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# Safety measures to address the year 2000 issue at radioactive waste management facilities

March 1999

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## FOREWORD

In resolution GC(42)/RES/11 on “Measures to Address the Year 2000 (Y2K) Issue”, adopted on 25 September 1998, the General Conference of the International Atomic Energy Agency (IAEA) — inter alia — urged Member States “to share information with the Secretariat regarding diagnostic and corrective actions being planned or implemented by operating and regulatory organizations at … fuel cycle facilities … to make those facilities Year 2000 ready”, encouraged the Secretariat, “within existing resources, to act as a clearing-house and central point of contact for Member States to exchange information regarding diagnostic and remedial actions being taken at … fuel cycle facilities … to make these facilities Year 2000 ready”, urged the Secretariat “to handle the information provided by Member States carefully” and requested the Director General to report to it at its next (1999) regular session on the implementation of that resolution. In the context of the Y2K issue, radioactive waste management facilities are relevant from the point of view of radiation safety.

The reports issued together are: Achieving Year 2000 Readiness: Basic Processes; Safety Measures to Address the Year 2000 Issue at Medical Facilities which Use Radiation Generators and Radioactive Materials; and Safety Measures to Address the Year 2000 Issue at Radioactive Waste Management Facilities. This report addresses means of dealing with the Y2K problem in radioactive waste management facilities.

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# *DISCLAIMER*

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# 1. INTRODUCTION

## 1.1. Background

Computer-based systems are widely used in radioactive waste management, for example, during operations of facilities and data processing and storage. A problem may occur if two digit data fields were used to represent the year. The "00", intended to represent the year 2000, may be misread, for example, for the year 1900.

There are further date problems associated with the application of computer-based systems (see Annex). It may happen that the year 2000 is not correctly identified as a leap year with the risk of failure on 29 February 2000 or 31 December 2000, which is the 366th day of that year. Other critical dates are even earlier, for example, 22 August 1999 or 09 September 1999 (9/9/99). The first date may be important for systems involving the Global Positioning System (GPS), for example, in the transport of radioactive waste. The second date is important for systems handling the year with two digits because 99 (or 9999) was used as an end-of-file marker or "STOP" code. Date related problems can affect the proper functioning of computer-based systems and may lead to errors or malfunctionings in operations and the management of records and files. Such errors or malfunctionings may result in safety problems which have to be avoided.

The severity and extent of the date problem in computer-based systems, simply referred to as "year 2000" or "Y2K" problem, for radioactive waste management facilities and activities should be evaluated and, as necessary, measures should be taken in order to ensure safe operations at all times.

The IAEA was requested by a resolution of the General Conference in September 1998 [1] to deal with the Y2K problem and act as a focal point of contact for Member States to exchange information regarding diagnostic and remediation actions being taken at nuclear power plants, fuel cycle and/or medical facilities which use radioactive materials to make these facilities year 2000 ready. The IAEA, amongst other activities, is developing a set of reports [2, 3], including the present report, which addresses the management of radioactive waste from all types of facilities and applications using radionuclides.

The guidance developed for achieving Y2K readiness [2] was written for nuclear power plants but the methods described are largely applicable to other nuclear installations and to many industrial facilities. It addresses, in particular, the assessment of the problem, remediations, contingency planning and regulatory considerations. It is drafted in such a way as to provide coverage of the Y2K problems associated with complex facilities.

In radioactive waste management the types of facilities and activities can be very diverse. They may range from the vitrification of high level reprocessing waste to the decay storage of waste from the medical application of short lived radionuclides. The need for and the use of computers in various radioactive waste management facilities and activities is also very diverse. It may range from fully computerized processes to the total lack of computer applications, in particular in simple radioactive waste management processes or steps. In view of this situation and the fact that the time for remediation of eventually existing Y2K problems is very short, guidance on the evaluation of impacts of the Y2K problem on the safety of radioactive waste management may help to establish readiness for the Y2K problem in time.

### 1.2. Objective

General guidance for achieving Y2K readiness is already available [2] which can also be applied to computer-based systems in the management of radioactive waste. The objective of this report is to provide assistance in the application of Ref. [2] to radioactive waste management, in particular its very diverse situations, and to guide the user of computer-based systems to those processes or activities and functions or parameters where safety may be critically influenced by Y2K problem.

### 1.3. Scope

This report evaluates eventual impacts of the Y2K problem on the safety of radioactive waste management. It addresses the various types of waste, their processing, storage and disposal, decommissioning activities and sealed sources in terms of the approach to the Y2K problem, eventual remediations or contingencies and regulatory considerations. It assesses also typical processes involved in radioactive waste management for their potential of being affected by the Y2K problem. It addresses also eventual impacts on records and data as well as instruments and measurements.

## 2. GENERAL CONSIDERATIONS

### 2.1. Basic steps in radioactive waste management

Effective management of radioactive waste considers the basic steps (shown schematically in Fig. 1) in the radioactive waste management process as parts of a total system, from generation through disposal. It should also be noted that characterization, storage and transportation may be necessary within or between radioactive waste management steps.

Storage of radioactive waste involves maintaining the radioactive waste such that: (1) isolation, environmental protection and monitoring are provided; and (2) actions involving, for example, treatment, conditioning and disposal are facilitated. It may involve unconditioned or conditioned radioactive waste. In some cases, storage may be practised for primarily technical considerations, such as storage of radioactive waste containing mainly short lived radionuclides for decay and subsequent release within authorized limits, or storage of high level waste due to thermal considerations prior to geological disposal. In other cases, storage may be practised for reasons of economics or policy.

