



REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

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PRESSURE-SENSITIVE AND TAMPER-INDICATING DEVICE SEALS FOR MATERIAL CONTROL AND ACCOUNTING OF SPECIAL NUCLEAR MATERIAL

A. INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) requires licensees possessing special nuclear material (SNM) to comply with requirements contained in Title 10, of the *Code of Federal Regulations*, Part 71, “Packaging and Transportation of Radioactive Material” (10 CFR Part 71) (Ref. 1); 10 CFR Part 73, “Physical Protection of Plants and Materials” (Ref. 2); and 10 CFR Part 74, “Material Control and Accounting of Special Nuclear Material” (Ref. 3). The NRC generally accepts tamper-indicating device (TID) seals for use in complying with the requirements in 10 CFR 71.43, 10 CFR Part 73, 10 CFR 74.31, 10 CFR 74.33, 10 CFR 74.43, and 10 CFR 74.51 through 10 CFR 74.59. Pressure-sensitive (PS) seals represent one type of TID seal.

This regulatory guide (RG) replaces the existing RG 5.10, “Selection and Use of Pressure-Sensitive Seals on Containers for Onsite Storage of Special Nuclear Material,” issued July 1973 (Ref. 4), and the existing RG 5.15, “Tamper-Indicating Seals for the Protection and Control of Special Nuclear Material,” issued March 1997 (Ref. 5), with a new regulatory guide titled, “Pressure-Sensitive and Tamper-Indicating Device Seals for Material Control & Accounting of Special Nuclear Material.” As a replacement, this guide describes a number of improved TIDs and PS seals developed in recent years, primarily in response to commercial interests outside the nuclear industry. This guide, among other things, distinguishes between genuine and nongenuine manufactured seals and stresses serial number

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This guide was issued after consideration of comments received from the public.

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identification to aid in the control of material or to alert shipping and receiving personnel to containers that were opened in transit. This guide also incorporates recommendations for ensuring that TIDs are properly applied.

This regulatory guide contains information collection requirements covered by 10 CFR Part 71, part 73, and Part 74 that the Office of Management and Budget (OMB) approved under OMB control numbers 3150-0008, 3150-0002, and 3150-0123. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number. The NRC has determined that this Regulatory Guide is not a major rule as designated by the Congressional Review Act and has verified this determination with the OMB.

B. DISCUSSION

Background

The existing RG 5.15, “Tamper-Indicating Seals for the Protection and Control of Special Nuclear Material,” describes several types of commercially available TIDs, one of which includes PS seals for use in the material control and accounting (MC&A) of SNM. RG 5.15 considered, among other things, the function and limitations of these seals for various MC&A applications, focusing on the protection of SNM in transit between facilities.

This revised RG replaces RG 5.15 as well as RG 5.10, which concerns only PS seals on containers used for onsite storage of SNM. This revised RG examines all MC&A-related uses, including PS seal devices that did not exist when RG 5.10 was originally written. The U.S. Department of Energy report DOE/DP-0035, “Safeguards Seal Reference Manual,” issued December 1986 (Ref. 6), describes the evaluation of eight types of seals, including a “paper” seal (but not including fiber optic seals), to determine and compare the time required to defeat each type of seal (i.e., breaking, removing, and reassembling the seal without leaving any signs of tampering). The report noted that, except for the paper seal, the time required for removing and replacing the original seal varied between 15 seconds and 60 minutes. The report also indicated that the paper seal was not defeated; however, the study provided no concrete evidence regarding the expertise of the person who attempted to defeat the seals.

Early PS seals were inexpensive compared to other types of TIDs. Seals available in 1986 were rudimentary compared to the technology of PS seals in use today. In addition, past NRC findings show that TIDs, including PS seals, can and have been defeated when used incorrectly. The question remains as to how easily they can be defeated under the constraints imposed by the conditions of their application. This is discussed in Section 2.2.

1. NRC Requirements

1.1 Requirements in 10 CFR Part 71

In 10 CFR 71.43(b), the NRC requires that all package designs to be approved by the NRC incorporate a feature, such as a seal, on the outside of the package that is not readily breakable and that, while it is intact, would be evidence that unauthorized persons have not opened the package. NRC staff interprets the words “not readily breakable” as referring to accidental breakage during routine handling.

1.2 Physical Protection Requirements in 10 CFR Part 73

In 10 CFR 73.26(g)(3), the NRC requires licensees to ship strategic special nuclear material (SSNM) in containers that are protected by tamper-indicating seals. In 10 CFR 73.46(c)(5)(ii), the NRC requires licensees to store certain forms of SSNM in tamper-indicating containers, and in 10 CFR 73.46(d)(10), the NRC requires licensees to seal certain containers of contaminated waste before these containers are removed from a material access area to ensure that they are not used to remove SSNM from the area.

1.3 Material Control and Accounting Requirements in 10 CFR 74.59

Those Category I licensees authorized to possess and use formula quantities of SSNM are subject to specific requirements defined in 10 CFR 74.59(f)(2)(i) and 10 CFR 74.55(a)(1), which require that licensees authorized to possess and use formula quantities of SSNM develop procedures for tamper-safing containers, for vaults containing SSNM that is not in active process, or for controlled access areas that provide protection at least equivalent to tamper-safing. SSNM that is in active use is subject to separate process monitoring requirements.

1.4 Material Control and Accounting Requirements in 10 CFR 74.43

Those Category II licensees authorized to possess and use SNM of moderate strategic significance are subject to the detailed requirements of 10 CFR 74.43(c)(3), which states that licensees authorized to possess SNM must maintain and follow procedures for tamper-safing containers and vaults containing SNM.

