The Atomic Act also requires any nuclear facility that was originally licensed according to the old act on State Supervision on Nuclear Safety of Nuclear Facilities (no. 28/1984), to be re-licensed in compliance with the new Atomic Act. Furthermore, some existing fuel cycle facilities have been declared as nuclear facilities and their operators are obliged to license them following the requirements of the Atomic Act.

Fourteen regulations, which represent the second level of regulation, follow the Atomic Act. They develop the requirements of the Atomic Act in specific areas (transport, quality assurance, emergency preparedness, radiation protection, etc.). For the licensing of fuel cycle facilities, the provisions of the following regulations are most relevant: Regulation No. 184/1997 Coll., on Requirements for Ensuring Radiation Protection; Regulation No. 195/1997 Coll., on Basic Design Criteria for Nuclear Installations with Respect to Nuclear Safety Radiation Protection and Emergency Preparedness; and Regulation No. 106/1999 Coll., on Nuclear Safety and Radiation Protection Assurance during Commissioning and Operation of Nuclear Facilities.

The licensing process of any new nuclear facility in the CR is based on the provisions of Czechoslovak Act No. 50/1976 Coll., on civil construction. Following this act there are three stages of the licensing process for the construction of a new nuclear facility: siting permit, construction permit, and operational permit. These are granted by the respective district authority with the prior approval of the necessary state authorities. Among the most important belong to the siting, construction and operational approvals issued by the SUJB after the evaluations of the respective Safety Analysis Report (siting, preliminary and pre-operational).

The licensee has other substantial obligations derived the Environmental Impact Assessment Act (No. 244/1992 Coll.). The licensee must prepare and publish an Environmental Impact Assessment Study, which is evaluated by the independent expert(s) nominated by the Ministry of Environment. This study becomes the subject of a public hearing, and a declaration of position (either positive or negative) from the Ministry of Environment ends this process. The SUJB is not allowed by the Atomic Act to issue its approval until this procedure is complete.

FRANCE

Owing to the extent of nuclear activities in France and the type of risks involved, it is imperative that stringent nuclear safety provisions be adhered to. Such provisions must safeguard people and property against dangers, harmful effects or inconvenience of any kind arising from the operation of nuclear installations and the transportation of radioactive or fissile materials.

The French nuclear regulatory system is based on the premise that the prime responsibility is that of the operator. The public authorities ensure that this responsibility is fully assumed in compliance with the relevant regulatory provisions.

The respective functions of public authorities and operator are structured as follows: the authorities define general safety objectives while the operator proposes technical solutions, justifying that the objectives could thereby be attained; the authorities assess the efficiency of the solutions proposed while the operator implements the approved provisions; and finally the authorities check in the course of inspections that the provisions have been correctly implemented and draw their conclusions.

Within the public authorities, the responsibility for supervision of nuclear plant and transport operation safety is entrusted to the Ministers for the Environment and for Industry. The responsibility for definition and implementation of the nuclear safety policy is entrusted to the Nuclear Installation Safety Directorate (DSIN), under the joint authority of the above two ministers. The DSIN, the NSSS Control Office (BCCN) and the Nuclear Installation

Departments (DIN) of the Regional Directorates for Industry, Research and the Environment (DRIRE) together form what is known as the “Safety Authority”. The Safety Authority carries out its supervisory functions in the following areas: the safety of Basic Nuclear Installations, the environmental impact of Basic Nuclear Installations, nuclear safety related radiation protection, the transportation of radioactive and fissile materials for civil use, and radioactive waste.

