

Safety Guide 100

**DESIGN GUIDE FOR PACKAGING AND OFFSITE TRANSPORTATION
OF NUCLEAR COMPONENTS, SPECIAL ASSEMBLIES, AND RADIOACTIVE
MATERIALS ASSOCIATED WITH THE NUCLEAR EXPLOSIVES
AND WEAPONS SAFETY PROGRAM**

CHAPTER 7.0

PACKAGING OPERATIONS

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ACRONYMS

ALARA	As Low As Reasonably Achievable
DOE	Department of Energy
DOT	Department of Transportation
DRS	Design Review Summary
NDE	Non-Destructive Evaluation
NRC	U. S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
QA	Quality Assurance
SARP	Safety Analysis Report for Packaging

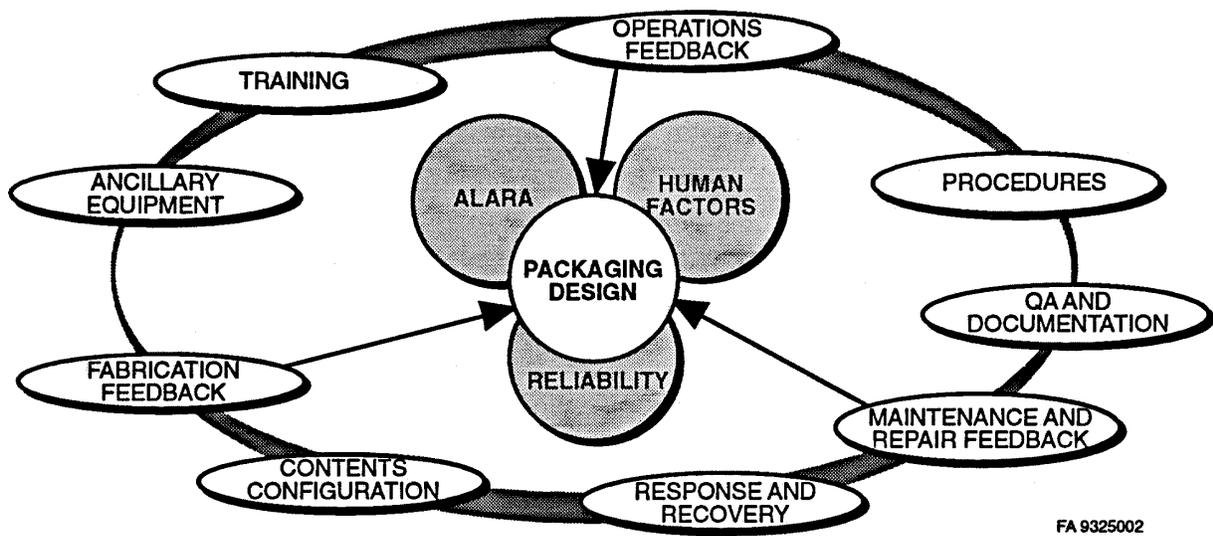
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7.0 PACKAGING OPERATIONS

7.1 INTRODUCTION

This chapter discusses packaging design considerations based on the operation of the unique class of radioactive material transportation containers designed for weapons components and special assemblies. Radioactive materials considered for packaging under this guide include uranium metal parts, plutonium parts, and tritium bottles, as well as assemblies containing these parts. Packaging design is driven by regulatory requirements. Those requirements are addressed elsewhere in this design guide. This chapter includes general discussions of packaging operating principles and features which, based on user experience, packaging designers should apply to their designs and should incorporate into operating and maintenance procedures or instructions. The chapter stresses the importance of addressing the user's needs and establishing the user-desired operational features early in the packaging design and of avoiding oversights and operational problems that would require the packaging users or operators to improvise afterwards. The chapter also addresses the importance of keeping exposure to radiation as-low-as-reasonably-achievable (ALARA) standards, human factors, and system reliability within the design effort.

This chapter is divided into five key topics related to packaging design considerations: operations and maintenance, handling, procedures and training, records and documentation, and other operational aspects. Figure 7.1 shows how operational considerations should be integrated within any packaging design effort.



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Fig. 7.1. Operational considerations in packaging design.

7.1.1 Scope and Applicability

This chapter of the design guide focuses on the operational aspects of weapons and special assemblies packages, specifically Types A and B packages. This guide is written for the packaging design team and discusses desirable features, components, and operating schemes to be incorporated into packaging designs that must be operated by military personnel who are not necessarily nuclear or packaging experts. It also addresses the needs of high-volume production-line users and their operations. It is applicable to the specific packaging handling and operations required to use the package in compliance with applicable certification and regulatory requirements, including the following:

- Loading
- Closure and preshipment testing
- Preparation for shipment
- Unloading and empty shipment preparation
- Long-term storage
- Inspection, maintenance, and repairs
- Records and documentation

7.1.2 Purposes and Objectives

This chapter establishes a framework to ensure that operations are given proper consideration within a packaging design effort and to establish a communication channel to provide the designer with feedback from lessons learned by the field operators (users) and fabricators (as shown in Fig. 7.1). To accomplish this communication, a cooperative working relationship should be established early in the

design process. This document describes concepts and specific packaging features that a design team should consider during the initial design phase.

A packaging design is a compromise that uses the available resources to best meet both the regulatory and operational requirements of the user. Each design feature represents an effort to balance the range of user needs and requirements; the designer looks at the range of options available and selects the ones that meet the regulatory requirements, protects the user, and costs the least in the process.

The designer must address user issues early in the design process. User requirements that are ignored at this stage often must be dealt with after the design is completed; their resolution often has significant cost and schedule implications. The package designer must consider ALARA whenever design decisions are made, and must give appropriate attention to component reliability, especially when a component failure can significantly affect achievement of ALARA objectives. The packaging user should be provided with a highly reliable, unambiguous, and easily verifiable packaging designed to be operated and maintained with a minimum of special tools, hardware, equipment, or instruments at a variety of different facilities and under a wide range of operating conditions. The packaging design team is responsible for the development of generic operating procedures and task or activity lists for proper use of the packaging. The packaging user will provide facility-specific operating procedures that provide the interface between the facility's equipment and capabilities and the packaging designer's operating instructions or generic procedures.

The design team should interview packaging users who now use packages similar to the type proposed, then incorporate their feedback to improve upon the final packaging design. The design team should document the process throughout the design effort to demonstrate its consideration of ALARA and

human factors issues. For packages designed to be used at one or a limited number of specific facilities, the applicable characteristics of the user's facility should be factored into the design effort as practical.

The human factor issue is also an important consideration in packaging design. The designer addresses the main human factor issues by simplifying both the packaging design and the users' requirements. Current packaging operations should be assessed, and empirically proven design features should be retained or refined. Any substantive changes to those proven designs, components, or operational techniques should be justified. Packaging operations that are unambiguous, intuitively obvious, and provide ease of handling will reduce the risk of errant operations, mistakes during use, and the incentive to circumvent compliance to cumbersome procedures. Addressing human factors in a packaging design effort will also help develop the documentation program necessary to ensure conformance to the packaging Certificate of Compliance.

7.1.3 References and Definitions

References consulted during the development of this chapter include:

- *Cask Designers Handbook*, Oak Ridge National Laboratory.^[1]
- Code of Federal Regulations, Chapter 10, Part 71.^[2]
- Regulatory Guide 7.9.^[3]

Definitions related specifically to the operational aspects of a packaging design effort are as follows:

- **Ancillary equipment:** packaging, handling, or operating equipment that is typically supplied by the packaging owner and is not specifically called out in the Safety Analysis Report for Packaging (SARP). It is necessary for safe and proper packaging operations and includes such items as special lifting fixtures, handling pallets, and/or mating adapters that would not normally be included in a facility's normal complement of equipment. The designer should minimize the need for ancillary equipment to the extent possible.
- **Closure verification testing:** inspection or tests to demonstrate that the packaging containment is properly assembled and meets applicable leak-rate criteria.
- **Special tools:** hand tools or instruments not typically found in a standard tool supply, such as high-range torque wrenches or helium-tuned mass-spectrometer leak-detection equipment.
- **Packaging owner:** holder of the packaging Certificate of Compliance or primary DOE facility user.
- **Periodic testing:** verification that the equipment or components continue to meet design specifications. Normally, the testing period cannot exceed 13 calendar months.
- **Incidental maintenance or repairs:** steps defined by the packaging designer and included within generic operating procedures for replacing or repairing specific components during normal packaging operations.
- **Validated:** written procedures for packaging handling, maintenance, or repair that have been proven effective through empirical evidence or expert examination.