Pretreatment of waste is the initial step in waste management that occurs after waste generation. It consists, for example, of collection, segregation, chemical adjustment and decontamination and may include a period of interim storage. This initial step is important because it provides in many cases the best opportunity to segregate waste streams, for example, for recycling within the process or for disposal as ordinary non-radioactive waste when the quantities of radioactive materials they contain are exempt from regulatory controls. It also provides the opportunity to segregate radioactive waste, for example, for near surface or geological disposal.

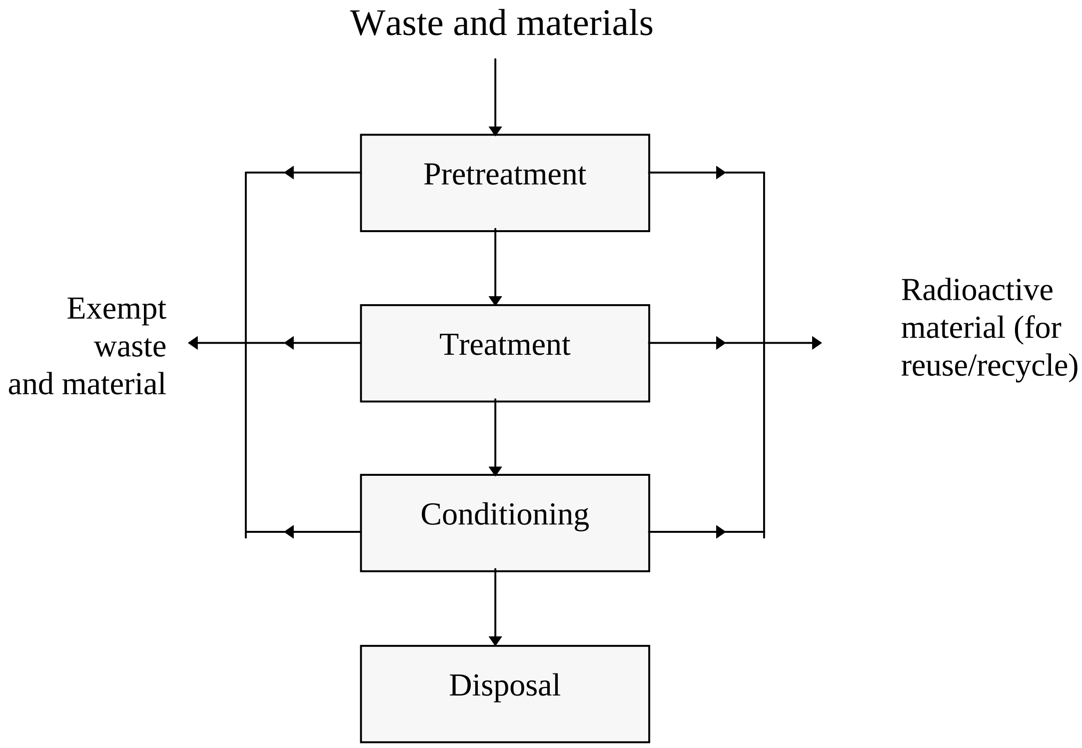


*FIG. 1. Basic steps in radioactive waste management.*

*Characterization, storage and transportation of waste and materials may take place between and within the basic radioactive waste management steps. The applicability of these steps will vary depending on the types of radioactive waste.*

Treatment of radioactive waste includes those operations intended to improve safety or economy by changing the characteristics of the radioactive waste. The basic treatment concepts are volume reduction, radionuclide removal and change of composition. Examples of such operations are: incineration of combustible radioactive waste or compaction of dry solid radioactive waste (volume reduction); evaporation, filtration or ion exchange of liquid radioactive waste streams (radionuclide removal); and precipitation or flocculation of chemical species (change of composition). Often several of these processes are used in combination to provide effective decontamination of radioactive waste streams.

Conditioning of radioactive waste involves those operations that transform radioactive waste into a form suitable for handling, transportation, storage and disposal. The operations may include immobilization of radioactive waste, placing the waste into containers and providing additional packaging. Common immobilization methods include solidification of low and intermediate level liquid radioactive waste, for example in a cement or bitumen matrix, and vitrification of high level liquid radioactive waste in a glass matrix. Immobilized radioactive waste, in turn, may be packaged in containers ranging from common 200 litre steel drums to highly engineered thick-walled containers, depending on the nature of the radionuclides and their concentrations. In many instances, pretreatment, treatment and conditioning take place in close conjunction with one another.

Disposal is the final step in the radioactive waste management system. It consists mainly of the emplacement of radioactive waste in a disposal facility with reasonable assurance for safety, without the intention of retrieval and without reliance on long term surveillance and maintenance. Safety is mainly achieved by concentration and containment which involves the isolation of suitably conditioned radioactive waste in a disposal facility. Isolation is attained by placing barriers around the radioactive waste in order to restrict the release of radionuclides to the environment. The barriers can be either natural or engineered and an isolation system can consist of one or more barriers which are designed according to the disposal option chosen and the radioactive waste forms involved.