1.5 Material Control and Accounting Requirements in 10 CFR 74.31 and 74.33

Those Category III licensees authorized to possess SNM of low strategic significance are subject to the detailed requirements of 10 CFR 74.31, “Nuclear Material Control and Accounting for Special Nuclear Material of Low Strategic Significance.” In 10 CFR 74.33, “Nuclear Material Control and Accounting for Uranium Enrichment Facilities Authorized To Produce Special Nuclear Material of Low Strategic Significance,” the NRC defines similar requirements for uranium enrichment facilities. Although these requirements do not specifically refer to “tamper-safing,” licensees are required to maintain a current knowledge of the items and store them in a manner such that they can detect unauthorized removal of substantial quantities. Category III licensees often find it convenient to use tamper-indicating seals to ensure the long-term validity of measurement data.

2. Seal Characteristics

2.1 Seal Functionality

NRC regulations require licensees to consider specific security procedures and to implement them to ensure that they achieve an acceptable level of protection of SNM at all times. The use of tamper-safing devices on containers or vaults is one such level of protection used to secure the integrity of SNM either when it is in transit or stored on site. The one overriding objective of TIDs is to ensure that no tampering or entry has occurred while the seal is on the container. Therefore, for MC&A purposes, the degree of confidence in the selection of a TID sealing system will vary depending on the system’s unique characteristics and intended use. Various types of commercial seals have been developed to meet specific NRC requirements. Although these seals have essentially the same elements, their properties are different. For example, a key property of seals is frangibility (i.e., they are easily broken). Because a seal

is not expected to present a serious obstacle to entry or tampering, it is considered a weak obstruction that an unauthorized person can overcome with little effort. Thus, before procuring or using any TIDs, licensees should be certain that they clearly understand what they are trying to accomplish and should evaluate the use of available seals in terms of this understanding.

TID seals on containers used for onsite storage of SNM are passive devices that indicate, upon inspection, whether tampering or entry has occurred. TID seals may also identify where a theft may have occurred in the transportation chain. Receiving warehouses often do not open shipping cartons until the contents are needed. Therefore, the discovery of missing items raises the question of whether the items were stolen in transit or in the warehouse.

In these cases, a TID seal would not need any serial identification or holographic logo but rather a clear and immediate indication that the carton had been opened. If an unauthorized person had tampered with the TID seal before the shipment arrived, it should be readily apparent that a theft most likely occurred in transit. Likewise, if the warehouse accepts shipments with seals intact and later finds a broken seal, a theft most likely occurred during storage.

Thus, the function of a tamper-indicating seal in the context of MC&A is to ensure that a container or vault is properly closed and secured against accidental opening, authorized but undocumented opening, or unauthorized opening. If a TID seal has not been tampered with, the container has not been opened, and its contents are most likely still intact. If the TID seal has been tampered with, the container has most likely been opened, and assurance that the contents are intact is lost, even though nuclear material may or may not be missing. An accidental opening of a container (e.g., if an operator happens to open the wrong container) is the least likely scenario. Historically, authorized but undocumented openings most commonly occur when an operator is instructed to resample a container and then fails to document the changed net weight. The unauthorized opening of a container presumably is for the purpose of theft of all or a portion of the contents.

2.2 Seal Limitations

The most successful methods used to attack sealing systems are those that exploit the weaknesses of the sealing system rather than the tamper-indicating seal itself. A sealing system would fail at the seal if it could be opened and reclosed without leaving any indications of tampering. All tamper-indicating seals, including PS seals, can be defeated given adequate time and resources. In the context of MC&A, the question is not whether unauthorized persons can defeat the seal, but whether they can defeat it given the available time and resources under the constraints imposed by the conditions of its use. For example, when a seal is used as part of a disarmament agreement that nuclear weapons will not be removed from long-term storage, it is necessary to recognize that the presumed adversary has time measured in months and essentially unlimited resources. When a seal is used in a high-security material access area, it is equally necessary to recognize that the presumed adversary has limitations on what tools or chemicals he or she can bring into the area and a time constraint that may be measured in minutes.

In the past, written reports (Refs. 7, 8) differed in their conclusions regarding the correlation between the time required to defeat a seal and the cost of the seal itself. Licensees should consider the reported vulnerability of TIDs being defeated in the context of the situation in which the device is used. Those who have evaluated various seals for tamper resistance have generally limited themselves to what they termed “low-tech” approaches whereby the individual performing the tampering does not have any assistance from other individuals. On the other hand, the evaluations have allowed for the fabrication of a tool at a local machine shop or the purchase of chemicals from a chemical supply company to defeat the seals. The evaluations also presumably allowed the exchange of cooperative advice on how to develop a defeating technology. If, with practice, a person can learn a technique for defeating a PS seal that works

half of the time but damages the seal half of the time so that tampering is obvious, the statement “the seal can be defeated” should be qualified to note that, with practice, the seal sometimes can be defeated but that there is also a significant risk of failing and leaving evidence of the attempt.

All TID seals are subject to the four potential vulnerabilities discussed below.

2.2.1 Substitution

All seals are vulnerable to being destructively removed and replaced by new seals. Under this scenario, the potential exists for an entire sealed container to be removed (e.g., stolen) and replaced with an identical container (i.e., one that is empty or that contains only low-value material) bearing a new seal. In this situation, TID seals are of value only if the seals used are uniquely identified and this identity cannot be duplicated. Those individuals performing the unauthorized act should not have access to a supply of blank seals that are not clearly distinguishable from the originals. This type of failure presupposes a weakness in the identification of the seals. Therefore, all users of seals should require assurance from the manufacturer of the seals that they are unique, that they will not be supplied to other users, and that the masters will be controlled. Most vendors advertise that their seal designs are protected and that they will not sell the same design to a second customer. To protect themselves against a breach of this understanding, licensees should take the following precautions:

