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NUCLEAR MATERIAL CONTROL IN THE UNITED STATES

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ABSTRACT

The Department of Energy has defined a safeguards system to be an integrated system of physical protection, material accounting and material control subsystems designed to deter, prevent, detect, and respond to unauthorized possession, use, or sabotage of SNM. In practice, safeguards involve the development and application of techniques and procedures dealing with the establishment and continued maintenance of a system of activities. The system must also include administrative controls and surveillance to assure that the procedures and techniques of the system are effective and are being carried out. The control of nuclear material is critical to the safeguarding of nuclear materials within the United States. The U. S. Department of Energy includes as part of material control four functional performance areas. They include access controls, material surveillance, material containment and detection/assessment. This paper will address not only these areas but also the relationship between material control and other safeguards and security functions.

BACKGROUND AND INTRODUCTION

In the beginning of the nuclear era, the small amounts of nuclear material coupled with the secretive environment in which nuclear work was done provided the necessary material controls. It was not long, however, before a need for more stringent and broader material controls became obvious. The expansion of the use of nuclear materials from weapons applications into commercial applications such as reactors also highlighted this need for additional controls resulting the United States Atomic Energy Act of 1954. This act provided for the degree of control that was felt to be needed in both the commercial industry as well as in the weapons industry. This Act still serves as the guiding legislation for the control of nuclear materials in the United States.

In 1946 the Atomic Energy Commission (AEC) was formed to manage nuclear materials and facilities. In 1974 the AEC was replaced by the Nuclear Regulatory Commission (NRC) for privately owned nuclear facilities and by the Energy Research and Development Agency (ERDA) for the government's nuclear weapons program. In 1977, ERDA was reorganized into the Department of Energy (DOE). The Department of Defense (DoD) is also responsible for protecting nuclear weapons in its custody. As a signatory of the Nonproliferation Treaty (NPT) the United State's civilian nuclear facilities are subject to International Atomic Energy Agency (IAEA) circulars. In his speech to the United Nations in September 1993, President Clinton stated, "...the US will...submit US fissile material no longer needed for our deterrent to inspection by the International Atomic Energy Agency" (Nonproliferation and Export Control Policy, the White House Fact Sheet dated September 27, 1993). This has created that possibility that facilities which are part of the government nuclear weapons program may be subject to IAEA inspections. Thus, in the United States there are four different agencies, the DOE, the NRC, the DOD and the IAEA, which are involved in control of nuclear materials.

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In the early periods of the nuclear age, material was controlled and protected through a combination of intense administrative and personnel controls as well as armed personnel and physical protection. As time progressed, the intensive administrative and personnel measures became categorized into standard administrative procedures associated with nuclear materials and classified information. During this same time frame technological approaches which could provide physical protection for the materials were adopted to reduce the number of personnel associated with guarding and protecting the materials. Both of these developments are considered to be a natural evolution of the material control process as knowledge of its existence and its application became more widespread. The material control protection program was designed to achieve two general goals. First it was desired that the number of individuals who had access to the materials or knew the details associated with the classified nuclear business be limited to a small and trusted population. The second goal was to restrict physical and information access to only those individuals who had an authorized need.

Nuclear materials control includes:

- responsibility for the nuclear material
- vigilance over the nuclear material
- governing the movement, location and use of nuclear material
- monitoring the inventory and processing status of nuclear material
- detecting unauthorized activities against nuclear material, and
- investigating and resolving apparent losses of nuclear material.

In the context of this paper, the threat against which material control provides protection is the malevolent insider. Most industries provide some form of protection against insider malevolence. This is particularly true in the high value and/or sensitive industries involved with commodities such as precious metals, gems and nuclear materials. The insider is an adversary with knowledge of facility operations and authorized access to such operations. This adversary can be anyone at the facility and the more responsibility an individual has, the more capability he has to compromise and bypass the protection systems. An insider threat is formidable because many of the conventional forms of protection, such as barriers and access control, are routinely and necessarily bypassed by such individuals in the performance of their job responsibilities. There is evidence that suggests the need for increased protection against the insider threat. Societal conditions that increase white collar crime also seem to be more prevalent today.

This paper will discuss how these functions of material control are achieved and the primary elements associated with the implementation of the material control program. We will discuss components of material control and the administrative, procedural and technological elements which exist today as a result of this evolutionary protection program.