Although it is planned to dispose of most types of radioactive waste by concentration and containment, disposal may also comprise the discharge of effluents (for example, in liquid and gaseous form) to the environment within authorized limits, with subsequent dispersion. For all practical purposes this is an irreversible action and is considered suitable only for limited amounts of specific radioactive waste.

### 2.2. Safety of radioactive waste management facilities and activities

Safety assessment is a key issue in ensuring that a radioactive waste management facility or activity is being carried out in accordance with legal and regulatory requirements. It covers failures of systems, equipment, etc. and, in the end, must demonstrate that the process or activity can be operated safely, even if an assumed failure should occur. Failures of computer-based systems would normally be covered by such an approach. In the case of the Y2K problem, it may not be possible to rely on this approach because a backup system that may have been installed to prevent failure, would also fail as a consequence of a common mode failure. Therefore, the Y2K problem needs a special assessment if computer-based systems are involved in radioactive waste management.

Radioactive waste management involves a huge variety of processes and activities (see Section 2.1). It may comprise, on the one hand, processes and activities involving open radionuclides and active systems to retain radionuclides, for example, in the vitrification of high level reprocessing waste, and, on the other hand, situations where the radionuclides are fully contained, for example, a fully conditioned radioactive waste ready for disposal.

In the case that open radionuclides and active systems are involved, failures caused by the Y2K problem could result in a release of radionuclides to the environment or into the facility or the generation of out-of-specification products. In all these cases, undesirable avoidable exposures would be the consequence of non-resolved Y2K problems. It has to be acknowledged that in radioactive waste management the response of a process or activity to a failure may be slow so that there may be ample time to resolve the issue before any radiological consequences occur. The slowness of the process can be taken into account when dealing with Y2K problems but does not justify ignoring this problem.

The following Sections provide information on the principal approach to the Y2K problem in radioactive waste management and on safety issues that are of highest importance and demand primary attention. This information is designed to provide assistance on how to apply the generic approach to the Y2K problem presented in Ref. [2] to radioactive waste management.

## 3. APPROACH TO THE YEAR 2000 PROBLEM

This report recommends a strategy for Y2K readiness based on that set out in Ref. [2], but elaborated to accommodate the specific variety of radioactive waste management facilities and activities. The Y2K strategy emphasises the essential elements, explains their importance and provides guidance for accomplishing the programme. The programme consists of four principal phases:

— Initial assessment;
— Detailed assessment;
— Remediation; and
— Contingency planning.

The regulatory authorities should ensure that their licensees (operators) are aware of the Y2K issues and are responding effectively to them. Regulators also need to monitor the implementation of the Y2K programme by the operator.

The programme manager at a facility is responsible for the management of the Y2K programme and is responsible to the facility management, which is responsible for the safety and operability of the facility. The programme manager accomplishes the objective of the programme by implementing the steps identified in Ref. [2], Section 2.

### 3.1. Initial assessment

The purpose of this initial assessment is to establish an inventory of items that are required to be reviewed, determine the importance of each item to the facility and schedule those items that require further analysis during detailed assessment. Initial assessment is the first step toward accomplishing the Y2K readiness of each item.

Initial assessment, as described in this report, employs a method that takes a potentially large population of items and reduces it to the minimum appropriate population. The traceabillity of important devices is to be maintained.

It is proposed that for radioactive waste management facilities the first step in the initial assessment phase is to establish a “Preliminary Inventory”, based on the guidance set out in Section 3.2.1 of Ref. [2]. This Preliminary Inventory establishes, by careful examination of the equipment in the process, whether there are any items that are date sensitive. At the end of this initial review it should be clear which facilities do or do not have computer-based systems in them. If in this initial review it can be established that the radioactive waste management facility does not involve the use of computer-based equipment or that any such equipment is not date sensitive, then it can be declared as Y2K ready. Further guidance is given in Section 5 on the sensitivity of radioactive waste management processes to the Y2K problem.

The review should identify each of the processes at a facility and identify their potential hazards. It should identify the process functions and the main plant parameters associated with the control and protection of the process. The broad consequences of process control and protection system failure should be identified, based on existing plant safety analyses.

Once this first step has been initiated and information becomes available on the equipment in the facility, each item that is potentially date sensitive can be “classified” using the approach set out in Section 3.1 of Ref. [2]. Classification determines whether an item is of sufficient importance to be included. For radioactive waste management the review of the waste management facilities and activities should identify the on-line computer-based systems that are important to the safety of the plant. At the end of the classification a grouping is recommended into categories that are related to the consequences, for example:

(1) No safety impact as nothing happens due to the nature of the radioactive waste;
(2) Increase or additional occupational exposure, caused by reworking;
(3) Release of radionuclides into the facility or to the environment, caused by the failure of equipment; and
(4) An event such as an exothermic reaction (e.g. fire or explosion).

Section 5 provides detailed examples of this application of the proposed approach.

For radioactive waste management facilities and activities that lead directly to the first category it is recommended that no further action be taken as the consequences of the Y2K problem, even if they occur, do not constitute a safety problem.

For the second category, specific consideration needs to be given since, despite there being no direct safety concern, the necessary reworking of an off-specification waste form, waste package or component may lead to an operational condition not taken into account in plant design for normal operation and may lead to additional radiation exposure and additional waste.

The last two categories have direct safety implications and need to be included in the classification process to establish the Y2K inventory.