- All TID seals should bear a unique logo. Printed logos should be applied using a process that ensures deep ink penetration. Holograms and logos printed in ultraviolet ink (which fluoresces under an ultraviolet light) are available from several suppliers and are harder to duplicate.
- Seals should be manufactured in a bright, easily recognized color. Some vendors consider red to be the default color, but the use of red is not essential if that color is also used for other purposes. Licensees can use color-coded seals to provide each seal custodian with a unique color, or the color-coded seals can denote the particular type of nuclear material (e.g., plutonium, mixed oxide, highly enriched uranium, or low-enriched uranium).
- All seals should bear a unique serial identification code imprinted by the manufacturer. Unlimited possibilities exist, but the alphanumeric code sequence should provide enough characters to last longer than the likely lifetime of the seal design. The serial codes should be short and as simple as possible to help seal custodians quickly recognize whether the serial codes are correct or not. One or two characters can be added to identify the material balance area so that each seal custodian can have a unique set of seals. The inclusion of more than one or two leading zeros (e.g., 0000012345) should be avoided. If the coding sequence becomes exhausted, licensees should have the seals completely redesigned, even if technology improvements do not mandate the adoption of a new sealing system. To facilitate the recognition of serial codes and reduce manual recording errors, a barcoding system is recommended. The barcode can be printed directly on the seal.

2.2.2 Removal and Reapplication

TID seals are vulnerable to being removed and reapplied. The NRC found cases where TID seals consisting of braided metal wires were improperly applied, leaving a significant amount of extra wire in the looped portion of the seal enabling the wire to be cut and replaced into the trap. Proper application (e.g., pulling the excess wire all the way through the trap) of TID seals is essential to preventing this type of failure. Clear installation instructions describing proper application and uses of TID seals should always be available. PS seals are also subject to removal and reapplication. The NRC found cases where plastic seals were applied to surfaces where the seal had not been properly tested for leaving evidence of

removal. Therefore, it is important that licensees consider the surfaces to which PS seals will be applied and the solvents that could be used to aid in removal of such seals. Before committing to a specific PS seal, the staff recommend that licensees develop a complete list of containers to which they will apply seals, and they should establish for each container those seals that cannot be removed and reapplied. Manufacturer recommendations should be followed on what seal should be used based on the application conditions. Special cases relating to PS seals are presented below.

2.2.2.1 Removal before the Adhesive Has Cured

Most adhesives develop full strength over a period of time, which can range from minutes to days. Many PS seals used in MC&A work are used only for a few days before the container is opened and the contents are processed. The licensee should establish the minimum required curing time for PS seals with the vendor through testing. Procedures for using the seals should specify the length of time that sealed containers need to remain in the custody of the person(s) who applied the seal to allow for the adhesive to develop adequate strength. The length of time should be based on the manufacturer's recommendations and test results.

2.2.2.2 Removal without Solvents

An unauthorized person should not be able to remove a PS seal by any means available. Most PS seals will not peel away when simply pulled at one edge, but many seals were developed for use on Kraft paper envelopes, corrugated cardboard cartons, or plywood boxes. Some adhesives that work well on those surfaces do not necessarily work as well on steel, stainless steel, glass, or plastic. Some PS seals may be removable from these latter surfaces with the careful use of a razor blade scraper.

Some adhesives lose their adhesive properties when they are subjected to climate change such as extreme cold. Placing a container in deep freeze for 1 hour is a viable scenario only if a suitable deep freezer is available. Also, the plastic seal itself undoubtedly will become very brittle when it is subjected to extreme cold, and any attempt to remove the seal may fracture it.

Even if the manufacturer states that the removal of a seal is not possible, the licensee should confirm this by testing seals to see if they can be removed from the containers on which they are to be used. The licensee should confirm the results by using the manufacturer's documented procedures and the samples used. The experiments should be documented, both with regard to what was tried and observations as to the degree of success in removing the seals. If, after five to six trials, the experimenter has not succeeded in lifting more than a small portion of the seals, the licensee can consider the seals acceptable. If the experiment achieved partial success in removing the seals and if the seals otherwise have desirable features, the licensee may wish to perform more extended testing. If, after multiple attempts, the experiment cannot extend occasional partial success into complete success, the licensee can accept the seal. If any significant number of attempts leads to complete success, the licensee should choose another seal or restrict the seal to containers for which success was not possible.

2.2.2.3 Removal with Solvents

It should not be possible to remove a seal by softening the adhesive with any solvent readily available within the facility. Kraft paper, corrugated cardboard, and plywood have porous surfaces. Any attempt to use solvents to remove a seal is likely to leave evidence of tampering. Metals, glass, and plastics have nonporous surfaces and are not likely to be affected by solvents (although some plastics may dissolve or swell when they come in contact with some solvents). The seal manufacturer may be able to advise licensees on what solvents will or will not work; if not, licensees should perform controlled testing. As a minimum, the licensee should test the following solvents:

- a. water,
- b. alcohol or ethylene glycol (antifreeze),
- c. acetone or other easily available ketones,
- d. naphthalene, toluene, or xylene (lacquer thinner or paint remover),
- e. gasoline, kerosene, or mineral spirits,
- f. quaternary ammonium solvents (some brand-name household cleansers), and
- g. any solvent chemical that the licensee uses either as part of its nuclear operations or as a cleaning solvent.

Benzene, chloroform, carbon tetrachloride, and the trichloroethylene family of dry cleaning agents may be more difficult to obtain, but licensees should consider them as possible solvents for the removal and reapplication of seals. Specialized chemicals that can be obtained only from chemical supply houses are more questionable if they are not used in the facility and are therefore not readily available through that route. In addition to considering the availability of solvents, licensees should consider whether existing security procedures would prevent the transport of a solvent into a nuclear material control area.

Industrial cleaners and the brand-name liquid cleansers that are available from supermarkets may work well in removing PS seals, but they may also destroy the adhesive or bleach the pigment. If they do not noticeably alter the seal itself, the licensee should consider whether the seal could be reapplied using commercially available glue.

If containers are intended for continual use or for cleaning and reuse, licensees should consider whether the procedures used for this cleaning and reuse would also facilitate the unauthorized removal and reapplication of the seals.

Licensees should follow all applicable guidance concerning chemical safety when performing the types of tests described in this section.