The effectiveness of the Safety Authority depends on its credibility, both at home and abroad. This implies the necessity for provisions for providing information to the public, in compliance with transparency requirements and the development of international relations, notably with foreign counterparts. From the regulatory standpoint, nuclear installations are classified in different categories corresponding to procedures, which are more or less binding, depending on the degree of potential risk involved. The Safety Authority is entrusted with definition and application of the regulations to the main permanent nuclear installations, known as “Basic Nuclear Installations” (BNI), except for classified plants working on national security projects (CBNI), which report to the High Commissioner for Atomic Energy, by delegation of powers from the Minister for Industry. The BNIs are listed in Decree 63-1228 of December 11, 1963. BNI’s include nuclear reactors except for those equipping a means of transport; particle accelerators; plants for the separation, manufacture or transformation of radioactive substances, notably nuclear fuel fabrication plants; spent fuel reprocessing plants or radioactive waste conditioning plants; and installations for the interim storage, disposal or use of radioactive substances, including waste. However, the latter three types of installation are only required to comply with BNI regulations in cases where the total quantity or activity level of the radioactive substances exceeds an amount defined, according to the type of installation and the radioelement considered, by a joint ministerial order issued by the Ministers for the Environment, Industry and Health respectively. Nuclear installations which are not considered as Basic Nuclear Installations may be required to comply with the provisions of the law of 19 July 1976 covering installations classified on environmental protection grounds (ICPE). The DSIN keeps permanently updated a list of Basic Nuclear Installations.

In France nuclear safety is based on the defence in depth principle, which notably involves a series of successive provisions (lines of defence) aimed at offsetting technical or human shortcomings. Each separate line of defence has to be as reliable as possible, but only collectively can they attain the extremely low accident probabilities compatible with nuclear safety requirements. Beyond these provisions, the method postulates the failure of all the preventive measures taken and the occurrence of accident situations, the consequences of which must then be mitigated. This deterministic approach is supplemented by probabilistic assessments to estimate the safety level actually achieved and, more importantly to identify weak points in the installations. In this context, the following aspects are notably considered in the course of technical safety assessments: prevention — each barrier has to be examined with respect to construction materials used, quality provisions made, adaptation to operating conditions, resistance to ageing phenomena; surveillance engineered safeguard actions.

Even under normal operating conditions, nuclear installations can have an environmental impact, notably through the release of liquid or gaseous effluents, whether radioactive or not. This impact has to be kept within acceptable limits by appropriate plant design and operating procedures.

In certain cases, technical radiation protection requirements can have negative consequences for nuclear safety and vice versa. For example, the increased biological shielding of valves can raise operational flexibility difficulties, or tests, justified on nuclear safety grounds, may not be without consequences for staff involved in limited access areas. It is consequently important that the nuclear safety and radiation protection authorities should be able, in all cases, to co-ordinate their actions, which would thereby be strengthened by the additional support afforded and which, where necessary, could be subjected to arbitration, thereby ensuring optimum decisions. With this in view, the Safety Authority works in closely with the Directorate-General for Health (DGS) and the Office for Protection against Ionizing Radiation (OPRI) that is responsible for the supervision of radiation protection in France. The scope of safety inspections are thus being extended to cover the closely related problems of radiation protection.

GERMANY

The basis of all activities in the nuclear field in Germany is the Atomic Energy Act from 1959, last revised in 1994. This federal law declares that the responsibility for regulations is a federal task and distributes licensing actions in specific fields to several subsequent authorities. For transport, final repositories and for interim storage of fuel the licensing authority is the Federal Office for Radiation Protection. For waste storage, for nuclear power plants and other nuclear facilities and for all handling of nuclear materials, the responsibility for licensing is given to the State authorities.

The Federal Ministry for Environment and Reactor Safety has to survey all regulations because of the federal responsibility.

The basic conditions for issuing a licence are also prescribed in the Atomic Energy Act. There has to be a need for keeping, treating or using the nuclear materials. The applicant and operations personnel have to be proven to be reliable and to be appropriately trained. It has to be shown that all needed provisions are made to avoid consequences and damages for people or in the environment or to keep them as low as reasonably achievable considering the status of science and technology.