Preliminary Inventory Analysis provides an objective means of excluding items from the inventory. At the end of this phase it should be clear what computer-based systems are involved in radioactive waste management and what their relevance is to safety. The initial assessment helps to ensure that subsequent phases focus only on items of importance to the programme.

### 3.2. Detailed assessment

The purpose of detailed assessment is to obtain or generate sufficient information about an item to determine its expected behaviour on critical dates. Detailed assessment results (see Ref. [2], Section 4 for details) are used to make decisions regarding remediation and/or contingency planning.

There are two main steps to completing the detailed assessment. Firstly information should be sought from the vendor on the item with regard to its date sensitivity. The vendor’s willingness and qualification to support the facility’s Y2K programme should be evaluated, the aim being to determine whether the vendor will participate in the evaluation and provide certification of an item’s performance. A vendor’s unwillingness or inability to support the Y2K programme may have significant implications for the way in which investigation tests or remediation can be carried out.

The second step in the detailed assessment is an evaluation of the item’s sensitivity to the critical dates. In the situation where the vendor has provided information, a verification of the validity of the information, as it relates to the specific item, should be arranged by the operator of a facility or activity. Where this is carried out by the vendor, it should be checked by the operator.

Where the facility is not able to obtain information from the vendor or involve the vendor in conducting the evaluation, the facility should carry out a formal evaluation and arrange for this to be checked.

Two methods of evaluation are identified in this report, based on the detailed information provided in Ref. [2] Section 4.2. “Inspection” and “Investigative Testing” are acceptable means to determine the acceptability on the item (see Ref. [2], Sections 4.2.1 and 4.2.2 for details).

## 3.3. Remediation

The purpose of remediation is to address the failure modes identified in the detailed assessment. During remediation the programme manager should track the timeliness of delivery of purchased material and the progress of conversions, replacements, deletions, retirements and vendor efforts. Remediation efforts that are not timely require the programme manager’s attention.

From the schedule of remediation forms, priorities should be set by considering:

— Classification of an item;
— Competing project schedules;
— Availability of qualified personnel; and
— The number of items of a given type.

### *3.3.1. Remediation strategy*

Once an item has been determined to be susceptible to Y2K failures or that there is a likelihood of failure, a remediation strategy should be selected. Strategies include:

— Retire/remove the item from service without providing a replacement;
— Replace/remove the item from service and provide an alternate means of fulfilling the function performed by the item;
— Modify/alter the existing item to remove the noted Y2K problem; or
— Work around the problem which provides a means of satisfying the functional requirements without correcting the Y2K fault.

The remediation strategy chosen should take account of the time available from when a strategy is selected to the critical date that will cause the item to have a problem, as there may be insufficient time to install and validate modifications or replacements.

### *3.3.2. Perform remediation*

Once a remediation strategy has been chosen, the next step is to perform the remediation.

Where “retire” has been chosen, the facility should treat the retirement of an item as a modification to the plant and follow its usual modification procedures to establish that it is safe to retire the item.

Where “replace” has been chosen, it removes the item from service and replaces it with another. Two aspects should be addressed; firstly the facility should treat replacement of one item with another as a modification to the plant and follow its usual modification procedure to establish that the replacement is safe. The second aspect is that the replacement should be completely reviewed for Y2K readiness and be Y2K ready or compliant.

Where “modification” is chosen, the usual modification procedures for the facility should be followed to establish that the proposed modification is safe.

Where “work-around” is chosen the facility should recognize that Y2K compliance or readiness is not achieved. Work-around is not a preferred remediation strategy but it is pragmatic reality. The facility should analyse any work-arounds to ensure they are achievable and safe. Consideration should include failure modes, interaction effects and consequences of failure upon staff resources.

Work-arounds include rolling dates back, for example, January 1, 2000 could be set to January 1, 1972 as 1972 begins on a Saturday and was a leap year, as is 2000. Shutting down the radioactive waste process over the critical date periods also constitutes a work-around. For radioactive waste management facilities this may be a viable approach, particularly if the work production process does not normally operate continuously. A facility that proposes this course of action should be able to demonstrate in advance of the critical date that the restart of the process after the critical date is safe by providing specific date related tests on the item during the restart.

Whichever remediation strategy is chosen, a validation activity should be carried out by the facility to establish that the remediation is successful. Further details on remediation are provided in Section 5 of Ref. [2].

### 3.4. Contingency planning

Contingency planning is an integral activity to the Y2K programme. Contingency planning is a process that may begin at any time subsequent to the initial assessment and may continue throughout the programme.

The primary goal is the preparation of individual contingency plans which have to be combined into a single integrated contingency plan. Contingency plans are developed to deal with specific hazards associated with internal or external sources.

The following are recommended steps for developing contingency plans:

— Risk identification — determines risks to the facility from Y2K induced events;
— Risk analysis — reviews the identified risks, determines potential failure modes and consequences, and documents pertinent information;
— Risk management — uses information from risk analysis to determine mitigation strategies. It should consider Y2K induced risks and their interdependences; and
— Validation — reviews the results of risk management and provides confidence that the contingency plan will effectively mitigate the risk.

Contingency plans should be subject to the same elements of the facility processes and programmes discussed under Remediation and should be submitted to the programme manager when completed.