2.2.3 Alteration of Label Data

It should not be possible to alter recorded data on the TID or PS seal without the alteration being apparent. In the past, PS seals often served as container labels on which the operator wrote information, such as the batch number or net weight. With today's highly computerized systems, the serial identification number, which is permanently printed on the seal, may be the only recorded information. The computer then uses that number to correlate the container with separately recorded batch and measurement data. If the licensee must hand-record data on seals, it should establish that this information cannot be erased or washed off without the alteration being readily apparent. The use of a simple barcode and scanner may help aid in identification. Barcodes can be applied to multiple types of TIDs, including PS seals, cable-type TIDs, and others.

Licensees should not rely solely on a seal serial number for container identification because removal or attempted removal of the seal will render the serial number unreadable. In this case, a facility may lose access to information about the contents of the container. Container numbers that are separately

marked on containers will help licensees identify the container and its supposed contents even when the seal has been removed or destroyed. Pairing of codes (one on the TID and one on the container) may be used to ensure that TIDs remain attached to the proper container.

2.2.4 Alteration of Separately Recorded Data

Licensees should control computerized or hand-written data associated with seals for containers to prevent or detect any attempt at unauthorized alteration of that data. A detailed discussion of information security measures for protection of recorded MC&A data is outside the scope of this RG, but it is still an essential part of using tamper-indicating seals. A seal might be defeated and the MC&A records altered to reflect the quantity left in the container. If neither falsification were detected, the theft would be discovered only as part of the inventory difference at the time of the next physical inventory. Another possibility is that the theft involves an unsealed quantity and that the MC&A records on sealed quantities are altered to conceal the theft. An adversary could remove a seal, tamper with the contents of a container, and then apply a new seal. In such a scenario, it is essential to have records indicating which seal is supposed to be on the container in question.

2.3 Practical Considerations

One important practical consideration is how the seal is affixed to the container. Nearly all TIDs other than PS seals assume that the container has been constructed in such a manner as to facilitate the application of a seal. Other than the 200-liter drum, many containers in common use in the nuclear industry are not constructed to facilitate the application of seals. Plastic bottles are used in a range of sizes and shapes; all have screw lids and no way to secure a seal. Ten-liter corrugated cardboard “ice cream cartons” are used for dry materials, especially scrap and waste. These containers have a snug-fitting slip on the lid but no provision for fitting a seal.

PS seals are ideal for these types of containers because they adhere well and cannot be removed. A screw lid cannot be removed without being unscrewed; any small seal that would break if the lid were unscrewed should work well. Lids that simply slip onto containers may be more of a problem. If a corrugated cardboard carton can be deformed sufficiently to remove the lid without breaking the seal, then either two seals should be used, or the seal must cover more than one point. The use of a strip seal that can be wrapped around the container-lid joint would be preferable to a seal that crosses over the top to seal the container-lid joint at two opposite locations. In any case, the licensee should verify, for all containers for which seals are to be used, that the chosen seal will prevent the container from being opened.

Another practical consideration is the reuse of previously sealed containers. If a container is to be reused, then the licensee should remove the remnants of the previous seal by either scraping them off or by using solvents. The question of removal for undetected reapplication no longer applies, so razor blade scraping, which causes a PS seal to break into pieces, is acceptable. Also, removing a PS seal with industrial or household cleansers will destroy the seal in the process of cleaning. Most facilities prefer not to spend time removing remnants of past seals and would prefer to apply new ones. Nonresidue void type seals are available and typically used for these applications. The licensee should verify that, for all containers intended for multiple uses, remnants of any previous seal can be removed with an acceptable amount of effort.

Some TIDs such as PS seals often are designed for application to a flat surface. Extending a seal across the top of a container and down a portion of one side may introduce a bend, which the PS seal interprets as an attempt at tampering. Licensees should verify that seals will not self-destruct during application.

2.4 Commercially Available Tamper-Indicating Device Seals

The several types of commercially available seals have a very broad range of capabilities. This guide describes some commercially available seals that are acceptable to the NRC for safeguarding SNM. Other seals may be approved on a case-by-case basis.

2.4.1 Padlock Seal

The padlock seal is a one-time seal that is destroyed when removed. The most secure design requires a hammer to drive a hardened steel shackle into a steel block. This seal is very rugged and may be used when accidental damage is likely and a lock is also needed. Unlike other TID seals, this seal was designed to be used as a serious obstacle to entry.

A conventional padlock with a small hole drilled through its body and shackle is available. A TID can be threaded through this hole once the padlock has been installed. If the padlock is tampered with, the TID will be broken or blemished to reveal the tampering event.

2.4.2 Type E Cup-Wire Seal

The Type E seal consists of two metallic cups and wire. The ends of a loop of wire are passed through the hasp (one of the cups) and crimped together. The two cups are then pushed together, enclosing the crimped ends of the wire.

A fingerprint of the seal may be artificially created by inscribing scratches on the inside surfaces of the seal; the scratches are photographed before the seal is applied. At the container inspection point, the seal is removed and sent to a laboratory for analysis and comparison with the original photograph. The seal is destroyed in the examination. The Type E seal, when fingerprinted, is considered a high-security seal. Defeating the seal would require penetration and repair techniques that would not leave any visible evidence under a microscopic examination of the surfaces. While the seal could be defeated by cutting and rejoining the wire without leaving marks, the use of multistrand wire makes concealing evidence of tampering difficult.

2.4.3 Car/Ball End Seal

The car/ball end seals are steel strap seals. A latching mechanism, a piano-wire loop that captures both ends of the strap, is located inside a crimped ball at one end of the strap. The tip of the seal is designed to extend through the lock housing and can easily be viewed through a special sight-inspection hole in the housing. The company's name, logo, and sequential serialized identifiers can be embossed on the seal strap.

Once the car/ball end seal is in place, it should be checked to ensure that there is a proper amount of end play in the latching mechanism. The seal is destroyed when it is removed for examination. The person conducting the postmortem examination should compare the removed seal to a sample seal and carefully inspect the exterior and interior surfaces to detect forgery. The ball housing should be opened to verify that all the internal parts are present.