COMPONENTS OF MATERIAL CONTROL

Access control - Graded protection, based on the quantity and attractiveness of the nuclear material, is provided to nuclear materials. Only properly authorized personnel shall have access to nuclear materials, information, and data and equipment used in material control functions. Access control functions govern the movement of people and nuclear material and can detect unauthorized movements. Controls are established at points between security areas to control personnel

movements, detect contraband (such as weapons and explosives), detect unauthorized movement of nuclear material and also provide monitoring for environmental or health physics requirements. Access controls are one of the primary means to help compartmentalize facilities thus limiting access to nuclear material. If problems develop concerning the possible loss of nuclear materials the historical record of personnel movements would be invaluable in identifying the possible adversary. One of the primary approaches for detection of malevolent intent and/or activity by an insider is monitoring them on passage through the boundaries of multiple protected areas.

Material surveillance - In order to provide vigilance over nuclear material and/or detect unauthorized activities, material surveillance is performed. This can be accomplished using either people or technology such as video cameras. Monitoring devices, sensors and the two-person rule are utilized to provide the necessary assurance that nuclear material is being protected. This is particularly important in very complex operations such as processing or manufacturing activities. This function plays a critical role in supporting materials accountancy by providing confirmation that nuclear material has not been diverted. Visual surveillance/direct observation (e.g., two-person rule, monitoring by external personnel) can provide assurance that only authorized activities occur and assess special nuclear material movements or inventory status. Visual surveillance requires reasonable assurance that activities are observable and that the observer will recognize, correctly assess and report activities that are unauthorized or are inconsistent with established safeguards requirements. Surveillance also can be used to effectively mitigate the possible threat from possible insider adversaries. The existence of both video and people observation not only provides a deterrent to unauthorized acts but also helps in resolving apparent losses of nuclear material.

Material containment - Both administrative and technical measures are utilized to make sure that nuclear material remains contained in it's proper location. Nuclear facilities are divided into security areas. The level of barriers, detection and access control measures varies depending upon the quantity and attractiveness of the nuclear material present. As one gets closer to the nuclear material the protective measures generally become more stringent. Material balance areas are established to help provide administrative controls to ensure that nuclear materials are controlled in accordance with proper protection concepts.

Detection and assessment - Detection furnishes both real time and delayed information. In some cases, such as detection by physical protection sensors and portal detectors, the assessment occurs as soon as the detection is conveyed. In other cases a historical review of records is an appropriate assessment. In order to detect the removal of nuclear material from authorized locations and provide notification to protective forces detection and assessment systems are utilized. These may include tamper indicating devices, portal monitoring, waste monitors, sensors, daily administrative checks and other measures. These systems can provide an effective way to detect theft or diversion of nuclear material.

ADMINISTRATIVE ELEMENTS

As indicated above, administrative elements have played and continue to play an extremely important role in the U. S. materials control program. The first stage of this program is to establish criterion for the characteristics of individuals who will be allowed to participate in this industry and ensure that this criterion is met. Once this level of trust has been achieved, it is necessary to establish who is responsible for various administrative control elements within the industry.

Several steps are taken both initially and on a continuing basis to develop confidence that individuals can be trusted with information and nuclear material access. The first step is to conduct a full scope background investigation to ascertain characteristics of these individuals. The characteristics of interest include trustworthiness, loyalty to their country, honesty and other desirable personality traits and attitudes. These characteristics are ascertained initially by interviews with friends, neighbors, and business associates who have known the individual over a relatively long period of time. The results of these interviews and any other historical information which may have been obtained are then reviewed and a clearance to have access is either granted or denied.

Once a person has been cleared for access , employed and assumes assigned job responsibilities they are also subjected to periodic reviews of similar information as that acquired during the initial review. All individuals who are cleared at the higher levels are required to have a review every few years. Individuals who have specific access to nuclear materials are on a program which requires more frequent reviews. This program is currently called the Personnel Security Assurance Program. It includes not only the investigations mentioned earlier but also medical evaluations and financial and debt reviews. Supervisory oversight in these cases is also more stringent than for those individuals who do not have access to nuclear materials.