- **Substantial safety hazard:** the use of a component, material, or operation that causes a deviation from the design basis and/or a substantial reduction in the degree of protection provided for public health and safety.

7.2 KEY DESIGN CONSIDERATIONS FOR PACKAGING OPERATIONS

This section discusses key packaging operational considerations: operator exposure to ionizing radiation, human factors, packaging system reliability, and quality assurance (QA). These considerations are interrelated and are the overriding packaging system operational design considerations.

Radiation from weapons components and special assembly packages is quite low. However, a large number of packages may be handled, and minimizing radiation exposure and complying with ALARA are issues the packaging designer must address during the design process. Radiation exposure is increased by time-consuming or cumbersome operations, requiring personnel to work close to the package, and lack of shielding (when needed) in occupied areas near radioactive materials.

ALARA requires the consideration of any aspects of packaging design that could increase radiation exposure to operators, transportation workers, and the public. To comply with the intent of ALARA, the packaging designer must address the operability, reliability, and maintainability of each component specified for the packaging. Complicated components, operating techniques, or requirements for special tools or processes may compromise reliability and unnecessarily expose packaging operators to additional radiation. A packaging that is simple to operate will minimize reliance on special tools, techniques, and processes and may enable the use of high-speed automatic or production-line processes that would further reduce the chance of operator error, corrective actions, and subsequent additional

radiation exposure. Potential occurrences that may produce elevated radiation levels (including background radiation levels) should also be considered in the ALARA program.

Design features that take less time to manipulate or operate and are more reliable are favored over those features that are more complicated, need special tools or fixtures, or are more susceptible to system component failure. Features that promote automatic, high-speed, or production-line handling can also contribute to meeting ALARA goals. In addition, a simplified design will result in fewer human factors problems and will assist in reducing the incidence of operator error. Reduction in the number of incidents wherein the packaging must be inspected, reloaded, or handled also contributes toward an overall ALARA program. Finally, system reliability and packaging use can be enhanced by a passive, sturdy design that has minimal reliance on special tools, operating techniques, or procedures.

7.2.1 Guidance for Design to Limit Operator Exposure to Radiation to Levels As Low As Reasonably Achievable

Operator radiation exposure received during the handling of radioactive materials packaging arises from two major sources: the contents of the package and background radiation at the package-handling facility. In general, the most effective packaging design will minimize radiation exposure to operators by simplifying the packaging design to permit rapid, reliable, and verifiable loading, assembly, and containment leakage testing.

This section presents guidance to ensure that packaging designers take into consideration packaging features and operations (user-handling) aspects that contribute to operator radiation exposure. Its aim is to encourage designers to make reasonable efforts to develop designs that reduce levels of exposures. Three primary factors must be weighed when establishing an ALARA design basis:

1. No radiation exposure should be received without some commensurate benefit.
2. Any radiation exposure received should be reduced to the extent practical considering cost and the state of technology used.
3. Under no circumstances can absolute radiation exposure limits established by regulation be exceeded.

Three principles keep operator exposure ALARA:

1. Minimize the amount of time spent in the exposure area
2. Maximize the operator's distance from the source of the exposure
3. Provide shielding to reduce the strength of the source of the exposure

The designer must incorporate and balance these principles to achieve ALARA in the packaging design. Of these principles, the packaging designer can best control the time element by making the packaging simple to operate. This simplicity will also contribute to production-line and robotic operations. Simplicity reduces the time required to operate the package and minimizes both the user's contact with the package and the amount of time spent in any background radiation environment. Background radiation in work areas is assumed to be maintained ALARA as a result of the facility radiation safety programs. The designer should note that maximizing distance (from the package) could involve the use of special long-handled tools or remote operations that may both drive up the time and cost elements of packaging use and reduce the overall system reliability. Shielding must be provided to meet minimum transportation requirements; however, in the case of special assembly packaging, adequate shielding is often provided by the structural components of the packaging. Additional or supplemental

shielding, if necessary, may be considered for areas where workers would be positioned to conduct handling or maintenance operations. Some examples of design features for ALARA are as follows:

- Operations should be kept simple and intuitively obvious, using the minimum number of components. The designer should note where simultaneous operations could be conducted, such as leak testing on port covers and closures.
- Ports should be supplied for containment verification, venting, purging, draining, and flushing; they should be located at the top of the packaging and near the outside to allow the operator to work at arm's length from the package surface. Quick-connect fittings (that do not compromise closure or other protective devices) facilitate operations and reduce the amount of time to make connections to the package.
- Easy removal and replacement of components (e.g., port covers and containment lids should include such features as tapered lead-ins to assist in fitting and to prevent hangups. Numerous small components that can be easily dropped or lost may contribute to increased operating times; the tendency to drop or mishandle components or items can be exacerbated if users are required to wear protective clothing (gloves, faceshields, etc.) during packaging operations.
- Components that are routinely removed and/or replaced should be keyed to assure proper positioning. Alignment keys, grooves, or pins accurately locate the component and its corresponding fastener.
- Replaceable parts such as valves, bolts, washers, and O-rings should require only commonly used hand tools for installation.

- Remotely handled or replaced items should be specifically designed to enhance their compatibility with robotics systems. Bolts should provide tapered (bullet-nose) lead-ins, and the bolt head should align with the robotic gripper.
- Packaging design should follow general criteria for contamination control. Surfaces should be smooth and free of pockets or crevices that could trap contamination or extend decontamination time.

Table 7.1, ALARA Design Review Summary (DRS), or a similar format should be used to document the relationship between a packaging design and its corresponding effect on total radiation exposure. The DRS can document the estimated radiation exposure to users by comparing the expected exposure from a package or component design with the measured exposure from similar packages or the results of other appropriate estimating methods. Estimated exposures for each operating activity in the DRS should be used to influence packaging design. The ability to reduce exposure should be one factor considered in making final design decisions.

In addition to exposure as a result of package operations, estimates for exposure received from routine maintenance and inspection should be used to help determine a life-cycle exposure burden.

An ALARA DRS form should be completed and retained as documentation of consideration of ALARA influence on the packaging design. Changes in the design of packaging or components can be tracked by revising the original exposure estimates from the DRS forms. Packaging designed for production line operations may need a refined version of the DRS form.

Table 7.1. ALARA design review summary (DRS)

	A	B	C	D
Packaging operation ^a	Exposure rate ^b (in mrem/h)	Number of people involved	Estimated time to complete (h)	Exposure for operation (in person- mrem)
1.	_____ ×	_____ ×	_____ =	_____
2.	_____ ×	_____ ×	_____ =	_____
3.	_____ ×	_____ ×	_____ =	_____
4.	_____ ×	_____ ×	_____ =	_____
Total exposure (in person-mrem)				_____

^a Includes maintenance and inspection activities.

^b Exposure from package contents only; package design does not include facility-specific background levels.