2.4.4 Fiber Optic Seal System

Fiber optic seal systems consist of fiber optic loop material, seal bodies, and a seal signature reader-verifier. Two types of fiber optic seal systems are commercially available: (1) active reusable and (2) passive single-use. Active reusable systems are primarily used in the transportation of nuclear

materials. The system is active in the sense that its electronic seal body sends an encoded digital pulse stream through the fiber optic loop to check for continuity. This design enables the detection and recording of the time, date, and duration of each fiber optic loop event, whenever the digital signal is interrupted. Opening the fiber loop or removing the fiber termination from the receptacle results in an “open” indication. An external housing around the seal body is necessary to prevent inadvertent opening of the loop. Seal-tampering information is obtained by attaching the seal to a reader and retrieving the stored contents of the seal. This reading is done in situ, without affecting the seal’s integrity.

Passive single-use seal fiber optic systems are primarily used in long-term storage of SNM. The fiber optic cable can be cut in the field to any length, up to 30 meters. The cable ends are inserted into a one-piece seal body. The compression of the individual strands forms a unique grouping. The seal body contains a serrated blade that, when pressed in place, randomly severs a portion of the cable fibers. The combination of the unique grouping and the striated pattern forms a unique signature that can be viewed and recorded by a seal reader at the loop termination. The seal is verified by comparing the image obtained during the inspection to the image obtained when the seal was initially installed. This comparison is subjective, but any variation in the pattern should be obvious.

2.4.5 Tamper-Evident Wire Seal

The tamper-evident wire seal consists of a braided metal wire that has one end permanently attached to a solid metal trap. New types of TIDs are available which use other materials for the body of the trap. The other end of the braided metal wire is then looped through the container of SNM and is then inserted through a hole in the solid metal trap that is designed such that once the wire is inserted through the trap, it cannot be pulled back through or otherwise removed unless the wire is cut. These seals use stranded-nonbraided or loosely braided metal wire that is designed to fray when cut (i.e., the individual strands separate due to the release of tension) making it extremely difficult to reinsert all of the strands back into the trap. Some manufacturers offer seals of this type that allow barcodes to be etched into the body of the trap.

2.4.6 Pressure-Sensitive Seal

Based on work reported in the literature (Ref. 8), at least 25–30 PS seals are commercially available. Many of these seals have features in common. In selecting PS seals, licensees should consider the need for additional equipment (e.g., the number of laser pens needed if a laser-encoded seal is selected), the need for operator training, the extent of the necessary documentation, and the time and effort required for seal verification.

All vendors advertise that they recognize the importance of protecting seal designs and thus will not sell the same design to any second purchaser. Most vendors also advertise that they will destroy all production scrap, including any excess production not delivered to the purchaser. Licensees should explore this question explicitly with all prospective vendors to ensure a clear understanding that the seal design that the vendor is offering is protected.

The licensee should also consider the possibility that a seal could accidentally break. The cost or effort required to investigate one accidentally broken seal could easily far exceed the added cost of seals that are less susceptible to accidental breakage.

2.4.6.1 Security Decals

The simplest PS seals are those referred to as security decals or void tapes. One type will leave a residual void message on the application surface if tampered with that must be cleaned before the

application of a new seal. A nonresidual type provides a void message on the label surface but does not leave a residue on the container. A third type is the destruct-type or frangible-type which incorporates security cuts that permit the label to break if tampered with. Some of these may be constructed of a material that fragments if any attempt is made to remove it. A security decal consists of a piece of vinyl, which may be virtually any size or shape, bearing whatever printed information is desired. (Most security decals are, strictly speaking, not decals.) A serial number can be included, and this serial number can be a barcode form for ease of verification or inventory. Security decals are inexpensive, and the ease of removal makes them suitable for containers intended for repeated use. They may not provide sufficient security for use with SSNM or for offsite shipments. Licensees should always review the TID requirements before determining which TID to apply to a container. Some Category II or Category III licensees may consider security decals adequate for internal use to preserve the integrity of measurement data.

2.4.6.2 Optically Variable Devices (Holograms)

The optically variable image, or hologram, is well established as a technology that is easy to use and verifiable in the field. Whether it can be counterfeited depends on how much effort one is willing to apply. Small printers usually do not have the equipment and expertise to produce holographic images, but most large printers can produce holograms. A holographic company logo may be considered for inclusion when PS seals are selected and designed to provide additional authenticity. Some manufacturers can incorporate a hologram directly onto a void-type PS seal.

2.4.6.3 Multiple-Layer Security Tapes

A PS seal of necessity consists of at least three layers. On top is the vinyl or other material used as the seal. Next is a layer of adhesive, and finally, there is a removable slip-sheet layer that protects the adhesive until the seal is to be used. The addition of a second vinyl layer and a second layer of adhesive can make a seal considerably more difficult to remove nondestructively. The intermediate adhesive is considerably weaker than the adhesive holding the seal to the container, and simple attempts to peel the seal away from the container will separate the layers, leaving at least part of the design still on the container.

Multiple-layer security tapes applied to paper, cardboard, or wood provide considerable tamper resistance. The difficulty of removing a multiple-layer security tape depends on the nature of the tape used and the surface to which it is being applied. Licensees who choose to use multiple-layer security tapes should test the seals on the containers on which they are to be used.

2.4.6.4 Tamper Tape Seals

The tamper tape seal was developed as a less expensive, yet reasonably secure, alternative to an ultrasonic intrinsic tag that Pacific Northwest Laboratory developed in anticipation of Strategic Arms Reduction Treaty applications (Ref. 8). The top layer consists of glass beads embedded in a brittle bonding material. If transfer is attempted, the beads are disrupted from the bonding layer, and the logo pattern reflected from beneath the glass beads is distorted. Verification of the logo pattern requires visual observation with a light source such as a small flashlight held perpendicular to the surface of the tamper tape seal.