The regulation standards below the Atomic Energy Act are set in a hierarchical structure. At the first level below the Act are regulations for radiation protection, provisions of insurance for accidents, and final disposal. Below this level is a series of safety requirements specific for several fuel cycle facilities. These are concerning plants for enrichment, MOX fuel fabrication, uranium fuel fabrication with high or low enrichment. Two others are under development for interim storage of spent fuel and for UF_6. In addition to the legal requirements, all technical standards and codes have to be considered.

In the safety requirements, detailed criteria for the type of facility according to the process used for fuel treatment are given, e.g. siting, external events, protection against releases, radiation protection, subcriticality, construction and design, quality assurance, operation, accident analysis, waste management, emergency measures and decommissioning. So the main topics which have to be considered during licensing are prescribed for design in a detailed manner and can be used to check the safety of the facility.

INDIA

For more than four decades the Department of Atomic Energy in India has ensured that nuclear facilities are designed and operated safely. As a result, a sound regulatory system has evolved through a series of government acts and rules including: the Atomic Energy Act, 1962; the Radiation Protection Rules, 1971; the Atomic Energy (working of Mines, Minerals and Handling of prescribed substances) Rules, 1984; the Atomic Energy Regulatory Board (AERB)1983; the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987; and the Atomic Energy Factory Rules, 1996.

The Atomic Energy Regulatory Board is mandated to review and authorize the safety of fuel cycle facilities for their siting, construction, and operation. Authorization at each stage is preceded by a detailed review from three different levels.

In the first level the project is reviewed by the Site Evaluation Safety Committee, Civil Engineering Safety Committee and Project Design Safety Committee. The recommendations of these committees are reviewed at the next level of scrutiny by an Advisory Committee for Project Safety Review (ACPSR). This committee passes on recommendations, based on its own assessments, to the AERB, which is a statutory authorizing agency.

The Site Evaluation Report submitted to AERB should contain inter alia the emergency preparedness and design basis accident scenario for the respective facility. To obtain a grant of authorization for commissioning, the plant is required to submit a Preliminary Safety Report, a QA programme, a list of all commissioning tests, and the acceptance criteria. The authorizations are issued for different commissioning phases. When the plant seeks clearance for regular operations it should submit additional documents to AERB including:

1. Final Safety Analysis Report
2. Detailed report on the commissioning operations
3. Technical Specifications for Regular operations
4. Radiation Protection Manual
5. Emergency Preparedness Manual.

The AERB has put in place a three-tier review system to provide a comprehensive review of the safety status of nuclear installations and enforcement of safety regulations during the operational phase of nuclear installations. At the plant level, a plant operation review committee reviews all operations and maintenance activities in the plant with potential safety problems. This committee reviews all unusual occurrences, deviations from technical specifications, modifications in the plant and changes in the plant procedures. At the second level, the Health Physics Unit at the plant provides information for the Unit Level Safety Committee, which in turn reports to the Safety Review Committee for Operating Plants (SARCOP) of AERB. Chairman SARCOP is an ex-officio member of the board of AERB. Unit level safety committees are constituted by Chairman SARCOP and have in their membership experts from AERB.

Apart from the report from Unit Level Safety Committee, SARCOP receives as inputs for its review periodic reports from the AERB’s Directorate of Regulatory Inspection and Enforcement and quarterly reports of Health Physics Units. SARCOP is empowered to impose restrictions or suspension of operation of the facility. Other regulatory requirements with which the nuclear fuel cycle facility must comply include: licensing of operating personnel;

issuance of authorization for disposal of radioactive wastes; maintenance of emergency preparedness; and compliance with Atomic Energy Factory Rules. The reviews by the safety committees consider not only radiological safety but also industrial hygiene and safety and the environmental safety of the plants.

Over the years, the AERB has put in place a sound regulatory framework and mechanism which permit the Department of Atomic Energy to construct and operate the nuclear fuel cycle facilities with out undue risk to the operating personnel and members of the public.