7.2.2 Guidance for Design to Incorporate the Principles of Human Factors Engineering

This section includes guidance for the incorporation of human factors and explores options that will minimize the potential for human error, identify and correct potential human factor-related safety and reliability problems, and enhance the useability and safety of the packaging system. Addressing human factors involves specifying design features to ensure the correct assembling, inspection, and testing of packaging components. The packaging design should not accommodate incorrect hardware or components, and attempts to assemble or use an incorrect part or component should become obvious to the user. Packaging failure modes and anticipated operator error should be examined, and packages should be designed to fail in a safe mode. The following design guidance should be considered for human factors:

- Systems and components should be designed to give positive indication of proper (or improper) assembly or fit. For example, valves should be the type that show the valve position. Ball valves with a position-indicating lever and click-style operation would meet this criterion. Port covers that would not fit if the valve were improperly positioned would serve to reinforce correct assembly and may help in preventing inadvertent valve opening during transportation. Lifting fixtures should be designed to capture the lifted component, and features should prevent disengagement while the lifted component is suspended and handled.
- Areas on the packaging designed for contact operations should provide sufficient space for hand manipulation. For example, fasteners designed to be removed or replaced should either be surface-mounted or provide at least 1 in. of space for manual manipulation. Components should be keyed to assist in assembly; they should be stamped or otherwise marked to inform the user of their function (i.e., a drain connector should be marked "drain"). Torque sequences and

applicable torque values could be stamped into or onto components adjacent to fasteners or components.

- Tests and inspections to verify conformance to the package certificate requirements should use commonly available instruments, fluids or gases, equipment, and procedures. Air pressure loss indicated by simple pressure gauge and vacuum decay indicated by gauge are preferred methods. The volume tested (such as the volume between two O-rings) should be minimized to reduce the time required to conduct the test.
- Acceptance and rejection criteria must be clear, unambiguous, and not subject to individual interpretation — for example, "no bubbles or no pressure (vacuum) change in 10 min from initiation of the test."
- Experienced operating personnel should review and analyze, from an operations perspective, each design feature or component of the packaging to assess its reliability and determine its potential for contributing to errors in assembly, handling, and use. These reviews should be documented and become part of the design data record.
- Packaging components should be small (light) enough to permit operators to remove or replace them by hand (manually) but large enough to allow easy recovery if they are inadvertently dropped. (Note that user dexterity and vision can be affected by protective clothing requirements).

- Blind fit-ups of components must be eliminated from the design to the extent possible. Drain tubes or diptubes that mate to the underside of the lid should be avoided. Cavity drains (when applicable) should be routed through the (top) side of the package or through a slot in the lid.

Operator review of the packaging design will help determine if the packaging design incorporates features that assist rather than burden the packaging users.

7.2.3 Guidance for Design to Enhance Packaging System Reliability

This section presents guidance to ensure that the design of the packaging system incorporates materials, components, and features that, to the greatest extent practicable, are easily used, cleaned, and maintained. The packaging system must be viewed as a composite of components. They are like links in a chain; the fewer links there are and the stronger each link is, the less the chance of failure. Components that require frequent replacement should be designed to minimize the time and effort required to replace them. Components designed to be tested, inspected, or recertified routinely should make use of standard testing or inspection techniques most likely to be available at user facilities. Minimal reliance on special inspection tools or instruments and inspections and tests based on visual inspection is preferred.

To the extent possible, the package must be designed to meet its performance requirements by using passive rather than active systems which rely on the correct action by personnel. Reliability of the package system can be reduced if unique or specialized devices or components are used. The number and complexity of each specialized device or component must therefore be minimized. The use of specialized devices or components can be justified only in terms of measurable reductions in packaging handling times or radiation exposure. As much as possible, packaging designs should require only the

use of standard tools or equipment for their operation. The following design guidance should be considered for reliability:

- Packaging design should include features and components that incorporate operator experience.
- Special handling, testing, or inspection equipment should be specified only if no reasonable alternative exists. Special equipment such as helium-sensitive mass spectrometer leak-detection equipment, surface-hardness testing instruments, redundant lifting fixtures, and yokes should be justified in terms of operator safety, ALARA, cost, and durability.
- The packaging design should minimize the need for special tools that would have to be supplied to users of the package. Instead, the design should allow the use of standard hand tools and handling equipment likely to be available at any user facility.
- Components or items that are removed during routine operations (such as closure lids) should be designed to be stored or set down in any orientation without causing damage to the item or any other integral component. In particular, O-rings or gaskets should be inset for protection.
- The use of inspection, testing, and maintenance items should be minimized; scheduled inspection and maintenance frequencies should be maximized.

7.2.4 Guidance for Quality Assurance Program

The packaging designer must apply Quality Assurance (QA) to selected packaging design activities, including packaging operations. The activities must conform to applicable codes and standards

including Department of Energy (DOE) Order 5700.6C and 10 CFR 71 Subpart H. The primary application in the operations area is in the development of handling and maintenance procedures for loading, unloading, tests and inspection, routine maintenance and repairs, and storage and retrieval.

The packaging designer must have in place a system that detects non-conformance and permits the documentation of approvals to deviate from design bases. The designer must establish controls for the independent overview of deviations and record keeping systems to track and document quality-related activities. Finally, the designer must provide for periodic audit of the system to provide independent verification of performance.

7.3 KEY DESIGN CONSIDERATIONS FOR PACKAGING HANDLING

This section identifies and discusses design issues for contact, remote, and automated handling; contents configuration; containment closure and verification; and decontamination.

The packaging designer should know about the facilities, conditions, and the skill levels of personnel likely to use the packaging. The packaging designer must also become familiar with the properties of potential contents. Finally, the designer must note the features in the design that have the potential for becoming contaminated and understand standard techniques for decontamination.