The tamper tape seal can be removed by subjecting it to extreme cold, which causes the adhesive to lose its strength. Licensees who may want to use the tamper tape seal should consider whether extreme cold (at least -20 degrees Celsius (-4 degrees Fahrenheit)) is a factor under the conditions of use.

2.4.6.5 Optical Chemical Coatings

Optical chemical coatings are not in themselves seals. However, they are relevant because they can be incorporated into PS seals and because doing so gives the seals considerable additional tamper resistance, as well as authenticity. The coating is transparent when viewed directly. When viewed from different angles, the image contained in the coating (e.g., the company logo) changes from transparent (invisible) to orange and then to green. The coating is not itself a thin film but rather a chemical coating having no structural strength. It self-destructs if there is any attempt to remove the seal in which it is incorporated. Also, the coating cannot be duplicated by any currently available graphic technology.

Another type of chemical coating is a chemical taggant that is added to the surface printing ink of the PS seal. An example of this would be an infrared taggant. An infrared sensor would be required and would respond to the taggant in the ink, verifying the seal's authenticity.

2.4.6.6 Laser-Encoded Seals

Some manufacturers offer seals with optically coded information that can be viewed only with a special hand-held laser device. The information recorded could be a corporate logo or it could be the serial identification number. Unlike the microprinting used on U.S. currency, optically coded information cannot be read under high magnification, nor can it be copied or optically remastered. Because the subsurface image is not obvious either to the naked eye or under high magnification, this offers security advantages over holograms.

2.5 Seal Verification

The integrity of all types of seals needs to be verified at the time the seals are removed. Many seals need periodic verification while still in use. TID seals selected for MC&A use should be verifiable in the field. Nearly all TID seals are destroyed when the container is opened.

During the periodic verifications required by 10 CFR Part 74, plant personnel should be able to confirm not only that the seal is still intact but also that it is the same originally applied seal and that it has not been tampered with. This does not mean that seal integrity should necessarily be apparent "at a glance." The tamper tape seal described in Section 2.4.6.4 above requires examination in the light of a flashlight shining perpendicularly to the seal surface. Another type of seal requires examination through a lens. The seal with optically encoded information requires examination with a hand-held laser-viewing device. In all cases, however, the licensee can perform field verification to determine that the seal has not been tampered with.

Licensees should consider what measures or tools are necessary to perform verification of seals. Consideration may be given to seals that require no tools for verification and that offer clear evidence of tampering. Use of barcodes requires appropriate barcode readers but usually allows for faster confirmation of identification data.

3. Procedures for Using Tamper-Indicating Device Seals

3.1 Control of Seals before Use

At the time purchased seals are delivered, the manufacturer should provide the licensee with precise instructions. Accompanying paperwork should specify exactly how many seals are being delivered with beginning and ending inventory numbers, and receipt verification should be sufficiently

clear to verify that all seals are accounted for. If seals are missing, the licensee does not necessarily need to discard the lot, but it should perform a detailed inventory to determine the missing serial numbers, and all individuals authorized to use the seals should be warned that the missing numbers will require immediate investigation if they appear later on containers.

Licensees should distribute seals only to individuals authorized to apply them or to custodians who will distribute them to users on an as-needed basis. Licensees should securely protect both distributed seals and the stock that is reserved for later distribution. There is no regulatory requirement to verify the inventory of unused seals at intervals, but this is generally good practice.

3.2 Seal Application

Only those individuals who are authorized and trained to apply TID seals to containers should apply them. Training should include instruction on the types of containers that can be effectively sealed with the available seals, the method used to apply seals, and verification that seals have been properly applied. In most cases, applying a seal to a container has no meaning unless the quantity of nuclear material in the container is known. Seal application procedures should include establishing that this is the case and that the measured quantity data are properly recorded. Attention may be given to the manner in which TIDs are packaged and ease of handling for applications where personnel protective equipment is required.

Pursuant to 10 CFR Part 74, clear records need to be kept regarding seal use. The minimum information that must be recorded includes the date of use, the identity of the person who applied the seal, the identity of the container to which the seal was applied, and the seal serial identification. Use of barcoding and other identification means may enhance the speed and accuracy of MC&A activities. If a serial number on the seal is used as a correlation with materials accounting data, then these accounting data must also be recorded.

In each building or material balance area, only one person should be the seal custodian and one or more individuals other than the seal custodian should be authorized seal appliers. This limits the ability of either the custodian or the applier to falsify his or her own work. For SSNM subject to a two-man rule, the seal applier is subject to the same “second-person” constraint whether or not the seal applier is also the seal custodian. For SNM of less strategic importance where the two-man rule does not apply, the same considerations that led to a decision not to impose two-man restrictions on other activities should also lead to a decision not to require a separation between seal custodians and seal appliers. The important consideration is that proper procedures exist for the appropriate control and use of seals and that the necessary materials accounting data are properly recorded.

3.3 Seal Verification during Storage

The continued integrity of TID seals should be verified at intervals that will depend on the material under protection. Where feasible, containers should be stored in such a manner that the licensee can verify TID seals with a minimum of container handling. If containers are stored in protective overpacks or closed storage units, the licensee should consider applying the seals to the overpacks rather than to the containers. The use of barcodes may aid in this process.

Casual observation that every container appears to bear an intact seal does not constitute adequate seal verification. The verification should include an examination of the seal for evidence of tampering, an examination of the container itself for evidence of attempts to bypass the seal, and a determination that the seal has not been removed and replaced. This determination should be made by comparing the serial number or other unique data recorded on the seal. For some seals, the person performing the verification

may have to examine the seal under special lighting conditions or with a laser pen to read encoded information. If the person has a list of containers and applied seal numbers, he or she should be able to compare numbers on the containers with the list and to make appropriate checkmarks on the list. The use of barcodes may simplify this process. The alternative, which is slightly more time consuming but more effective in terms of preventing careless work, is for the person performing the verification to record seal numbers as containers are verified and then to make an after-the-fact comparison with an inventory of what should have been present.