Even though all cleared individuals might have access to nuclear materials, there are rigid controls established assigning specific individuals with specific responsibilities associated with material. A general principle which governs these responsibilities, however, is that no single individual will have the authority or the capability to compromise nuclear material. This has resulted in a two person rule which requires the presence of at least two people whenever significant amounts of these materials are accessed. This means that no single individual has possession of nuclear materials at anytime. In all these cases, however, there is usually one single individual who assumes primary responsibility. For example, for a storage vault there is a single individual who is assigned the vault custodian responsibility. That person is personally responsible for all activities within the vault. All of these activities, however, are carried out in concert with other individuals who are also authorized to access the materials. The scientists and the production workers who have access to the nuclear materials are managed by other individuals who share in their responsibility for the control of the nuclear material. In each organization there are specific management responsibilities to assure that all the nuclear material is maintained in its proper location. This management responsibility extends through the upper management in all the nuclear facilities. In addition to this oversight by the management at the nuclear facilities the DOE and the NRC also has oversight responsibility to assure both the safety and security of nuclear materials. There are also independent government organizations which conduct audits and evaluations to further provide confidence that the nuclear material is being used properly as well as being controlled and protected adequately.

PROCEDURAL ELEMENTS

Material surveillance procedures are implemented to assure that the material is used properly and that its security is not compromised. The two person rule discussed in the previous section is one of the primary material surveillance procedures which is implemented administratively. This same rule also applies to locks and combinations associated with securing materials. Additionally, historical logs are maintained to record who has had access to the nuclear materials.

Because of the nature of nuclear materials, many procedures are implemented to assure the safety of the workers as well as the surrounding habitat and personnel. These procedures also contribute significantly to the control of the nuclear materials. Such procedures include requirements to prevent criticality incidents, limit direct personnel exposure to materials and minimize contamination outside the immediate area in which the materials are handled.

The operations associated with processing nuclear materials are very sensitive to minor variations. As a result of this sensitivity many requirements established for very tight process control also contribute significantly to material control. Although these requirements are very dependent upon the process several guiding principles are followed. Because the material is very valuable, operations are established to minimize the loss of material from the process. Because the creation of radioactive waste results in significant economical problems, operational requirements are also established to minimize waste associated with the process.

Waste monitoring is implemented to detect theft or diversion of material utilizing the waste streams. It also provides a quality control measurement on waste to assure that inadvertent passage of material does not occur in these streams.

Lastly, all operations desire and strive to achieve economic operational efficiency which also adds to the control of the nuclear materials.

Even though stringent operational and safety requirements are adhered to, independent inventories are also conducted on a relatively frequent basis. During the course of these inventories high confidence is gained as to the quantities, types and locations of all nuclear materials. Daily administrative checks can also be performed and include a variety of detection capabilities depending on how the program is implemented. In general, these checks determine if unauthorized activities with the SNM has occurred or if other activities have occurred which could have safeguards significance.

All of these procedural elements are outlined in plans generated by the facilities. These plans then must be formally approved by the DOE or NRC. This approval process includes comparison of the plans to the established requirements as well as an overall evaluation of their effectiveness in controlling nuclear materials. Once the plans are approved the sites are then required to conduct their operations in accordance with those plans. The independent auditing organizations utilize these plans to confirm that the site is conducting their operations according to the approved plans.

TECHNOLOGICAL ELEMENTS

One of the most important elements associated with material control is material measurement. To establish how much and what type of material is being controlled with any degree of confidence we must first know what that material is. To this end, significant developments have occurred over the last 40 years to provide the best measurements possible. Of particular importance are accurate measurements relative to weight and isotopic composition of nuclear materials. The measurement techniques vary widely depending upon the type of materials being measured. For example, materials taken from a process may be in liquid form and therefore are very amenable to chemical analysis and characterization. On the other hand, materials assembled into an item may be more amenable to being measured by weight and nondestructive assay. The accuracy of such measurements varies considerably depending upon the type and form of the material. Under ideal conditions the

desired characteristics of the material can be characterized to within tenths of a percent. Under less than ideal conditions the accuracy is not nearly as good. The type of measurements impact the operations of the facility. As the United States moves from a processing regime to a storage regime there is a general tendency to prefer the nondestructive assay measurements as opposed to the chemical sampling methods.

The data acquired during the material measurement process is assembled into large computer based accounting systems. These systems also accurately keep track of the location of the material. When the accounting system is applicable to a bulk process, the accounting system becomes very sophisticated. In addition to containing the results of measurements, the accounting system also includes accuracy's associated with each measurement and thus through a statistical basis calculates limits of error and other such statistical measures associated with the material measurements. This allows the facility to create a quantified statistical confidence with respect to the amounts and types of materials that they possess.