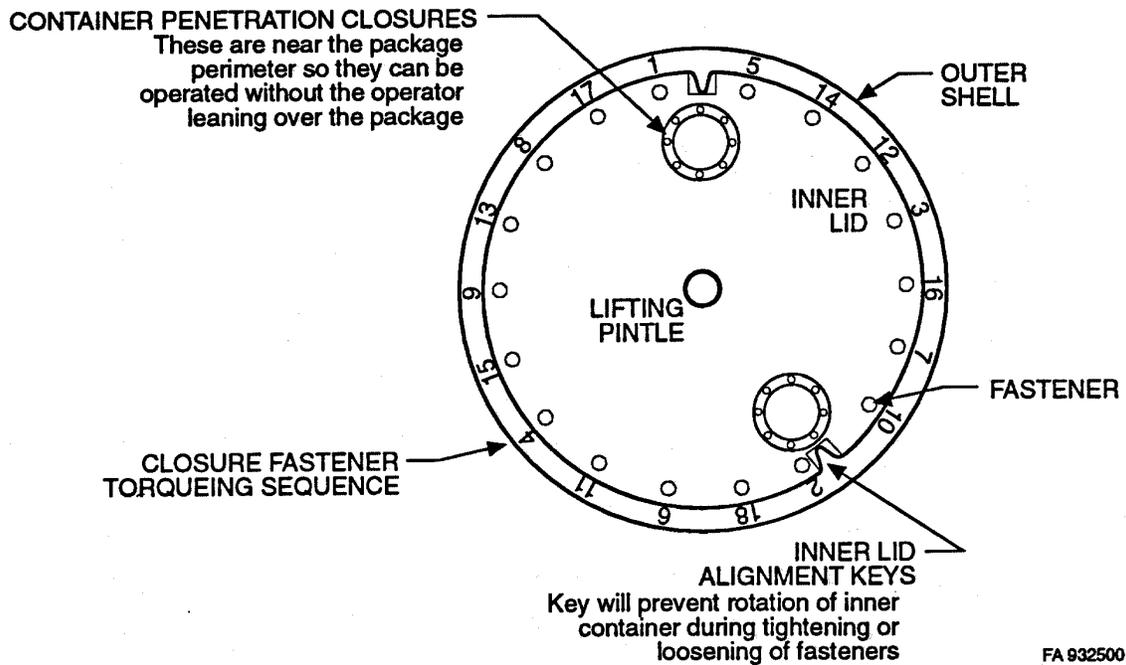
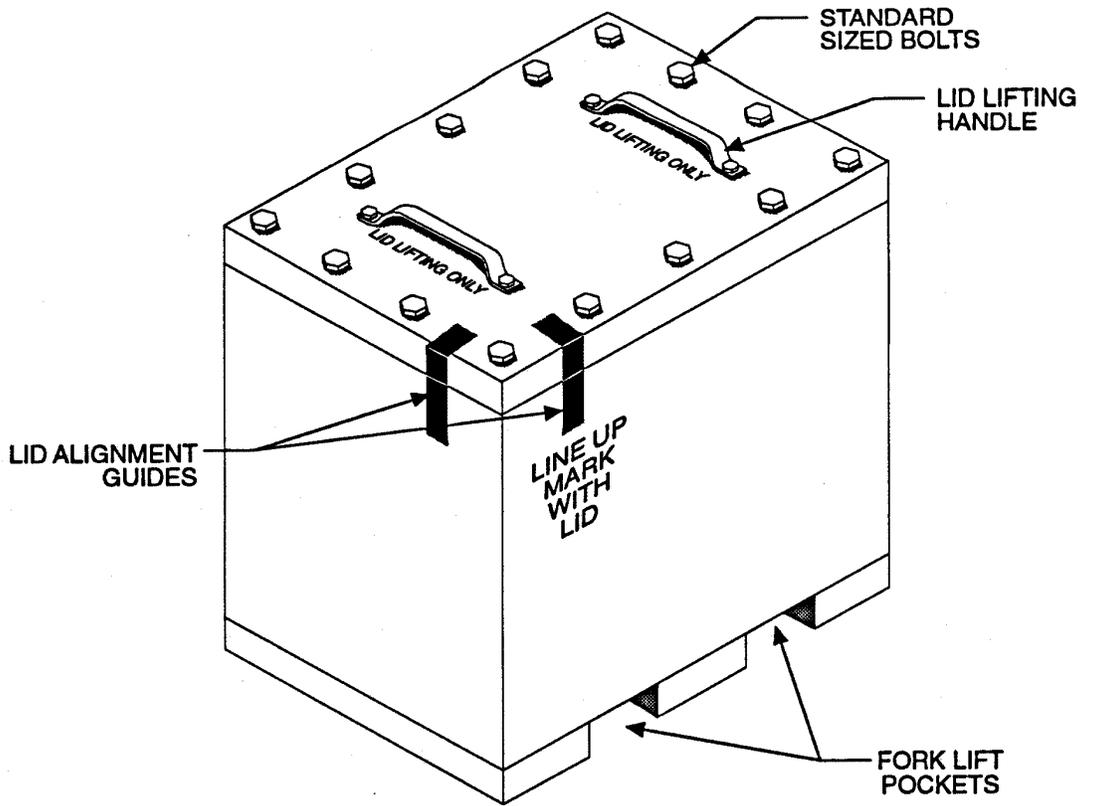
7.3.1 Guidance for Design for Contact Handling

This section discusses the radiological and mechanical hazards associated with contact handling and provides suggested designs to minimize those hazards. Most weapons component and special assembly package handling uses hands-on contact methods. In general, one can assume that contact-

handling steps for packaging assembly activities take less time to complete than remote handling. Contact handling does, however, place people in proximity to radioactive materials, which raises radiation exposure concerns that remote handling reduces. Contact handling involves human manipulation of the packaging components, including the use of conveyors, cranes, hoists, and other commonly used materials handling equipment and tools, increasing the exposure of the operating crew to mechanical injury such as crushing or pinching.

A packaging designer may assume that people operating a packaging at a facility know about facility hazards and facility equipment operating requirements. The operators can select and use the proper tools, lifting slings or fixtures, and handling equipment such as conveyor systems, overhead cranes, or forklifts to handle the packaging safely and assemble it in accordance with facility-specific operating procedures. The following design features may aid contact handling:

- Mechanical alignment keys that permit engagement of a component to be visually confirmed
- Valves or fittings that prevent uncontrolled release from or venting of the package containment
- Features that capture lifting fixtures and prevent slipping from the package while the package weight is supported by a crane or forklift
- Visual alignment marks or alignment pins for closures or port covers (Fig. 7.2 provides an illustration of some conceptual closure alignment aids)
- Minimal number of fasteners and limited variation of size between the fasteners



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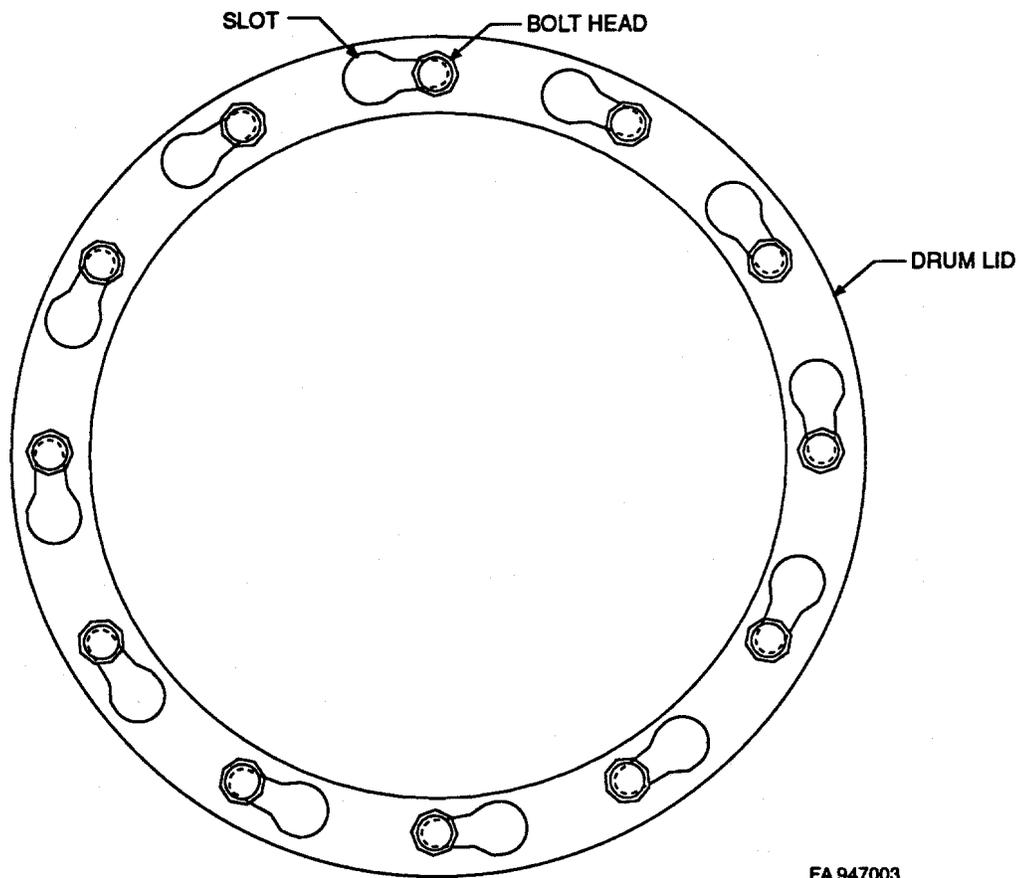
Fig. 7.2. Illustration of concepts to promote packaging handling.

