RADIOACTIVE WASTE MANAGEMENT FACILITIES & Y2K

STEPS FOR SAFETY

BY ERNST WARNECKE

Computer-based systems are widely used in radioactive waste management, for example, during operations of facilities and data processing. The potential severity and extent of Y2K issues pose challenges for ensuring that measures are taken to maintain safe operations at all times.

Failures of computer-based systems would normally be covered by the common approach to safety, e.g. by providing diversity and redundancy. In the case of Y2K issues, it may not be possible to rely on this approach because a backup system, which may have been installed to prevent failure, might also fail -- a so-called "common cause failure". Therefore, Y2K issues need to be assessed at waste management facilities. Fortunately, in the management of radioactive waste, the response of a process or activity to a failure will be slow in many instances, providing more time to resolve the issue before any radiological consequences occur. This feature of the process can be taken into account when dealing with Y2K problems but it does not justify ignoring them.

The IAEA's main guidance document for achieving Y2K readiness, though mainly directed at nuclear power plants, describes methods that 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 its activities to assist Member States, the IAEA has concentrated on providing guidance on the vulnerability of radioactive waste management facilities and activities to the Y2K problem, in support of national Y2K readiness efforts.

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 (gaseous, liquid and solid) and by the radiological hazard it presents (high-level waste or low- and intermediate-level waste). The radioactive waste, because of its chemical composition, may exhibit non-radiological properties — for example, it may be self-heating, pyrophoric, or hydrogen generating. These factors, and whether the radioactive waste has been conditioned, will determine the potential hazard associated with radioactive waste.

ASSESSING THE PROCESSES

Radioactive waste management processes and the production of waste packages are generally designed in a very specialized way to meet national, regulatory and customer requirements. In addition,

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equipment and plant operation will very much depend on characteristics such as the type and amount of radioactive waste to be processed. It also depends 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 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.

Consequently, guidance can only be provided generally. 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 (which should already exist for each facility as a basis for its licensing procedure) will be a basis for assessing Y2K issues in terms of associated hazards and potential consequences of failures and the risk associated with the operation of the respective facility.

Where computer-based systems are involved in the facility, 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, it is important to have supplier information and to verify it, which could be indispensable in many cases.

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. Important characteristics of these 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.

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 prescribed specifications. Instabilities or deviations of process parameters such as the supply of electric power to equipment may result in glass compositions that do not meet specifications and in 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 might not ensure that waste canisters are leak tight. Malfunctioning of the off-gas treatment systems may lead to an insufficient recovery of volatile radionuclides and chemically toxic substances, such as NOx, and a subsequent release to the environment.

In dealing with the Y2K problem for this process, priority should be given to those computer-based systems that could lead to failure of the off-gas treatment system, to melter and canister overflow, and to glass products that do not meet specifications.

Conditioning of spent fuel. Conditioning of spent fuel declared a waste is the alternative to reprocessing and subsequent vitrification of high-level reprocessing waste. Mainly repackaging activities are involved that are normally of a purely mechanical nature, not intended to affect the integrity of fuel rods. 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 Y2K issues. No spent fuel conditioning facility is expected to be in operation on any critical Y2K date.

Bituminization. The bituminization process is widely used to immobilize radioactive waste from fuel cycle facilities, including nuclear power plants and reprocessing facilities. Typically, low- and intermediate-level waste of varying composition is immobilized with bitumen.

Malfunctions could result in forms of bitumen waste that do not meet specifications. 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 that could result in contamination of the facility.

In dealing with Y2K issues for this process, priority should be given to those computer-based systems which could lead to a failure of temperature control, of the off-gas system and the feed adjustment, and to incorrect feed/bitumen flow rates.

Incineration. Incineration is an effective process to reduce the volume of organic radioactive waste in liquid and solid form. Complete combustion requires temperatures up to 1200° C, a proper dosage of the feed, and an efficient off-gas treatment system which is capable of retaining radionuclides and chemically toxic compounds, in particular dioxins but also hydrogen chloride, SO_2, and NO_x.