The integrated contingency plan provides facility management with a comprehensive perspective of the risks associated with Y2K induced failures. The programme manager should ensure that a facility specific integrated contingency plan is developed. The integrated contingency plan allows the facility management to posture the facility in such a way as to deal with events most comprehensively. Further details on contingency planning are provided in Sections 6.1–6.3 of Ref. [2].

# 4. TYPES OF WASTE

The management of radioactive waste involves a wide range of materials, processes and activities in an equally wide range of facilities of varying age and sophistication. Some of the processes are continuous while others involve batches or mechanical handling. These processes can be controlled or sequenced automatically but often, due to the slow nature of the process, they rely on, or make extensive use of, staff to perform an operation.

For processing needs, radioactive waste is often categorized by its physical form (i.e. gaseous, liquid and solid) and by the radiological hazard it presents (i.e. high level waste or low and intermediate level waste). The radioactive waste, because of its chemical composition, may exhibit other properties, for example, self-heating, pyrophorous or evolution of hydrogen on decomposition. These factors, and whether the radioactive waste has been conditioned will determine whether the radioactive waste is potentially hazardous.

# 5. ASSESSMENT OF RADIOACTIVE WASTE MANAGEMENT PROCESSES

Radioactive waste management processes and the production of waste packages are generally designed in a very specialized way to meet differing national, regulatory and customer requirements. In addition, equipment and plant operation will very much depend on characteristics such as type and amount of radioactive waste to be processed. It is also depending on whether the process under consideration constitutes a research installation, an auxiliary process or a stand-alone waste processing facility. Because of this wide range of facilities and activities and because of the varying potential hazards of the radioactive waste, a systematic approach should be employed to determining those waste types and processes that may be susceptible to the Y2K problem.

The following assessment of frequently applied radioactive waste management processes can only be of a generic nature which is intended to provide guidance to Y2K persons and to assist in setting priorities. In practice, plant operators, monitored by the regulatory body, need to assess each individual facility or activity, taking into account all characteristics of the respective process and control systems. A safety analysis should already exist for each facility (as a basis for its licensing procedure) that will have assessed the associated hazards and determined potential consequences of failures and the risk associated with the operation of the respective facility.

Where computer-based systems are involved in the plant, their failure will most likely have been considered as part of the safety analysis. However, the common cause failure associated with the Y2K problem is unlikely to have been addressed. Thus, investigations of the Y2K problem should focus on safety relevant process control or other equipment that uses date and time functions. To achieve reliable and complete knowledge supplier information and its verification could be indispensable in many cases.

Processes that do not involve any computer-based systems with the above mentioned functions are not considered to be Y2K vulnerable and do not require further consideration. An investigation on whether or not computer-based systems are involved should, therefore, be the first step of a Y2K assessment of radioactive waste management facilities and activities.

### 5.1. Vitrification

Vitrification is a process commonly used to convert high level reprocessing waste solutions from spent fuel reprocessing into a stable form suitable for storage and disposal. Several different vitrification processes are available which may include the following steps:

— Feed dosage;
— Calcination;
— Dosage of glass frit;
— Melting;
— Filling and closing of waste canisters; and
— Off-gas treatment.

Important characteristics of the vitrification processes are the high radiation levels, the corresponding heat generation, the high temperatures of the melting process and the high volatility of some of the radionuclides represented in such waste. The quality of the vitrified waste depends among others on process parameters such as:

— Homogeneity of the feed solution and melt;
— Temperatures of the calciner and the melter; and
— composition of process streams at all process stages.

To achieve safe operation, a proper interaction of control, measuring and alarm equipment is indispensable. Failure of process equipment or a breakdown of control systems may result in process streams or products not meeting the predescribed specifications. Instabilities or deviations of process parameters such as electric power supply of the melter, air sparging, melt stirring, vacuum and melter exit temperature may result in out-of-specification glass compositions and pouring rates that could affect long term stability of the product. Overflow of the melter or canister may produce contamination of cells and installations. Failure of the lid welding process does not allow to guarantee the leaktightness of the canister. Malfunctioning of the off-gas treatment systems may lead to an insufficient recovery of volatile radionuclides and chemically toxic substances such as $NO_x$ and a subsequent release to the environment.

In dealing with the Y2K problem in the vitrification of high level waste arising from spent fuel reprocessing, it is recommended to give priority to those computer-based systems that could lead to failure of the off-gas treatment system, to melter and canister overflow and out-of-specification glass products.

### 5.2. Conditioning of spent fuel

Conditioning of spent fuel, if spent fuel is declared a waste, is the alternative to reprocessing and subsequent vitrification of high level reprocessing waste. Conditioning of spent fuel is expected to include mainly repackaging activities, often in combination with the removal of spacers and end pieces of a fuel element. These activities are normally of a purely mechanical nature, not intended to affect the integrity of fuel rods. The preparation of waste packages suitable to comply with acceptance requirements of storage or disposal facilities may include the following steps:

— Removal of spacers and end pieces from the fuel elements;
— Packing of the individual fuel rods into a thick walled container; and
— Closure of the container.

Important characteristics of the spent fuel conditioning are the high radiation levels and the corresponding heat generation of the material to be processed, depending on burn-up and cooling time. If precautions are taken to prevent any damage to the fuel rod integrity in case of a system malfunction, no safety problems are expected to occur in the context of the Y2K problem.