- Identical torquing requirements for all fasteners on a packaging
- Avoidance of special tools or fixtures

7.3.2 Design Guidance for Remote and Automated Handling

This section discusses major operational considerations in the design of packaging components that incorporate remote handling capability. Remote operations can involve either packaging handling in a normal work area or remote operations within a shielded hot cell for hazardous, high-radiation, or security-related operations. Robotic and/or automated operations may be indicated for rapid routine packaging loading and unloading or to address radiation/contamination safety issues or security/safeguards issues. These operations may be especially useful where a large number of packages must be routinely handled. Remote operations can include an entire package turnaround or specific portions of a turnaround, such as loading or unloading or radiation surveys. Figure 7.3 shows a concept for a packaging outer lid that can be bolted or unbolted robotically. This concept works by rotating the lid when the bolts are loosened but not removed because robots arms have difficulty with bolt replacement and rethreading. If the lid weighs more than 50 lb and is sealed with O-rings, the rotation of the lid could damage the seals. If the lid is used on the exterior of a packaging, rainwater could collect in the keyhole area.

Robotic handling often requires additional effort on the part of the designers to simplify packaging operations. Designing for robotic handling can benefit both robotic and contact handling. Robotic or remote handling must not preclude human intervention, and efforts should be made to consider robotic failure modes and corrective actions. Features that might assist robotic handling include the following:



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TOP VIEW

Figure 7.3. Concept for robotic handling of packaging lid.

- Optical targets or alignment points and/or hard reference features to permit proper robot positioning and correct location of specific packaging components
- Components (such as fittings, covers, or bolts) that are self-aligning and provide for a tapered lead-in
- Components such as port covers, lids, and bolts containing a design feature that will permit grappling and retention by a robotic arm
- Use by robotic systems of a rack or stand to permit temporary storage and convenient retrieval of removed components or items and/or handling fixtures

Features that would enhance production-line handling aspects should not detract from the contact or remote handling facilities. In general, simple operations are preferred over complex operations. In addition, the packaging designer should note where two or more operations (such as inspection and decontamination) could be performed simultaneously.

7.3.3 Design Guidance for Packaging Contents Configuration

This section discusses design considerations for ensuring that the packaging will safely contain and protect all potential contents under all conditions of transportation and storage.

Configuration of a specialized container could be designed to prevent inadvertent loading of contents with improper mass or shape. The packaging designer must be aware of the form, properties,

weight, and dimensions of all potential contents to ensure that radiation, thermal, and pressure limits are not exceeded and that the system is subcritical as required in 10 CFR 71.55.

Spacers, end pieces, cones, and/or foam padding may be incorporated in the contents' assembly to center the contents within the packaging, prevent movement (and subsequent impact forces against the containment in drop-accident condition) under normal conditions of transport, absorb impact forces in the event of the hypothetical accident condition, provide for thermal insulation in the event of fire, and exclude water or other foreign substance from contacting the component or assembly. Spacers or padding included may also have to be protected from the rigors of handling by structural foil or wrap. Metal "peanuts" are also acceptable in certain applications as filler around the contents.

The designer should assume that packaging components may become contaminated from the contents of the package.

7.3.4 Design Guidance for Containment Closure and Verification Features

This section discusses operations considerations in selecting the components of the containment boundary, including mechanisms, fasteners, seals, aids to assembly, and verification testing of packagings to meet requirements for providing containment. The requirement for proper package assembly is contained within 49 CFR 173.448 and 10 CFR 71.87. Designers should consider the following guidelines:

- Closure of the primary containment should use a minimum number of fasteners or clamps. The designer should avoid the use of special fasteners or seals that must be tightened to unusually high torque values.

- A penetration might be provided into the containment vessel to allow for venting excessive pressure, sampling before opening the container, or backfilling the vessel with inert gas. The designer must provide a means to leak test the penetration seal (i.e., valve) to the same criteria as the containment vessel seal.
- Replaceable items, such as seal rings or bolts, should be made of materials or metals that are softer than their corresponding packaging base part; the rule of thumb is to sacrifice the replaceable part before the irreplaceable part. For example, metallic O-rings should be specified of a softer alloy than the base metal of the closure or the packaging inner container body.
- Closure fasteners should be tightened or tensioned to readily achievable values (less than 300 ft-lb) that can be attained using commonly available hand tools (torque wrenches). Fasteners should neither be unusually long nor have an inordinate number of threads. Lubricants should be specified to prevent thread damage or galling. The packaging design should provide proper counteraction for any torque applied to fasteners or other components. Figure 7.2 shows a concept for counteracting the rotation of a closure lid when tightening closure fasteners.
- Closure fastener tightening or loosening sequences should be indelibly marked on the closure lid (1, 2, 3, etc.); closure fasteners should use a common-size bolt head and should mate with typical hand tools. In some cases, special provisions can be made to provide fasteners with standard bolt heads and inset (allen-type) capability to provide both contact and remote compatibility.
- Seal surfaces (polished areas) and seals (O-rings, etc) should be protected from damage when the closure is being disassembled, reassembled, stored, or handled. Guide pins and

circumferential bosses, slots, and/or grooves can be used to assist in the proper assembly and protection of packaging and components.

- Removable components, such as lids, closure bolts, and nuts, should be capable of being handled normally (able to sustain a minimal drop and storage on racks, tables, benches, or floors) without fear of component damage.
- The designer must specify leak test acceptance and rejection criteria based on a recognized standard, such as ANSI N14.5 or other regulation.
- Closure verification testing should be completed by high-pressure or vacuum testing using commonly available or portable instrumentation (such as certified pressure gauges) without the use of sophisticated laboratory analytical instrumentation, when possible.
- The designer must specify containment requirements for packaging acceptance and periodic (annual) recertification and for per-use assembly tests to verify proper component function.
- The designer should specify procedures for replacing seal rings and refurbishing machined seal surfaces when applicable. The designer should also consider specifying repair techniques or procedures for containment components.

7.3.5 Design Guidance for Decontamination

The packaging designer should (for conservatism) consider that at some time during the lifetime of the packaging it will become internally and externally contaminated and may have to be

decontaminated. The designer should study commercially available decontamination techniques so that they are compatible with the packaging materials and construction. Decontamination would be a routine requirement for packages used in radiation or contaminated areas. Package surface contamination is caused by the deposition of radioactive materials (contamination) within microscopic imperfections on a surface and also by weak ionic bonding to surface films or oxides. Higher levels of contamination could be experienced on the inner surfaces of the containment as a result of contents release within the containment boundary. Design philosophies favor avoiding features or components that would trap contamination or that could not be decontaminated. Specifically, the designer should adhere to the following guidelines:

- Avoid specifying design (such as seams, crevices, grooves, ledges, horizontal surfaces, nondrained bolt holes, or blind holes) features that would accumulate contamination.
- Describe any features, materials, finishes, and coatings used to prevent contamination or aid in decontamination. Surfaces should be corrosion resistant. Stainless steel should be passivated after being polished or bead blasted. Painted surfaces should be of epoxy-type (or equivalent) that are resistant to chemical or abrasion damage. Any coatings should adhere tightly to the substrate material and avoid cracking or pitting that could result from temperature variations. However, paints or coatings specified for areas that would be routinely stripped [for visual or other nondestructive evaluation (NDE) inspection] should be more easily removable.
- Understand standard decontamination techniques and chemicals. Typical decontamination techniques include soap and water washing, steam cleaning, and acetone wiping of the affected surfaces. Application of surface stripping agents or coatings may be indicated in some cases. More aggressive methods would actually remove surface materials by strong acid etching; bases

(such as permanganates); and surface electropolishing, sanding, or grinding. The designer should note wherever passivation of a treated surface may be required to ensure continued material certification. The package containment boundary should incorporate features that would permit flushing, recirculating, and draining potential decontamination solutions. Otherwise, the containment boundary would have to be manually mopped or wiped, increasing operator exposure.

- Detail the types of techniques or chemicals (such as sanding or use of corrosive chemicals) that could irreparably damage the packaging components (such as seals or O-rings) or call into question the continued certification of materials or finishes. The designer should be aware of an increased propensity for treated surfaces to become more easily recontaminated.