Information concerning the date and time of verification, the identity of the person doing the verification, and any noteworthy observations (e.g., “seal scratched, but integrity not compromised”) should be recorded. Any pattern in the observations should be considered carefully. In the example given, the licensee may want to modify the conditions of storage to eliminate accidental scratching or other forms of damage that do not compromise seal integrity. If seals are still being scratched, the licensee may need to seek a more detailed explanation.

Under some conditions (e.g., receipt of sealed nuclear material from off site), a facility may need to verify seals that it did not apply and that do not match its own seal stock. The facility should ask the shipper to supply both a sample seal for visual comparisons and a list of serial numbers or other identifying data for the seals that are actually used. Including a list of serial numbers with shipping papers is common practice; making this information available to the individuals who should verify seal integrity is less common. Serial numbers in the MC&A department’s files are of little value; a copy of those numbers should be made available to the individuals responsible for seal verification.

The reverse situation also arises. Under some conditions (e.g., shipment of sealed nuclear material to offsite locations), a facility may need to entrust seal verification to individuals in another location working for a different employer. The facility should supply the receiver not only with a list of serial identification numbers but also with a sample seal and with instructions for seal verification. With some seals (e.g., those using laser-encoded information), the receiver may need to obtain special equipment.

3.4 Seal Verification at the Time of Removal

When the contents of a sealed container are to be used, it is important that the facility perform one final seal verification procedure before the seal is removed. The seal should then be either removed and returned to the custodian or destroyed. While most often TID seals are destroyed upon removal, simple cancellations (e.g., writing “void” across the seal, tearing a PS seal in half and peeling off the two fragments, or discarding the TID seal in the nearest trash bin) are usually insufficient. If the seal can be removed even in a seriously damaged condition, it should be returned to the custodian who should either store it in the same manner as that of unused seals or completely destroy it. Section 2.2 discusses “practicing” before attempting to defeat a seal. Removed but incompletely destroyed seals constitute an easily accessible source of practice seals.

The facility should document the details of the final verification to the same degree as it would the details of seal application and interim verification. The facility should also record the date and time of seal verification and removal, the condition of the seal before removal, the identity of the individual(s) removing the seal, the disposition of the seal or seal fragments, and the disposition of container contents. There should also be a notation to the effect that the individual(s) removing the seal compared the seal with the data recorded at the time that it was applied to the container and found no discrepancies.

3.5 Written Procedures

As with all other aspects of material control and physical security, it is important that licensees prepare written procedures, that they keep them current, that they make them available to the individuals who actually do the work and assure that they follow those procedures. Licensees should include the following topics in their written procedures:

- a. procedures for deciding who should be designated as seal custodians or seal applicers and for documenting the decisions made,
- b. procedures for the control of TID seals before they are used,
- c. procedures for applying TID seals to containers, including the types of containers authorized for use with TID seals, the method used to apply the seals and to verify that they are properly affixed, and the data that must be recorded at the time that the seal is applied to the container,
- d. procedures for both interim verifications and verifications before the removal of TID seals, including the frequency of verification, examinations to be performed, and data to be recorded,
- e. procedures for the disposition of removed seals or seal fragments or for the destructive removal of seal fragments before releasing the container for reuse,
- f. procedures to follow in the event that seal breakage, replacement, or tampering is detected,
- g. procedures for handling the accidental breaking of a seal, and
- h. training procedures, including any required testing.

C. REGULATORY POSITION

Provided that the licensee has considered the vulnerabilities, conditions of use, and other considerations as described in this RG, and followed the recommended procedures in this RG, the NRC staff generally accepts TID seals for use in complying with the various requirements in 10 CFR 71.43, 10 CFR Part 73, 10 CFR 74.31, 10 CFR 74.33, 10 CFR 74.43, and 10 CFR 74.51 through 10 CFR 74.59. The NRC will also consider the adequacy of licensees' proposed seal procedures as compared to the discussion in this RG.

To be acceptable, a sealing system based on TID seals should include the following features:

- a. The seal should bear a unique serial identity combined with unique information that identifies the licensed facility using the seal. Both the serial identity and the logo or other identifying information should be applied in a manner that makes undetected removal difficult. The licensee should explicitly establish with the manufacturer that it will not sell identical or closely similar seals to any second individual, that it will adequately safeguard print masters, and that it will destroy all printing waste in a manner that would preclude salvage.

- b. The seals should be applied in a manner that ensures that the contents cannot be removed from the sealed container without compromising the integrity of the seal or the container.
- c. Measurements to determine container contents and the seal application should be coordinated in a manner that ensures that the contents could not be changed between the time when the measurements were made and the seal was applied.
- d. For seals used for offsite shipments or for any use where the seal may be exposed to the elements, the seal chosen should be able to withstand such exposure without alteration in a manner that might be confused with tampering or that might destroy any indications of tampering.
- e. Seals should only be available to and only be applied and removed by individuals authorized for that purpose. Written procedures should ensure that individuals authorized to handle seals are properly trained and that they maintain proper records of the seals used, verified, and removed.
- f. Removed seals should be completely destroyed or should be protected by seal custodians using the same procedures as those for unused seals.
- g. Written records of seal use should be maintained.

Compliance with this guide is not mandatory. Existing systems or commitments in NRC-approved MC&A and physical security plans need not be modified to correspond with the discussion in this guide.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees¹ may use this guide and information regarding the NRC's plans for using this Regulatory Guide. In addition, it describes how the NRC staff has complied with the Backfit Rule, 10 CFR 50.109 and any applicable finality provisions in 10 CFR Part 52.