Since no spent fuel conditioning facility is expected to be in operation on any critical date under consideration, no further attention is given to the conditioning of waste of that type.

### 5.3. Bituminization

The bituminization process is widely used to immobilize radioactive waste stemming from auxiliary and rework units of fuel cycle facilities, including nuclear power plants, and other installations. The process consists mainly of the following steps:

— Concentration and chemical adjustment of the liquid waste;
— Feed and bitumen dosage;
— Extrusion;
— Filling and closing of containers; and
— Off-gas treatment.

Typically, low and intermediate level waste of varying radionuclide composition is immobilized with bitumen. Important process parameters of the chemical adjustment/precipitation/decanting process are density, temperature, pH and dosage of additives. The quality of the bituminized waste depends on:

— Feed composition;
— Feed and bitumen flow rates; and
— Temperature and other extrusion parameters.

Malfunction could result in an incompatible adjustment of the feed. Temperature and flow rates influence water separation and product composition as well as product homogeneity, which may result in an out-of-specification bitumen waste. A failure of the off-gas system may lead to an insufficient recovery of radionuclides. Temperature control is essential to avoid fire or other thermal reactions during extrusion and filling of containers resulting in contamination of the facility.

In dealing with the Y2K problem in the bituminization of low and intermediate level waste, it is recommended to give priority to those computer-based systems which could lead to a failure of temperature control, of the off-gas system and of the feed adjustment and to incorrect feed/bitumen flow rates.

### 5.4. Incineration

Incineration is a very effective process to reduce the volume of organic radioactive waste in liquid as well as in solid form. The main components of that process comprise:

— Feed dosage;
— Combustion process, including support heat; and
— Off-gas treatment.

In most cases incineration does not result in a final waste form as the ashes are typically subject to compaction or immobilization, for example, by cementation.

To achieve complete combustion, requires temperatures up to $1200^0$C, a proper dosage of the feed and an efficient off-gas treatment system which is capable of retaining radionuclides as well as chemically toxic compounds, in particular dioxins but also HCl, $SO_2$, and $NO_x$.

A lack of temperature control and feed dosage may result in out-of-specification ash products and uncontrolled exothermic reactions which may affect proper functioning of the off-gas system.

Malfunction of the off-gas treatment bears the potential of a release of radioactive substances, corrosive and toxical chemical compounds (dioxins, HCl, $SO_2$, $NO_x$) to the environment.

In dealing with the Y2K problem in the incineration of organic radioactive waste, it is recommended to give priority to those computer-based systems which could lead to failures of control of temperature, feed flow and off-gas systems.

### 5.5. Drying

Drying is used to remove liquids or humidity from solid radioactive waste. Drying is also applied to solidify radioactive waste solutions or suspensions in order to produce solid products. The necessary heat energy can be provided by electricity, steam or other media. The application of a vacuum may allow drying at lower temperatures to avoid eventual degradation of thermally sensitive compounds. The vapor arising from the drying process will be condensed. Ventilation and off-gas systems are installed to avoid any unacceptable releases to the environment and to prevent the occurrence of dangerous air/gas concentrations which could cause exothermic reactions. Failures in the control of the relevant process parameters, such as temperatures, feed flows and auxiliary media, ventilation and off-gas, may lead to out-of-specification products. Damage of ventilation and off-gas systems due to overheat, fire or explosion could result in a release of radionuclides to the environment and contamination of the facility.

In dealing with the Y2K problem in drying of liquid radioactive waste, it is recommended to give priority to those computer-based systems which could lead to failures of control of temperature, feed flow and off-gas systems.

### 5.6. Cementation

Cementation is the most commonly used process for the immobilization of solid and liquid low and intermediate level waste from almost all types of nuclear installations. A wide variety of cementation processes is being applied, ranging from manually to highly automated ones and from directly operated to remotely controlled ones. The radioactive waste under consideration varies from close to zero contaminated substances to highly contaminated or activated components with the corresponding radiation levels.

According to the nature of the radioactive waste, different processes are applied. In the case of solid radioactive waste (e.g. hulls, scrap or dismantled process components), the material may simply be put into a container, for example a drum, and covered with cement or concrete in order to fill the space between the solids with a matrix material.

Liquid radioactive waste sometimes (with solid residues) or precipitation products are commonly mixed as a slurry into the cement to achieve homogeneous products. This can be done by an in-drum mixing process or a continuous or batch-wise mixer. The steps applied in the cementation of radioactive waste vary greatly with the type of process applied. In almost all cases there is no serious potential of exothermic reactions and fires or explosions. There is also no substantial release of airborne hazardous substances or radionuclides. Only the hulls from spent fuel reprocessing are prone to self-ignition and need to be kept under water until further treatment. The low temperatures and the mainly mechanical character of the process steps as well as their simplistic nature ensure that the cementation process can be applied without major hazards. Wrong dosage of feed and matrix material may lead to out-of-specification products in case of malfunctions of components or control devices. In such cases the product may, for example, not have the anticipated mechanical properties or may even not solidify.

In dealing with Y2K problem in the cementation of low and intermediate level waste, it is recommended to give priority to those computer-based systems which could lead to failures of control of chemical composition and the feed/matrix ratio.