7.3.6 Design Guidance for Ancillary Equipment

As a general rule, it is desirable to minimize the need for special tools or ancillary equipment to operate a packaging. In many cases, however, a specific facility will need ancillary equipment. If a packaging designer can justify the use of ancillary equipment from the perspective of safety, ALARA, or cost, ancillary equipment should be designed to follow the same basic requirements as those of the design for the packaging, and should therefore be simple too.

- Fabricate and operate
- Maintain, inspect, and repair
- Decontaminate, assemble, and ship

7.4 KEY REQUIREMENTS FOR PROCEDURES AND TRAINING

Continued compliant performance of the packaging system relies on validated written procedures augmented by training. Training assists in ensuring correct performance and documentation of required handling, assembly, and routine tests and inspections according to the certificate. Training requirements are often specified by the user facility; training can be conducted in formal classroom or videotape sessions or can involve on-the-job observation by a knowledgeable individual using validated procedures. Facility readiness reviews should be completed to ensure immediately compliant packaging operations. The readiness review can be augmented by handling equipment shakedown during procedure validation. Packaging operations can be videotaped to provide for future training.

Written procedures for packaging use are a requirement for DOE- and Nuclear Regulatory Commission (NRC)-certified packages. Documentation of the completion and verification of key preparation steps on checklists provides evidence that the package was properly assembled and meets applicable compliance requirements. Written procedures can be categorized in three ways.

The first category is the package-handling procedures provided by the packaging designer in Chap. 7 of the SARP. The procedures typically provide a listing of the basic steps required to properly handle, assemble, and prepare the package for shipment in compliance with the design bases in the SARP and with the expectation that personnel radiation exposure will be ALARA. The packaging designer should minimize the inclusion of generic or site-specific operating procedures into the SARP either directly or by reference, since a minor change in the operating information (for convenience or as a result of operator feedback) could require an amendment to the certificate.

The second category of packaging procedures is the generic procedure, which contains the information from the SARP description of basic steps expanded to provide additional details, techniques, notes, and warnings applicable to packaging operation. The packaging designer provides the functional steps listed in SARP and generic procedures because of expert knowledge of the packaging system. The designer understands how the components of a packaging must be handled to ensure both continuing compliance to the certificate and maintaining personnel exposures ALARA. The generic procedure does not contain site-specific details; these are left to the third category of procedure, the site-specific procedure, which incorporates specific site information (including work rules, prerequisites, and personnel qualifications) into the appropriate locations in the generic operating procedure. This incorporation results in a single procedure for the site operator to use that conforms to the requirements of the SARP. Checklists, which provide written and signed documentation of completion of an activity, can either be incorporated within the procedure or stand alone. Nevertheless, if a checklist is required for package use, each use of the package should be documented on a separate checklist. Each packaging user should establish a schedule for periodic (annual) procedure review and revision and should implement a program to permit periodic or temporary revisions in response to specific conditions.

7.4.1 Procedures Contained in the SARP

Operational steps included in the SARP must meet the minimum requirements of Regulatory Guide 7.9, Section 7. The SARP must list the steps necessary for loading, unloading, and preparing the packaging for transportation in a manner that is consistent with the analyses upon which the package approval is based. The designer is cautioned not to provide overly detailed procedures that could limit packaging-user discretion in performing the activity. The SARP must contain steps that will ensure that the user meets the routine regulatory determination requirements. The steps should be presented in the

expected order of completion and should contribute to maintaining personnel radiation exposure ALARA. Specific guidelines include the following:

- Operations procedures developed for inclusion in the SARP must address minimum operating requirements by listing only the functional steps necessary to ensure conformance to applicable design bases.
- Special tools or processes required must be clearly identified.
- Contents limits must be reiterated within the procedure. Applicable controls must be identified to verify compliance with content limits.
- Procedures must detail unloading operations even if they do not differ from loading operations.
- Procedures must also detail preparation for shipping empty packaging.

An example procedure in a SARP Chap. 7 might include the types of basic steps shown in Table 7.2.

7.4.2 Guidance for the Content of Generic Operating Procedures

This section describes the information to be provided by the packaging designer in a generic operating procedure (or operation manual). The procedure will be beneficial to packaging-user personnel as well as establishing the basis by which the package will be prepared for shipment according to all pertinent regulations and meeting all of the conditions specified in the certificate. Operating personnel

Table 7.2. Example of special assembly package loading procedure

Step	Description of Activity
1.	Remove packaging and other components from shipping pallet.
2.	Verify seal numbers and packaging serial numbers.
3.	Disassemble packaging and inspect components for damage or wear; red-tag any defective packaging or component in accordance with site QA program.
4.	Verify proper contents (less than xx kg ²³⁵ U) for packaging with packaging certificate.
5.	Install proper contents spacers in inner packaging container.
6.	Replace closure lid inner O-ring with approved equivalent.
7.	Replace inner containment closure lid; ensure proper lid alignment and fit.
8.	Inspect and replace inner container closure lid bolts and lubricate threads.
9.	Tighten closure bolts to final torque value of xx ± x ft-lb using calibrated torque wrench.
10.	Perform inner container assembly verification test by pressurizing the area between the inner and outer O-rings using air to xx psig ± x psig. Hold pressure for xx minutes. Acceptance criterion is no pressure drop indicated on calibrated 0 - xx-psig air pressure gauge.
11.	Install safety seal wire through bolts at xx degree intervals.
12.	Install outer container lid and torque retainer bolts to xx ± 6 ft-lb using calibrated torque wrench.
13.	Install tamper-indicating seal; record seal number on checklist.
14.	Complete radiation and contamination survey.
15.	Place proper labels (radioactive I, II, or III) on package.
16.	Replace container on shipping pallet; secure package tiedowns.

must use written procedures for packaging that conform to regulatory requirements in 10 CFR 71.81. To demonstrate compliance with Department of Transportation (DOT) requirements in 49 CFR 173.448, written procedures and signed checklists are needed to document proper package preparation. The length and complexity of the generic operating procedure depend on the complexity of the packaging and preparation requirements. A simple packaging that requires no special tools or skills to correctly assemble will require little or no generic procedures, whereas complex packages requiring a high degree of knowledge or skills could require extensive procedures. Checklists should be provided that document the completion of compliance and regulatory items. The generic operating procedure is typically more detailed than are the functional steps listed in the SARP.

To the extent practical, the packaging designer should also note specific conditions or circumstances that could be hazardous to the user or the packaging or could indicate packaging failure. The package designer should also develop generic operating procedures to provide the mandatory functional instructions required in addition to those suggested. Procedures should be contained within a written manual but may be contained in electronic format as input to overall facility operation and the QA program. Any major revisions to the generic procedure that the users deem necessary should be reviewed and approved by the design group. Specific requirements for event analysis and/or event notification should be included or referenced within the packaging operation procedures. Figures and illustrations should be used to communicate complex techniques or concepts to packaging users. To provide consistency, generic procedures should follow a standard format such as the one that follows:

1. **Description and Scope.** This section should provide the basis for the procedure, which steps are included or not included (particularly those steps involved with operating ancillary, test, or measuring equipment or instruments and repairs and replacements). It should include a brief

general discussion of the packaging, the contents, the certificate, and conformance to generally accepted standards and regulations.

2. **General Safety and Health Protection.** This section should list the designer's assumptions concerning the requisite health and safety programs for workers operating the packaging. Foremost would be radiation safety programs, followed by general industrial safety issues and vehicular safety (when applicable). The designer should assume a level of training consistent with Occupational Safety and Health Administration (OSHA) and DOT requirements for user facilities. These categories should also include discussion of the radiation and contamination concerns that the packaging could present, including decontamination notes. In addition, packaging component weights and special handling requirements may be detailed providing information concerning lifting slings or other devices.
3. **References.** This section should discuss other types of standards, prerequisites, procedures, specialties, equipment lists, and interfacing information required to operate the packaging. Examples include sling and lifting hardware selection, inspection, and use procedures; leak-testing instrumentation operating procedures; radiation and criticality safety procedures; and hazardous materials transportation procedures. In addition, packaging-specific documents such as the certificate, requisite drawings, and appendices (as appropriate) may be referenced.
4. **Equipment and Tool Listing.** This section should list any equipment required to correctly operate the packaging and prepare the packaging for shipment. In particular, a listing of required equipment that is not provided with the packaging, such as overhead cranes, sling, chains or lifting gear (not provided with the packaging), hand tools, instruments, specialty purge or cover

gases, and lubricants, should be specified. Minimum QA criteria for the equipment or item should also be specified.