Another element which is used in material control is called a tamper indicating device (TID) or a seal. These are devices which have a unique identity and are tamper resistant. It is difficult to either duplicate these devices or to modify them without a tamper indication. Normally each container of nuclear material has such a seal affixed. This seal is used to provide assurance that the container contents have not been compromised or modified. These seals are used during an inventory to minimize the number of samples measured. All of the containers in a particular storage area are examined to assure that the seal is in place and has not been tampered. A much smaller number of containers is removed from the area and are measured. A statistical evaluation is conducted to assure that high confidence in the results of the inventory is obtained. The TID neither alarms nor protects materials/containers to which it is applied. The use is that of an indicator (i.e., an indication of a potential covert violation of a container, vault, etc.), or as a possible deterrent to unauthorized opening or removal of a material container. There are a wide number of seals that can be used to protect nuclear material.

Areas containing nuclear materials are surrounded by at least one substantial boundary. Each of these boundaries utilizes a detection and assessment system to accomplish two primary purposes. The first is to detect unauthorized entrance into those areas. The second is to detect unauthorized removal of materials from these areas. We have a philosophy called Defense in Depth which requires multiple layers of detection to provide assurance that the material is intact and in it's proper location.

In the last several years techniques have been developed to actively monitor nuclear materials. The goal is to receive real-time information relative to both the authorized and unauthorized activities associated with the material. These systems monitor physical characteristics of the items being protected. Weight, radiation, temperature and other characteristics are monitored to provide assurance that the material is intact. These systems report to real-time monitoring stations so response can occur very rapidly when something anomalous occurs. Material monitors can detect a wide variety of activities that indicate something is happening to the material which may be part of a theft or diversion scenario. Specific material monitoring methodologies usually include either automated or direct observation approaches. Both approaches detect anomalies and report alarm conditions.

SUMMARY

Material control in the United States has evolved over the last 50 years. It began as part of the very restricted environment associated with the nuclear activities. As nuclear activities expanded, legislation was enacted and procedures as well as guidelines and laws were developed to control the nuclear material. Essential elements of the program include access control, surveillance, containment, detection/assessment as well as administrative aspects such as clearances to determine suitability for working with nuclear materials and specific assignment of material responsibilities. Many procedural elements are also in place. These are intended to provide material surveillance, assure safety of personnel, enable cost effective operations, and provide an independent means to assure that all procedures are followed and material is intact. There are also technological elements which provide for material control. Material is first accurately measured and then those measurements along with location data are stored in computer based accounting systems. Materials in storage as well as in operations are protected through the use of tamper indicating devices, intrusion detection systems and material monitoring systems. All of these elements are coupled together to assure that the material in the United States is under very positive control.

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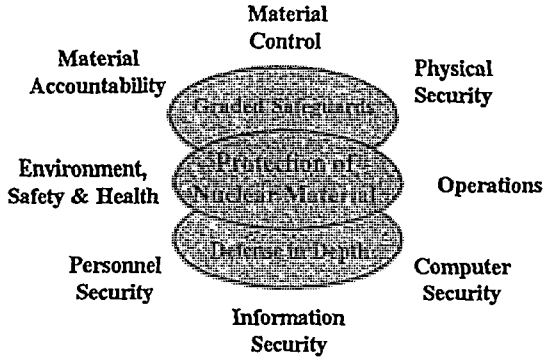
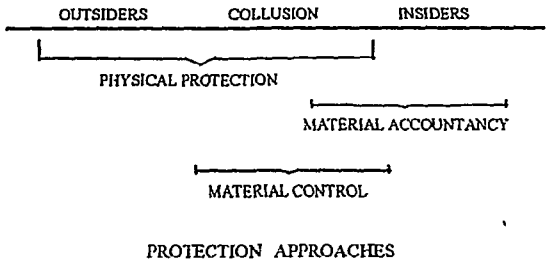


THREAT SPECTRUM



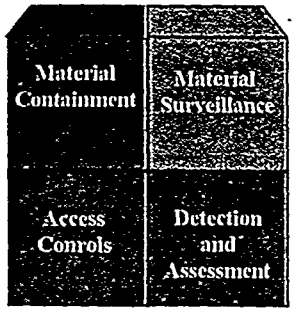
Why is nuclear material control important?