### 5.7. Compaction

Compaction is applied to a wide variety of solid radioactive waste. The solid radioactive waste, eventually placed in a cartridge or drum is placed into the tube of the press and compacted with a high force to a pellet. Moisture associated with the radioactive waste will be pressed out and collected. No particular hazards are associated with compaction of solid radioactive waste as long as explosive, pyrophoric or similarly hazardous material will not be compacted. No important safety features with a Y2K susceptibility can be identified.

In the case of a compaction of zircaloy hulls from spent fuel reprocessing attention has to be given to the inertization system to avoid risk of an eventual self-ignition which may affect ventilation and off-gas systems and may result in a contamination of the facility or a release of radionuclides to the environment.

In dealing with the Y2K problem in the compaction of hulls from spent fuel reprocessing, it is recommended to give priority to those computer-based systems which could lead to failure of control of the inertization system for preventing self-ignition.

### 5.8. Other waste treatment processes

In radioactive waste management, evaporation, ion exchange, precipitation may be applied as treatment steps, forming a part of the overall approach to the processing of liquid radioactive waste. They result in an intermediate product and lead to high volume reduction and efficient decontamination of non-volatile radionuclides. Safety issues resulting from a failure of equipment could be corrosion of equipment in the case of operation at an out-of-specification pH, risk of exothermic reactions or radiolytic gas release if organic material is present.

In dealing with the Y2K problem, it is recommended to pay attention to thermal waste treatment processes and give priority to those computer-based systems that control temperature and organic content in the radioactive waste stream.

### 5.9. Decommissioning waste

Maintenance of components or decommissioning of entire facilities may require special equipment or methods not routinely used under normal conditions of plant operation. Owing to the unique character of those processes, a case by case evaluation of the hazards associated with the respective demolition activity is recommended. However, the processing of radioactive waste resulting from decommissioning activities involves the processes outlined above. Therefore, no additional recommendations regarding the Y2K problem of computer-based systems need to be given.

### 5.10. Storage of radioactive waste

Storage facilities may contain unconditioned radioactive waste in liquid or solid form awaiting further processing. Owing to the static nature of the storage process, no change of volume and waste form takes place, and thus hazards may only occur as a result of the inherent properties of the stored radioactive waste, such as volatility, $H_2$ generation, heat production, self-ignition, explosion or pyrophoric behaviour. Liquid radioactive waste containing dispersed solids may be susceptible to settling of solids, which may be very difficult to remove from the storage tank. Therefore, depending on the type of radioactive waste, attention must be given to:

- ventilation to prevent fire or explosive air/gas concentrations or concentrations of corrosive substances;
- cooling systems to avoid changing of chemical composition, reaching of too high temperatures or critical concentrations due to evaporation of the solution;
- inertization of the system; and

— stirring or pulsing systems to provide homogeneous solutions and to avoid accumulation of dispersed solids.

The storage of conditioned radioactive waste involves normally waste packages that are designed for storage and verified to fulfil the requirements for storage. The only type of waste that needs further consideration is heat generating high level waste. In all known cases solid high level waste is stored using passive cooling systems with natural convection which do not depend on active systems.

In dealing with the Y2K problem in the storage of radioactive waste, it is recommended to give priority to those computer-based systems which control the active components of a storage facility that are relevant for safety, such as forced ventilation, inertization and stirring or pulsing of solutions, and the systems monitoring the stored radioactive waste.

### 5.11. Discharges and clearance

Discharge refers to the release of radionuclides to the environment within regulatory limits. Clearance refers to the release of waste from regulatory control at trivial radionuclide concentrations or amounts.

The discharge of gaseous substances to the environment as part of normal plant operation is carried out in connection with the operation of the plant and its off-gas system. The importance of off-gas systems has already been stressed, in connection with the assessment of the radioactive waste processing facilities (see Sections 5.1–5.8) and is covered there.

Discharges of liquids to the marine environment, rivers or sewage systems is usually operated batch-wise after careful analysis of the solution and compliance check with regulatory requirements. Unintentional discharges should be prevented by the design and construction. In some cases decisions on discharges or clearances are made based, for example, on decay calculations. In such situations calculations are date dependent. They may be wrong owing to the Y2K problem and can lead to unacceptable discharges or clearances.

In dealing with the Y2K problem regarding discharges and clearances, it is recommended to give priority to those computer-based systems that are used to perform decay calculations or similar types of calculations of radionuclide inventories of waste.

### 5.12. Disposal of radioactive waste

Radioactive waste to be disposed of permanently and the respective disposal facilities are designed and constructed in such a way that they operate safely. They can, particularly, remain unattended without the need for active safety measures for long periods of time. Credible radiation exposure scenarios or releases of radionuclides to the environment caused by the Y2K problem cannot be identified.

## 6. DATA GENERATION

Besides the direct involvement of computer-based systems in the on-line control of radioactive waste management facilities or activities, computers are used in the off-line monitoring and analysis of processes. Data are gathered, used and stored on all aspects of the radioactive waste management processes including, records on radioactive waste inventory, key performance parameters at certain stages in a process, the location of waste packages within a process and the location of waste packages within a storage or disposal facility. Data are also used in calculations, such as for decay estimates to make decisions about waste segregation. Data are also used to perform calibration of on-line measuring instruments.

Ensuring the accuracy, validity and retrievability of such data is an essential part of ensuring the safety of radioactive waste management. Where computer-based systems are used to gather, calculate and store such information, there is the potential for the computer-based systems to be vulnerable to the Y2K problem and the risk that data could be lost or corrupted.