ROMANIA

The Romanian regulatory body is represented by the National Commission for Nuclear Activities Control (CNCAN). The Commission's activity is financed from the state budget and in the past, it has been part of the Romanian Ministry of Water, Forests and Environmental Protection. In the Spring of 1998 it was reorganized as a distinct institution directly subordinated to the Romanian Government. Its president acts as a state secretary. CNCAN develops relations with institutions and organizations from both inside and outside the country. The Ministry of Water, Forests and Environmental Protection is the national central authority for environment protection. Inside the Romanian National Agency for Science, Technology and Innovation (ANSTI) are the functions of the National Atomic Energy Agency (ANEA) which is more involved in the nuclear scientific research process. The Ministry of Health organizes the monitoring network for radioactive contamination of food products, drinking water sources and population. The radioactive sources for calibration and the measurement equipment have to be approved by the Romanian Metrology Office and have to be periodically verified. All these ministries, as parts of the Romanian government, together with their regional branches, issue laws, decrees, regulations, norms and guidelines concerning the nuclear safety of uranium exploration sites, mining facilities and processing plants, waste management and quality assurance and quality control.

The CNCAN is the governmental regulatory body, responsible for full surveillance and control for all issues relevant to nuclear safety in the siting, construction, commissioning, and operation of all nuclear facilities in Romania. Quality assurance, quality control, radiation safety, safeguards, export control, physical protection and emergency preparedness are also regulated. CNCAN as the Romanian licensing authority is in charge of license issuance and control of the operators. To accomplish this, CNCAN issues detailed regulations for nuclear safety, radioactive protection, quality assurance, control of nuclear weapons, and issues procedures and equipment for physical protection and intervention in case of a nuclear accident.

A number of these Regulations have been issued, some of which will be updated later and all of which will be reviewed and updated to be consistent with the new Nuclear Act. In October 1982, a Quality Assurance Act (Law No. 6/1982) was enacted. Most of its provisions were also included in the new Law No. 111/1996 which is concerned with nuclear safety and which has a chapter of requirements pertaining to quality assurance.

In addition the CNCAN has issued a series of quality assurance norms, known as the AQ-01.AQ-07 series. These cover such topics as project management of nuclear installations; requirements for the design of nuclear installations, procurement of the products and the services for nuclear installations, requirements for the products and services of nuclear installations and for the construction, commissioning and operation of nuclear installations.

RUSSIAN FEDERATION

Federal law on “Use of Atomic Energy” was enacted in the Russian Federation at the end of 1995. This law determined the legal basis for the regulation of safety in connection with use of atomic energy.

By the decree of the President of the Russian Federation, “About federal executive authorities authorized to implement the state regulation of safety in connection with use of atomic energy,” (21 January 1997) it was determined that there are four Federal Executive Authorities empowered to implement the state regulation of nuclear, radiation and technical safety and fire protection in connection with use of atomic energy. These are the Federal Nuclear and Radiation Safety Authority of Russia (Gosatomnadzor of Russia); the Ministry of Health of the Russian Federation (Minzdrav of Russia); the Federal Mining and Industrial Regulatory Authority of Russia (Gosgortechnadzor of Russia); and the Ministry of the Russian Federation for Internal Affairs (MVD of Russia).

According to the Russian Federation Governmental Decree (No. 865; 14 July 1997 the issuance of licensing procedures is assigned to Gosatomnadzor of Russia. Gosatomnadzor through a Headquarters and seven interregional territorial offices as well as an Interregional Territorial Department and a Scientific and Engineering Centre for Nuclear and Radiation Safety has developed and implemented a legal basis for a system for state regulation of safety in the field of atomic energy use. Gosatomnadzor has also established the legal basis for a system for state regulation of safety in the field of atomic energy and has developed, approved and implemented the federal safety standards and rules to be used for atomic energy usage. Gosatomnadzor also licenses these activities, organizes research needed and informs the state authorities and the local population about changes in the nuclear and radiation safety situation.