Applicant and Licensees' Use

Applicants and licensees may (i.e., voluntarily) use the information in this regulatory guide to develop applications for initial licenses, amendments to licenses, or other requests for NRC regulatory approval (e.g., exemptions). Licensees may use the information in this regulatory guide for actions which do not require prior NRC review and approval (e.g., changes to a facility design under 10 CFR 50.59 which do not require prior NRC review and approval). Licensees may use the information in this Regulatory Guide or applicable parts to resolve regulatory or inspection issues (e.g., by committing to comply with provisions in the regulatory guide).

Current licensees may continue to use the guidance that was found acceptable for complying with specific portions of the regulations as part of their license approval process, which may be a previous version of this Regulatory Guide.

¹ In this section, "licensees" include applicants for standard design certifications under 10 CFR Part 52.

A licensee who believes that the NRC staff is inappropriately imposing this Regulatory Guide as part of a request for a license amendment or request for a change to a previously issued NRC regulatory approval may file a backfitting appeal with the NRC in accordance with applicable procedures.

NRC Staff Use

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this Regulatory Guide. The staff does not expect any existing licensee to use or commit to using the guidance in this Regulatory Guide in the absence of a licensee-initiated change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this Regulatory Guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action which would require the use of this regulatory guide (e.g. issuance of an order requiring the use of the Regulatory Guide, requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this regulatory guide, generic communication, or promulgation of a rule requiring the use of this Regulatory Guide) without further back-fit consideration.

During inspections of specific facilities, the staff may suggest or recommend that licensees consider various actions consistent with staff positions in this regulatory guide. Such suggestions and recommendations would not ordinarily be considered backfitting even if prior versions of this Regulatory Guide are part of the licensing basis of the facility with respect to the subject matter of the inspection. However, unless this Regulatory Guide is part of the licensing basis for a plant, a failure to comply with the positions in this Regulatory Guide, by itself, may not be identified by the staff as a violation.

If an existing licensee seeks a license amendment or change to an existing regulatory approval, and the staff's consideration of the request involves a regulatory issue which is directly relevant to this Regulatory Guide and the specific subject matter of the new or revised guidance is an essential consideration in the NRC staff's determination of the acceptability of the licensee's request, the staff may require the licensee to use this Regulatory Guide or its equivalent as a prerequisite for NRC approval. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

Conclusion

This regulatory guide is not being imposed upon current licensees and may be voluntarily used by existing licensees. In addition, this Regulatory Guide is issued in conformance with all applicable internal NRC policies and procedures governing backfitting. Accordingly, the NRC's staff issuance of this regulatory guide is not considered backfitting, as defined in 10 CFR 50.109(a)(1), nor is it deemed to be in conflict with any of the issue finality provisions in 10 CFR Part 52.

GLOSSARY

pressure-sensitive seals—Pressure-sensitive seals are usually strips of paper or plastic used to “seal” containers in such a way that opening the container would in some way alter the seal, making it clear that an unauthorized opening had occurred. Most pressure-sensitive seals in current use involve several layers of paper or plastic and are designed to reveal any attempt at removing the seal, including an unsuccessful attempt.

tamper-safing—Tamper-safing, as defined in Title 10, Section 74.4, “Definitions,” of the *Code of Federal Regulations* (10 CFR 74.4), means “the use of devices on containers or vaults in a manner and at a time that ensures a clear indication of any violation of the integrity of previously made measurements of special nuclear material within the container or vault.” Expanding on that definition, a tamper-indicating device (TID) is a device that provides tamper-safing information. In principle, a TID does not need to be a seal, but most TIDs in fact are seals. The expression “to seal a container” is in more common usage than the more precise expression “to tamper-safe a container” or “to apply a TID to a container.” In practical terms, all three expressions convey the same meaning.

vaults and containers—In 10 CFR 74.4, the definition of tamper-safing allows the use of tamper-safing devices on both containers and vaults. The distinction is one of size and mobility. Vaults usually are large (at least relative to containers) and massive and are constructed to withstand considerable physical attack. In contrast, most containers can be opened easily. Both containers and vaults have one element in common—whatever is inside the container or vault cannot be removed, escape, or accidentally fall out unless the container or vault is opened. If the vault or container is suitably protected against an undetected or unauthorized opening, then licensees can presume that the contents are secure.

REFERENCES²

1. 10 CFR Part 71, “Packaging and Transportation of Radioactive Material,” U.S. Nuclear Regulatory Commission, Washington, DC.
2. 10 CFR Part 73, “Physical Protection of Plants and Materials,” U.S. Nuclear Regulatory Commission, Washington, DC.
3. 10 CFR Part 74, “Material Control and Accounting of Special Nuclear Material,” U.S. Nuclear Regulatory Commission, Washington, DC.
4. Regulatory Guide 5.10, “Selection and Use of Pressure-Sensitive Seals on Containers for Onsite Storage of Special Nuclear Material,” U.S. Nuclear Regulatory Commission, Washington, DC, July 1973.
5. Regulatory Guide 5.15, “Tamper-Indicating Seals for the Protection and Control of Special Nuclear Material,” Revision 1, U.S. Nuclear Regulatory Commission, Washington, DC, March 1997.
6. DOE/DP-0035, “Safeguards Seal Reference Manual,” U.S. Department of Energy, Washington, DC, December 1986.
7. R.G. Johnston and A.R.E. Garcia, “Physical Security and Tamper-Indicating Devices,” *Proceedings of the American Society of Information Science Mid-Year 1997 Meeting, May 31–June 5, 1997*, pp. 43–46. This report was also published as Los Alamos National Laboratory report LA-UR 96-3827 (1996).
8. B.W. Wright and H.A. Udem, “Tamper Tape Seals,” *Proceedings of the 35th Annual Meeting of the Institute of Nuclear Materials Management, July 17–20, 1994*, Institute of Nuclear Materials Waste, Northbrook, IL, 1994, pp. 1161–1166.

² Publicly available NRC published documents are available electronically through the Electronic Reading Room on the NRC’s public Web site at: <http://www.nrc.gov/reading-rm/doc-collections/>. The documents can also be viewed on-line or printed for a fee in the NRC’s Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail pdr.resource@nrc.gov.