In dealing with the Y2K problem, priority should be given to those computer-based systems that are used in an off-line manner to support radioactive waste management processes, for example in the calculation and storage of data. The computer-based systems should be assessed for their vulnerability to the Y2K problem and, where affected, consideration should be given to developing a remediation strategy that ensures that data will not be lost or corrupted.

# 7. CONCLUSIONS AND RECOMMENDATIONS

## 7.1. Conclusions

(a) A systematic approach commensurate with the hazards involved is essential in order to ensure that Y2K compliance testing is carried out and that necessary remedial measures are taken in order to ensure the safety of radioactive waste management facilities.

(b) The systems for which the Y2K issue poses potential safety problems at radioactive waste management facilities include:

- systems involving “open” radionuclides and active components, such as systems for vitrification of high level waste or the incineration of organic radioactive waste, where an off-gas treatment failure could cause radionuclide releases into the environment;

- systems involving computerized process control, where a control failure could — for example — cause incorrect dosages of feed and matrix material, resulting in out-of-specification radioactive waste (needing to be reworked) or in a container or equipment overflow (requiring decontamination of the affected facility or equipment); and

- data processing systems, where — for example — an unnoticed incorrect calculation may have direct safety implications if clearance or discharge operations depend on computerized decay calculations.

(c) More specifically:

- in the vitrification of high level waste arising from spent fuel reprocessing, priority should be given to those computer-based systems which could lead to failure of the off-gas treatment system, to melter and canister overflow and to out-of-specification glass products;

- in the bituminization of low and intermediate level waste, priority should be given to those computer-based systems which could lead to a failure of temperature control, of the off-gas system and of the feed adjustment and to incorrect feed/bitumen flow rates;
- in the incineration of organic radioactive waste, priority should be given to those computer-based systems which could lead to failures of control of temperature, feed flow and off-gas systems;
- in the drying of liquid radioactive waste, priority should be given to those computer-based systems which could lead to failures of control of temperature, feed flow and ventilation/off-gas systems;
- in the cementation of low and intermediate level waste, priority should be given to those computer-based systems which could lead to failures of control of chemical composition and the feed/matrix ratio;
- in the compaction of hulls from spent fuel reprocessing, priority should be given to those computer-based systems which could lead to failures of control of the inertization system for preventing self-ignition; and
- in radioactive waste storage, priority should be given to those computer-based systems which control the active components of a storage facility that are relevant for safety, such as forced ventilation, inertization, and stirring or pulsing of solutions, and the systems monitoring the stored radioactive waste.

## 7.2. Recommendations

National authorities throughout the world and competent international organizations should be aware of the identified potential for radiation exposures caused by Y2K problems at radioactive waste management facilities.

Regulatory authorities worldwide should be encouraged to ensure that registrants and licensees of radioactive waste management facilities carry out systematic actions to identify the radioactive waste management facilities and activities that may be affected by Y2K problems and take remedial measures in line with the guidance provided in this report.

National authorities and registrants and licensees of radioactive waste management facilities should be encouraged to exchange, in a timely manner, the information acquired and experience gained through such systematic actions.

**Annex**

# CRITICAL DATES

The Y2K problem revolves around the inability of some systems to handle not only the date 1 January 2000, but also the other critical dates listed below:

- **22 August 1999:** this date is a problem for systems, which interface with the Global Positioning System (GPS), for example, the transport of nuclear fuel where knowledge of its location is important. The original GPS design allocated a 10-bit register to handle the number of weeks which had elapsed since the base date (or GPS epoch date) of 6 January 1980. The 10-bit week counter will rollover from its maximum value to zero on 22 August 1999.

- **9 September 1999** (9/9/99)**:** as in the case of 1 January 1999, this date is a problem for computer-based systems that handle the year of a date with only two digits and that use the number 99 (or 9999) as an end-of-file marker or "STOP" code.

- **1 January 2000:** this date is a problem for computer-based systems that handle the year of a date with only two digits, because they may misread 00 as the year 1900 instead of the year 2000.

- **29 February 2000:** this date is a problem for computer-based systems that do not correctly identify the year 2000 as a **leap year** and risk failure at 29 February 2000, because it is a leap day.

- **1 March 2000:** this date is a problem for computer-based systems that do not correctly identify the year 2000 as a leap year and therefore do not recognize 29 February 2000 as a leap day. 1 March 2000 is the day after the leap day and these systems may carry erroneous data.

- **31 December 2000:** this date is a problem for computer-based systems that do not correctly identify the year 2000 as a leap year and risk failure at 31 December 2000, because it is the $366^{th}$ day.

- **1 January 2001:** this date is a problem for computer-based systems that do not correctly identify the year 2000 as a leap year and may carry erroneous data on 1 January 2001, because it is the day after the 366th day (31 December 2000).

## REFERENCES


[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Measures to address the year 2000 (Y2K) issue, General Conference Resolution GC(42)/Res/11, September 1998, IAEA, Vienna (1998).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Achieving Year 2000 Readiness: Basic Processes, IAEA-TECDOC-1072, Vienna (1999).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Measures to Address the Year 2000 Issue at Medical Facilities which Use Radiation Generators and Radioactive Materials, IAEA-TECDOC-1074, Vienna (1999).

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