5. **Procedure Steps.** The procedure should list the steps in the order of completion starting with the receipt of the empty (or loaded) package. Each step should provide sufficient information that will direct the worker to perform the step correctly and be in position to proceed to the following step. Procedure checklists can be incorporated into the body of the procedure or can be documented on a separate record. After the procedure steps, the designer should include appendices to provide example procedure checklists and other data sheets required to confirm the workers' conformance to the certificate. The following four types of notes can be used within the procedure to provide additional information about safety and health protection concerns:

- **Warning** - a notation provided within the procedure before a step where a packaging operator could encounter a potentially dangerous health and safety condition,
- **Radiation Warning** - a notation provided within the procedure before a step where there is the potential for radiation (including contamination) exposure to the packaging operator,
- **Note** - a notation within the procedure before a step where an additional suggested handling technique or general information about the packaging or its associated equipment would be useful, and

- **Caution** - a notation within the procedure before a step where a condition could be encountered that would cause damage to equipment.

The generic procedures should:

- Ensure that handling and loading operations conform to the applicable design bases and assure that users can safely package or unload package contents
- Refer to specific certificate or SARP provisions such as closure bolt torque values, leak test limits, surface and one-meter radiation level limitations, contamination level limits, and contents form and properties
- Include a list of the tools and/or special equipment that the user facility must provide, including weight and capacity limits as appropriate
- Indicate where facility-specific procedures or operations may be required
- Provide a list of specific notes about potential hazards and possible damage to the packaging or components
- Establish guidelines for event reporting to regulatory agencies such as NRC or DOE
- Include routine recovery instructions in the event of a test failure or an incident that damages components or portions of the packaging (for example, replacing a seal ring or valve)

- Include special provisions for loading, unloading, or preparing an empty packaging
- Discuss packaging preparation for transportation, including hold-down requirements and specific vehicular limitations (when applicable)
- Include accepted processes or methods to aid in decontamination

An example of a portion of the information in a generic procedure is provided in Table 7.3. (This example is provided only for illustration). Refer to the equivalent Step 6 for the SARP Procedure (Table 7.2), "Replace Closure Lid Inner O-Ring with Approved Equivalent."

7.4.3 Guidance for the Content of Training Programs for Package Handling

This section describes the kinds of information and the types of function-specific training that may be required for operations personnel responsible for package handling in addition to any facility-specific training required by OSHA, DOT, or DOE regarding the proper handling, storage, or transportation of radioactive materials. Additional training may be necessary when special methods, techniques, or processes are specified by the designer for performing operations, maintenance, inspections, or repairs. The generic operating procedures should be used as the basis for training efforts; they are likely to be the extent of involvement for packaging designers.

- Individuals to be trained should be familiar with and qualified for using the facility's material handling equipment (overhead or jib cranes, utility services, vehicle or packaging transport systems, etc.). Individuals should also be trained to comply with facility safety, materials handling, transportation and storage, and criticality safety rules, as appropriate.

Table 7.3. Example of procedure steps within a generic procedure

6.0 Replace Closure Lid Inner O-Ring with Approved Equivalent

NOTE

Approved inner O-ring is part number XX--Parker-Hannefin 3/8 in. × 12.75 in. long. O-ring surfaces should be lightly lubricated with GE G-661 Silicone Compound before installation.

CAUTION

Inspect seal surfaces for damage or debris before replacing closure lid. If debris is not removed, serious damage could occur to the O-ring or seal surfaces.

RADIATION WARNING

Operator could be exposed to radiation and radioactive materials during this operation. High beta dose rates might be encountered. "Hot particles" could also be encountered. Health Physics should provide continuous radiation and contamination monitoring throughout this step.

- 6.1 Remove old closure lid inner O-ring.** Pry O-ring out of the O-ring groove using a flat-blade screwdriver. Use caution not to scratch polished surfaces. Dispose of O-ring in accordance with site disposal policies.
- 6.2 Inspect O-ring groove and seal surfaces.** Note any scratches, dings, or other defects that might prevent sealing. Clean any debris from polished surfaces using lint-free wiping cloth. If minor seal surface damage is noted, the surface can be polished smooth using extrafine (600 grit) emery cloth. More substantial damage must be repaired in accordance with Procedure A-3 in the maintenance manual.
- 6.3 Obtain new O-ring.** Remove new O-ring from packaging and inspect for defects such as cuts, tears, flat spots. Wipe any dust or debris off new O-ring using lint-free cloth. Lightly lubricate entire O-ring surface using GE-661-approved silicone lubricant or equivalent.
- 6.4 Install new O-ring into O-ring groove.** Carefully press O-ring into the O-ring groove using finger pressures. Use care not to roll or twist O-ring in the groove.

STEP COMPLETED BY: _____ **(SIGNED)** _____ **DATE** _____

- Training can include classroom, modular, videotape, hands-on/on-the-job, or a combination of methods, depending on the complexity of the packaging and special tools or equipment required to load, handle, and prepare for shipment in conformance to the requirements of the certificate and in accordance with facility safety rules and ALARA practices.
- Training may include a dry run of packaging handling operations.
- The extent of training required depends on the frequency and complexity of packaging being used. Production-line facilities are more likely to use specialized equipment, tools, and automated testing instruments.
- Training should be conducted by individuals with operations experience with the particular packaging, using the operating procedures as guidance.
- Training should include all aspects of packaging operations, including special tools, testing equipment or instrumentation, vehicle operations and packaging hold-down requirements, and documentation. QA, radiation safety, and maintenance personnel should be included in the training.
- For frequent packaging users, training should also include recovery procedures for routine component replacement and minor packaging repairs.
- Training and qualification/skill records may become part of the permanent documentation for the facility.

7.5 GUIDANCE CONCERNING PACKAGING OPERATIONS' RECORDS AND DOCUMENTATION

Because the characteristics inherent in the design of a packaging can dictate many aspects of life-cycle records requirements, a designer, cooperating with packaging users, can affect the complexity and scope of records that will become a part of a packaging's file. Many of these records will fall into the QA category requiring the packaging designer to establish a system to control and preserve important records. Preparation, collection, maintenance, control, and ultimate disposition of many packaging records is a packaging operations function the elements of which are influenced by a packaging's design, operations, maintenance, and test features. Packaging designers have direct influence on records requirements specified in packaging operating procedures (see Sect. 7.4) and packaging acceptance testing and maintenance (see Chap. 8). The designer should recognize that many packaging records requirements are determined by entities that are responsible for operations effectiveness, regulatory compliance, safety, and QA.

The first of the following sections is intended to give a packaging designer an appreciation for the type, characteristics, complexity, and scope of records that are typically prepared and maintained during the life of a packaging and of the complexity of the records maintenance activities that result. It is expected that the designer will take this information into consideration when making design trade-offs.

The second of the sections identifies packaging operations documentation that is typically controlled or specified by a designer and provides guidance on how design features of a packaging can be selected to reduce its complexity and scope.

7.5.1 Packaging Documentation Requirements

As a packaging is designed, constructed, delivered, operated, and maintained, a large number of records and documents will be generated to ensure that the packaging meets the design requirements specified in the certificate application (SARP). Certified materials, processes, and vendors are used for packaging construction. Acceptance inspection records are generated when the packaging is delivered. Routine inspections, maintenance, and recertification are required to retain the certificate or other equivalent certification. These activities are especially important with regard to long periods of storage or inactivity. Bar coding of major packaging components or subassemblies may help provide positive identification and traceability of those components throughout their lifetime.