The system of the legal basis and the implementing documents used for the regulation of the safety in the field of use of atomic energy can be represented the legal acts and the implementing documents. The legal acts include the main international contracts (agreements) of the Russian Federation; the federal laws of the Russian Federation; the decrees, orders of the President of the Russian Federation; the decrees of Government of the Russian Federation; and, the interdepartmental agreements of Gosatomnadzor of Russia. The implementing documents include the federal norms and rules for use in the field of atomic energy; the normative documents, approved by GAN; and the norms authorized by other authorities of state regulation of safety, and by the other federal executive authorities.

The system of the regulatory documents developed by GAN has Federal norms and rules for use in the field of atomic energy, Safety guides, and Directives. Federal norms and rules regulate technical and organizational aspects of safety. Federal norms and rules are developed as general provisions, norms or rules (requirements). Safety Guides describe ways and methods of meeting the requirements set forth by the Federal norms and rules. While Directives contain the organizational norms based upon legal and other regulatory acts. These norms set forth rules and regulations under authority of Gosatomnadzor of Russia. The main types of such documents are: statutes, typical documents (programmes, lists, etc.), and procedural guides (methodical instructions).

For granting the license, the applicant should submit to Gosatomnadzor of Russia the application including all necessary documents substantiating the safety of the licensed activity. After consideration of the safety of the submitted application, GAN makes a decision to either grant the license or refuse the license. If granted, Gosatomnadzor of Russia issues the licenses for a term of not less than 3 years, or another term if stipulated in the materials of the application.

Gosatomnadzor of Russia periodically conducts inspections on the appropriate facilities. The inspections of facilities and other organizations can be separated into complex, target and operating issues. The complex inspection provides a check of the facility on all (or greater part) of the safety related issues. The target inspection provides a detailed check of the facility on one or several safety related issues. The operating inspection provides a detail check of the implementation of the safety requirements on the working places and inside the facility subdivisions.

To solve the problem of maintenance of nuclear facilities and to provide radiation safety, the Government of the Russian Federation ratified on 22 February 2000 a federal purpose oriented programme, "Nuclear and Radiation Safety of Russia", for the years 2000–2005. The programme will seek a solution to the complex problem of managing radioactive waste and spent nuclear fuel to prevent their harmful effects on the population and environment and will define the maintenance and radiation safety measures for nuclear fuel cycle facilities.

Eventual results expected are the development and use of modern technologies for safe implementation of activities in the field of spent nuclear fuel and radioactive materials handling, and the utilization of a reliable method for isolation of radioactive waste and spent nuclear materials. The development and implementation of reliable and safe nuclear, radiation, explosive, and fire reliable (safe) technologies at nuclear fuel cycle facilities is also expected. Safety regulation and supervision of nuclear fuel cycle facilities also needs to address the variety of technologies used, and the presence of other dangers, in addition to the nuclear and radiation hazards.

Russia also expects to develop legislative norms, in such areas as administrative responsibility, reimbursement of damage and nuclear insurance. These aspects as well as the presence of essential white spots in the federal level legislative basis for the regulation of safety of nuclear fuel cycle facilities need to be addressed. The problem of addressing this basis for safety regulation of nuclear fuel cycle facilities in Russia today is rather acute. Both safe handling of radioactive waste and the safe handling of materials containing plutonium extracted from the military programmes (MOX fuel) need to be addressed.

UKRAINE

The basis for regulation of nuclear activities in Ukraine is the Law of Ukraine on nuclear power utilization and radiation safety dated 1995. This Law declares that the responsibility for regulation and safety realization of nuclear activity is distributed among specified participants. Both the Law on nuclear power utilization and radiation safety and the new Law of Ukraine on permit activity in field of nuclear energy utilization (dated 8 February 2000) contain the principal provisions concerning the licensing of nuclear fuel cycle facilities including nuclear power plants, mining, milling, interim spent fuel storage, waste treatment and waste disposal facilities and radioactive materials transport.