A lack of temperature control and feed dosage may result in ash products that do not meet specifications and in uncontrolled exothermic reactions which may affect proper functioning of the off-gas system. Such malfunctions hold the potential of a release to the environment of radioactive substances, and corrosive and toxic chemical compounds.

In dealing with Y2K issues for this process, priority should be given to those computer-based systems which could lead to failures of control of temperature, feed flow, and off-gas systems.

Drying. Drying is used to remove liquids or humidity from solid radioactive waste. It 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 may lead to products that do not meet specifications. 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 Y2K issues for this process, priority should be given to those computer-based systems which could lead to failures of control of temperature, feed flow, and off-gas systems.

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 or precipitation products are commonly mixed as a slurry into the cement to achieve homogeneous products. The steps applied in cementation of such 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 products that do not meet specifications 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 issues in the cementation process, priority should be given to those computer-based systems which could lead to failures of

control of chemical composition and the feed/matrix ratio.

Compaction. Compaction is applied to a wide variety of solid radioactive waste. The solid radioactive waste, which eventually goes into 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 the process as long as explosive, pyrophoric or similarly hazardous material will not be compacted. No important safety features with a Y2K susceptibility can be identified.

The situation is different when zircaloy hulls from spent fuel reprocessing are compacted. In this case, Y2K attention has to be given to the inertization system to avoid risk of an eventual self-ignition that may affect ventilation and off-gas systems. Malfunctions could result in a contamination of the facility or a release of radionuclides to the environment.

Other Processes. In radioactive waste management, the processes of evaporation, ion exchange, and precipitation may be applied as treatment steps, forming a part of the overall approach to the processing of liquid radioactive waste. Safety issues resulting from a failure of equipment could be corrosion of equipment, risk of exothermic reactions, or radiolytic gas release if organic material is present.

In dealing with Y2K issues, attention should be paid to thermal waste treatment processes, with priority given to those computer-based systems that control temperature and organic content in the radioactive waste stream.

STORAGE & DISPOSAL

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. 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 mixtures or unacceptable 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 normally involves 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 solid high-level waste. In all known cases, such waste is stored using passive cooling systems with natural convection which do not depend on active systems.

In dealing with Y2K issues in the storage of radioactive waste, 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.

Disposal Facilities. 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 Y2K issues cannot be identified.

DISCHARGES & 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 radionuclide concentrations or amounts which are so low that any associated potential radiation exposures are trivially small.

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 radioactive waste processing facilities.

Discharges of liquids to the marine environment, rivers or sewage systems are 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 Y2K issues, and thus could lead to unacceptable discharges or clearances.

In dealing with Y2K issues regarding discharges and clearances, priority should be given to those computer-based systems that are used to perform decay calculations or similar types of calculations of radionuclide inventories of waste.

MONITORING & ANALYSIS

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 Y2K issues and the risk that data could be lost or corrupted.

In dealing with Y2K issues, 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 Y2K issues and, where affected, consideration should be given to developing a remediation strategy that ensures that data will not be lost or corrupted.

EXCHANGING EXPERIENCE

This article draws upon more detailed guidance provided to national authorities through IAEA technical documents -- *Safety Measures to Address the Year 2000 Issue at Radioactive Waste Management Facilities*, and *Achieving Y2K Readiness: Basic Processes* -- published earlier this year.

Through these and other avenues, national authorities and competent international organizations have been made aware of the identified potential for radiation exposures caused by Y2K issues at radioactive waste management facilities. Regulatory authorities worldwide have been 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 issues and take remedial measures in line with the guidance documents. If necessary, the authorities can request support from the IAEA to provide assistance in achieving Y2K readiness.

Additionally, all national authorities, as well as registrants and licensees of radioactive waste management facilities, are being encouraged to exchange, in a timely manner, information and experience on Y2K issues.

To facilitate greater cooperation, the IAEA organized an international workshop in early July 1999 on the exchange of information concerning safety measures to address Y2K issues at radioactive waste management and nuclear fuel cycle facilities. ❑