As part of the operations of a radioactive materials packaging, the user must accumulate a number of records and generate documentation of proper packaging and shipment preparations. Proper authorizing documents that demonstrate qualifications for packaging use must be assembled and maintained. Signoffs and/or checklists must be generated to ensure of packaging conformance to applicable regulations and the certificate provisions. Procedures used to repair or recover from a nonstandard operating condition and inspection approval records permitting continued packaging use are also included. More serious repairs not covered in standard procedures require special documentation. Repairs or replacements to safety-related components such as containment, impact-absorbing, or thermal shields must comply with all applicable regulations. Repairs or replacements to other components including, ancillary equipment items, can be evaluated case by case for records and documentation requirements. These documents must be generated and maintained according to a program to ensure their future availability based on the record retention requirements. Some user documentation must be maintained for one year; other documents must be maintained for the lifetime of the packaging.

Records required to document the design, procurement, use, and maintenance of packagings include certifications, drawings, manuals, and use and maintenance records. Collection, storage, and use of documentation records must be in accordance with an approved QA program. Each time the packaging is used, procedure check-off sheets that document proper use and packaging condition should be generated. Defective components or parts or generic conditions that reduce the packaging effectiveness must be evaluated and reported to the regulatory agency. Each repair, replacement, or planned maintenance activity must also be documented. Specific design and design-related records that are generated and maintained over the life cycle of a package include the following:

- Packaging design and construction drawings with all applicable “as-built” changes included, along with documentation of a configuration control plan
- Packaging materials certifications and vendor qualification records
- Design, materials, or construction deviations and review/approval records
- Certificate of Compliance (most recent revision)
- Packaging owner/Certificate of Compliance holder certification and/or re-certification of the package and the date certification expires
- Drawings and other documentation specified in the certificate
- Registration as a "package user" with the appropriate regulatory agency (generally DOE)

- Packaging user's manual or generic operating instructions

Inspections and tests required to ensure conformance with the certificate for the package also result in the generation of required records and documentation. Testing of specific components and materials must be completed to verify quality and conformance to specification before their incorporation into a packaging. These tests must be specified by the designer. Some of the inspections and tests must be conducted by certified inspectors or QA personnel who must have minimum certified qualifications to ensure their ability to conduct the inspections and tests and accurately interpret the results. Records generated in the process of inspection and testing of a packaging include the following:

- Facility-specific packaging handling procedure
- Facility-certified personnel (as appropriate), including expiration of certification
- Packaging and contents check-off listings
- Certified tools (e.g., torque wrench calibrations), certified instruments (e.g., pressure/vacuum gauges), and records and documentation
- QA surveillance/inspection records and reports
- Leak-testing procedures, documentation, and approval/rejection
- Record of installation of closure seals

- Packaging radiological survey records (inbound and outbound)
- Inbound and outbound shipping documentation, including radioactive-materials shipping report (as appropriate), radiation/contamination surveys, driver's instructions, and emergency response guidance
- Final package/vehicle inspection, including package tiedowns
- Vehicle and carrier personnel certification records related to transport
- Highway routing instructions, advance notifications, communications instructions, etc.

Documentation required for repair and maintenance of packagings includes procedures, processes, materials and components, vendor qualification, and approvals. Chapter 8 contains additional details on repairs and maintenance. Documentation resulting from those repairs and maintenance activities not covered in a packaging's generic operating procedures includes the following:

- Repair procedures and approvals
- Repair processes and listing of certified materials and components, including purchasing records and vendor qualifications/approvals
- Inspections/approval of repair processes and acceptance of repairs
- Repairs to ancillary packaging handling equipment and/or instrumentation

- Deviation records and approvals (if applicable)

(Chapter 8 provides more details on repairs and maintenance)

Records and documentation are required for the approval, procurement, and use of replacement components or parts for a packaging. Many components or subassemblies will be provided with bar coding or serial numbers to establish traceability and QA. Records associated with replacement items include the following:

- Documentation of parts/components replacements on standard operating procedures
- Documentation of inspections, tests, and acceptance and approval to use
- Serial numbers of other tracing/purchasing documents on certified components

7.5.2 Guidance Regarding Reduction of Records Requirements

The packaging designer should consult with the current packaging users concerning specific documentation and record keeping requirements as implemented to meet DOE orders. While not a high-priority issue to the packaging design, minimization of the record keeping burden on the packaging users can be provided by the packaging design. The following suggestions are offered for meeting this goal:

- Specify commercially available materials or components whenever practical.
- Minimize the number of components or parts that comprise the packaging containment.
- Provide for single containment boundary testing for all containment penetrations.
- Specify components with an indefinite shelf life.

7.6 OTHER OPERATIONAL ASPECTS

The following sections discuss certain aspects that the packaging designer should address, although they may not strictly be covered by regulations. They could also be covered within the context of an appendix to the SARP or the existing procedure. Requirements for package tie-down to the transporter may be covered by generic procedures or may be covered by user-facility or carrier-specific procedures. Securing the package to the vehicle has both financial and regulatory components and cannot be left solely to the discretion of the vehicle operator. Ancillary equipment includes those tools, instruments, and other devices supplied by the packaging owner to support loading and preparation operations. Emergency response and recovery involves the package owner's response to transportation or handling emergencies, including the range of activities anticipated in recovering the package without causing further damage or hazard to the workers or the public.

7.6.1 Guidance for Design, Inspection, and Certification of Package Tie-Down Devices

This section discusses the requirements for securing the packaging to a transport vehicle, including those for devices, inspection, and certification. Instructions may be included within the generic operating procedure or may be contained within a separate attachment or appendix. The following items may be included under this category:

- Hold-down devices (including slings, chains, clamps) that secure the package to its transport vehicle or shipping skid or pallet
- Inspection and certification requirements for the hold-down devices or shipping skids

- Alternately acceptable means to provide proper package tie-down

7.6.2 Guidance for Use of Owner-Supplied Ancillary Equipment

This section discusses the requirements for use of ancillary equipment supplied by the packaging user, owner, or Certificate of Compliance holder. Instructions may be included within the generic operating procedure or may be contained within a separate attachment or appendix. These instructions may include the following:

- Instructions for using owner-supplied ancillary equipment, including unpacking and packing instructions and instructions for shipping the ancillary equipment either with or separate from the package
- Inspection requirements and owner approval for ancillary equipment (primarily related to lifting fixtures or devices), which must be reviewed for compliance to facility-specific programs
- Utilities (such as electricity, air, water) or supplies required to operate ancillary equipment
- Alternately acceptable means of packaging handling or operations without using the ancillary equipment

7.6.3 Guidance for Emergency Response and Recovery

This section discusses the requirement for responding to and recovering from an accident or incident involving the packaging. The designer should provide suggested techniques to mitigate

packaging damage and permit safe transportation to a repair facility or other alternative location, including the following:

- Acceptable alternate package lifting and pick points (e.g., using a sling around the circumference of a packaging)
- Unacceptable alternate lifting or pick points (e.g., using a lid ring or clamp to drag or lift an entire package)
- Acceptable alternate overpacks, such as salvage drums or fabricated boxes
- Acceptable alternate packaging orientation and securing to the vehicle, such as placing a damaged package into a partially filled gondola rail car or dump truck
- Acceptable temporary/emergency component substitutes, such as the use of standard fasteners to temporarily replace the same-sized "certified" fasteners

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7.7 REFERENCES

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3. U.S. Nuclear Regulatory Commission, *Standard Format and Content of Part 71 Applications for Approval of Packaging for Radioactive Material*, Regulatory Guide 7.9, Washington, D.C., 1986.

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