In accordance with the Law on permit activity in the field of nuclear energy utilization it is necessary to obtain licenses for all life cycle stages of any nuclear fuel cycle facility, including planning and the engineering survey for siting; design, construction, commissioning, operation, and decommissioning. These activities are regulated by the Ministry of Environment Protection and Nuclear Safety of Ukraine, and the conclusions of other State authorities are also considered. A license should stipulate the specific nuclear facility, the types of activities, the terms and limits of safe use, and the period of license validity. In order to obtain a license to carry out the specific type of activity in the field of nuclear power utilization, it is necessary to obtain a positive conclusion from the State experts on nuclear and radiation safety.

State experts' conclusions shall be binding on all subjects in the field of nuclear power use. The positive conclusion from the State environment experts as well as the State experts' conclusions on nuclear and radiation safety is the grounds for project financing. According to the Law of Ukraine, the following designs shall be subject to the State environment experts' conclusions: investment projects, feasibility reports, designs and detailed designs for construction of new enterprises, as well as expanding, reconstruction and modernization of enterprises in operation.

According to the Law of Ukraine on assurance of public health and well being, any planned construction is subject to the public health and hygienic experts' conclusions. The public health and hygienic experts' conclusion is a comprehensive study of documents (designs, regulations, etc.) including the dangerous factors connected to them and is based on observance of the requirements of public health standards. According to the Law of Ukraine on fire safety it is prohibited to construct industrial facilities without a preliminary experts' conclusion (examination) of design and other documentation on the facility's ability to meet the regulations on fire safety.

UNITED KINGDOM

All civil nuclear installations in the UK, which includes all of the nuclear fuel cycles, are subject to the Health and Safety at Work, etc. Act 1974 (HSW Act). Amongst the relevant statutory provisions of this Act are those parts of the Nuclear Installations Act 1965 that refer to issues of safety. Under the Nuclear Installations Act, no site may be used for the purposes of installing or operating any prescribed nuclear installation unless a nuclear site licence has been granted by the Health and Safety Executive (HSE) and is, for the time being, in force. The HSE has delegated responsibility for administering this licensing function to the Nuclear Installations Inspectorate (NII), a part of HSE's Nuclear Safety Directorate.

The licensing regime is established by NII through powers under the Nuclear Installations Act to attach conditions to the site license which are enforceable in a court of law. In addition there are the powers available under the Health and Safety at Work etc. Act, for example to issue enforcement notices. This regulatory regime has been successfully applied to a wide variety of nuclear installations within UK over many years and has been shown to provide a powerful yet flexible system of control capable of being matched to the degree of risk involved. The licensing regime covers a nuclear installation through its full life cycle from design to decommissioning and takes into account the need to regulate and control the management of radioactive waste.

The site licence is predominantly non-prescriptive and most conditions attached to it require the licensee, who has the sole responsibility for ensuring safety, to make and implement adequate arrangements to take account of specified requirements. An example of this for Accumulation of Radioactive Waste (Licence Condition 32) is:

The licensee shall make and implement adequate arrangements for minimizing so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on the site at any time and for recording the waste so accumulated.

This Condition also gives the HSE the power to formally approve the arrangements, to specify any limitations to the arrangements or, if it wishes, to specify the place and manner of waste accumulation.

A similar Condition gives the HSE the powers to direct the licensee to dispose of the accumulated or stored waste in accordance with an authorization, issued by the appropriate Authorizing Department, under the relevant legislation. Other Conditions relating to the control of nuclear matter on the site include monitoring, record keeping, radiological protection, training, documentation, emergency arrangements, quality assurance and, in particular, the requirement for the licensee to produce a safety case to justify safety during all stages of the installation's life. Safety aspects of the movement of radioactive matter within, onto and from the site and the keeping of radioactive material on site are also regulated by NII under the provisions of the Ionizing Radiation’s Regulations 1985, made under the HSW Act.

The aim of the NII is to secure the maintenance and improvement of standards of safety at civil nuclear installations and to protect workers and members of the public from ionizing radiation. To achieve this aim the NII is structured to enable priorities to be decided centrally; to respond rapidly to technical innovation and operational experience; to be consistent in the development and application of standards; and to apply the regulatory requirements consistently and coherently across the whole nuclear industry.