- Growing insider threat
- Possible risk from external adversaries
- Increased activities from nuclear disarmament
- Increased demands to meet environmental, safety and health requirements
- Limited resources to meet requirements
- Nuclear facilities being closed and decommissioned

Nuclear Materials Control Includes

- Responsibility for the nuclear material
- Vigilance over the nuclear material
- Governing the movement, location and use
- Monitoring the inventory and processing status
- Detecting unauthorized activities
- Investigating and resolving problems

Components of Material Control



Nuclear Materials Containment

Maintenance of nuclear materials in their authorized locations by establishing a series of boundaries at which unauthorized material movements can be detected.

Assists in compliance with health and safety and environmental requirements

Containment Elements

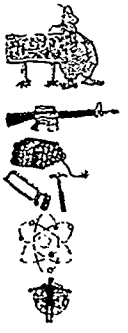
- Barriers - fences, walls, doors, ceilings
- Protected Openings
- Double locked steel door
- Flow of personnel/vehicles through designated portals.
- Defined boundaries for each integral process.
- Locks, safety protection equipment, glovebox
- Sealed containers
- Secure transfer carts/vehicles

Access Control

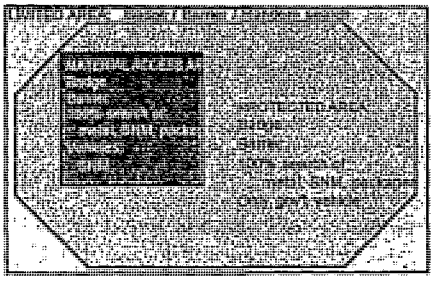
- Process of permitting authorized access or denying access to information, facilities, resources, or designated security areas.
- Controlling access to:
  - Nuclear materials accountability, inventory, and measurement equipment and data
  - Data generating equipment.
  - Other items, where misuse or tampering could lead to compromise of safeguards system.

Access Controls at Security Boundaries

- Done at multiple sequential boundaries
- Used for:
  - Personnel control
  - Contraband detection
    Guns
    Explosives
    Tools
  - Nuclear materials detection
  - Environmental monitoring



Access Control Defense-in-Depth



Procedural Components of Access Control

- Communications
- Against falsification or manipulation
- Alarm definition, response, resolution
- Detect/respond to unauthorized access
- Searches
- During emergency or other unusual conditions

Personnel Components of Access Control

- Personal identification
- Appropriate security clearances
- Personal security assurance program
- Need-to-know
- Passwords
- Enforcement
- Generate alarms
- Implement procedures

Equipment Components of Access Control

- Locks
- Biometrics
  - Hand geometry
  - Retina scan
- Access booth
- Badge readers
- Cameras

Material Surveillance

- Must be capable of detecting incorrect or unauthorized actions.
- Address the threat of unauthorized activities by personnel authorized access
- Serve as the the first detection mechanism.

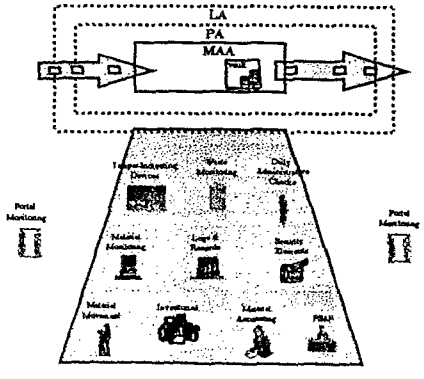
Material Surveillance Elements

- two-person rule,
- daily administrative checks,
- visual observation
- monitors and alarms
- digital image processing
- personnel tracking
- logs and records

Detection and Assessment

To detect and assess the unauthorized removal of nuclear materials, consistent with the graded safeguards concept, and interfaced with the facility's physical protection and other organizational systems.

Detection/Assessment Components



Portal Monitoring Detects:

- Unauthorized SNM removal
- Shielding to prevent SNM detection
- Contraband

TID's Provide:

- Indication of enclosure tampering during storage, transit, and sometimes in process.
- Cost-effective support for inventories and Daily Administrative Checks.
- Reduction of time-consuming measurements.
- Reduction in radiation exposure.

Material Monitoring Detects:

- A variety of anomalies associated with specific materials.
- Changes in characteristics, such as:
  Unique identification (Serial Number, TID)
  Movement (sensor or video)
  Attributes (mass, thermal, radiation)

Intrusion Detection Systems Detect:

- attempted or actual unauthorized access
- penetration through floors, walls, ceilings, and openings
- movement within the facility envelope