The NII is divided into three Divisions within which there are inspection, assessment and strategy Units. The inspection Units, as their name would suggest, are primarily involved in carrying out site inspection activities to confirm that licensees are complying with their legal obligations. The assessment Units provide specialist technical advice on the adequacy of the licensee's safety cases. The strategy Units liaise with HSE policy Directorates, to co-ordinate the setting of NII policy on a range of issues, and develop the strategic implementation of that policy within their Division.

Recent experiences in UK, in particular in the regulatory review of Dounreay in 1998, suggested the need for the site licence to include a Condition on ‘Organizational Change’. Such a Condition has now been incorporated in all site licences, to come fully into force by April 2000, requiring each licensee to have adequate arrangements to control any changes to its organizational structure or resources which may affect safety.

UNITED STATES OF AMERICA

In the USA, fuel cycle facilities are regulated under the Atomic Energy Act of 1954, et. seq., the Energy Reorganization Act, Energy Policy Act, National Environmental Policy Act, and Nuclear Waste Policy Act, et. seq. Government facilities operated on behalf of the Department of Energy are regulated under the rules and orders of the Department. These facilities include uranium and plutonium processing facilities, including defense facilities, at government installations such as the Hanford Reservation, Savannah River Site, and the Idaho National Engineering and Environmental Laboratory. The US Nuclear Regulatory Commission (NRC) regulates civilian nuclear fuel cycle facilities. State regulatory authorities may also license facilities, other than reactors, if they only possess small quantities of special nuclear material.

A license is granted if the NRC determines that the application fulfils the requirements established in Title 10 of the Code of Federal Regulations (CFR). In addition to the basic radiation protection standards in 10 CFR Part 20, facilities must comply with pertinent provisions in 10 CFR Part 30 (low level waste storage facilities), 10 CFR Part 40 (uranium milling and conversion facilities), 10 CFR Part 50 (nuclear reactors), 10 CFR Part 60 and 63 (proposed; high level waste and spent fuel disposal facilities), 10 CFR Part 61 (low level waste disposal facilities), 10 CFR Part 70 (uranium and plutonium processing facilities and enrichment plants other than gaseous diffusion plants), 10 CFR Part 72 (spent fuel storage facilities), and 10 CFR Part 76 (gaseous diffusion enrichment plants). These requirements contain a mixture of performance and prescriptive safety requirements that must be satisfied as the basis for license issuance.

Site specific requirements are established as conditions in the licenses as necessary to ensure facility safety and environmental protection. These conditions are established during the license application review. The review is guided by a variety of guidance documents, including Standard Review Plans, Standard Format and Content Guides, Regulatory Guides, and Branch Technical Positions.

Other federal and State regulatory agencies, such as the Federal Environmental Protection Agency and Occupational Safety and Health Administration, or State environmental agencies may impose additional requirements to control risks other than those radiological and nuclear.

Experience in the USA with these facilities has suggested the need for enhanced requirements for fuel cycle facilities. The rupture of a UF_6 cylinder in 1986 and a near criticality accident in 1991 raised concerns about control of non-radiological risks and control of facility changes, respectively. Based on these experiences, the NRC initiated a rulemaking in 1994 to amend the requirements for fuel processing facilities in 10 CFR Part 70. The amendments, which were proposed in July 1999, adopt a more risk-informed, performance-based approach to regulation. They emphasize the development of an Integrated Safety Analysis to identify risks, evaluate the consequences of credible accident sequences, and identify the safety controls and controls systems relied upon for safety. The NRC anticipates completing the requirements by June 2000. Similar amendments are proposed in 10 CFR Part 63, which will supersede the requirements for high level waste disposal at the Yucca Mountain site. Continued refinement of the requirements in 10 CFR Parts 40, 50, and 72 is expected.

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