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ANNEX "A"

DOMESTIC SAFEGUARDS CONTROL

DIVISION OF NUCLEAR MATERIALS MANAGEMENT

AUGUST 27, 1965

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DOMESTIC SAFEGUARDS CONTROL

DIVISION OF NUCLEAR MATERIALS MANAGEMENT

I. Historical Background

The need for safeguards control of nuclear materials has been a prime consideration of the AEC ever since its inception. Indeed, the many deliberations which led to the Atomic Energy Act of 1946, and to the formation of the International Atomic Energy Agency, assume that safeguards control is mandatory, and from that starting point debate the pros and cons of one system versus another.

DNMM's domestic safeguards control system is patterned largely after the technological control plan proposed by Bernard Baruch, then the U.S. representative to the United Nations.(1) Although his plan, calling for international ownership and management of essential nuclear activities, was not accepted by the U.N., his concept of technological controls was recognized to be basically identical to the measures normally associated with sound management and operation, and is equally applicable to an inspection type control system.

> "Included, for example, are accounting for essential materials, taking of inventories, checking and improving analytical . . . methods, establishing proper sampling procedures . . . The reduction of unaccounted losses . . . and the determination of the cause of changes in such losses are no less a part of efficient operation than a means of preventing diversion of fissionable materials."(2)

The NMM system of domestic materials control has been reviewed on numerous occasions, both by AEC and outside consultants. The latest review, reported in 1962 by Stanford Research Institute, concluded that the requirements of the AEC's domestic system for control as applied to contract material are generally applicable to special nuclear material without regard to the method of distribution, i.e., by contract, by lease, or by sale.(3) (See Section III.)

(1) Baruch, Bernard M., "The International Control of Atomic Energy," vol. VI, "Technological Control of Atomic Energy Activities," October 1946, Government Printing Office.

(2) ibid, pg. 170.

(3) Kinderman, E. M. and R. R. Tarrice, "Review of AEC Nuclear Materials Management Systems," August, 1962 (Secret-Restricted Data).

II. Domestic Philosophy

A. Definition of Safeguards Control

The term safeguards control as used herein is defined to mean "A continuing quantitative knowledge of the physical location and authorized utilization of all special nuclear material." It includes such activities as recording and reporting transactions, inventories, and losses; maintenance of adequate internal control, measurement, and physical inventory procedures; prompt and accurate detection and measurement of losses and loss mechanisms; and the reduction of unaccounted for quantities.

However, taken in a broad sense, this definition encompasses many diverse activities. For example, it also includes activities such as those by the FBI or CIA to detect clandestine activities, and those by AEC and other security groups to prevent theft or diversion by establishment of physical barriers. In some measure it includes the efforts of health and safety experts to prevent the spread of radioactive contamination. Measures such as import and export controls, limitations on production, possession, or transfer imposed by United States law and regulation also are important to domestic safeguards control. The most important safeguards control activity, however, and the one considered primarily in this report, is the system of material control, with inspection, to assure that nuclear materials can be accounted for as assigned to authorized facilities and utilizations.

This definition of safeguards control differs from the generally accepted international definition in several respects. First, the DNMM definition makes no mention of safeguarding equipment. No attempt is made to verify that a shutdown reactor remains shutdown, or that an experimental reactor is not used for experiments related to the improvement of nuclear weapons technology. However, in general, both of these controls are achieved indirectly through

the important requirement that all nuclear material be subject to the domestic safeguards control system.

Second, DNMM considers safeguards control in the context of authorized utilization rather than to peaceful use. This is because, from the U.S. point of view, the theft or unauthorized diversion of nuclear materials for clandestine weapons production is to be prevented or detected regardless of whether the source of the material is a peaceful application or an authorized AEC weapons production operation. A suspected theft of plutonium would be of serious concern, whether it came from AEC's Savannah River plant or from the privately financed NFS plant.

B. Basic Elements

Safeguards control as developed and implemented by the Division of Nuclear Materials Management is comprised of three essential interrelated components. The first is an information system of records and reports through which all material subject to control is accounted for by actual physical location. The second is a system of routine office review of all documents of transfers of SNM and of all periodically reported material balances, and the third is a system of periodic surveys or inspections to verify reported data and to assure that actual material usage is in accord with authorized activities.

It is worth emphasizing that safeguards control cannot be effective if any of these components is operated independently of the other, or if one component does not exist. The most carefully designed information system is meaningless unless data can be monitored and evaluated as reported, and then verified by actual inspection, and unless assurance can be obtained by actual inspection, that material is not being used for unauthorized purposes. On the other hand, the most rigorous inspection provides assurance only concerning the records audited and the material actually inspected, and is of little

value unless an information system exists to establish that all significant quantities of material have been offered for inspection.

To achieve coordinated safeguards control, the AEC requires that:

1. Both shipper and receiver independently advise AEC of all physical transfers;
2. All persons or facilities holding nuclear materials maintain appropriate records of their inventory, transactions, and losses and submit periodic material balance reports summarizing the same;
3. All facilities take and report periodic physical inventories;
4. At least the major fabrication and processing facilities submit, and maintain current, written descriptions of their material accounting, internal control, processing and measurement procedures; and
5. The AEC have the right to audit all pertinent records, to inspect the material, and to take samples where feasible.

C. Discussion

There is a general presumption in the U.S. that most American citizens are honest and loyal to their country. Thus it is generally assumed that while theft or diversion could occur as the action of a single person or as the organized activity of a relatively small group of people, diversion is not likely to occur as a management directed activity of any company, or as an organized activity of a group of companies.

This presumption, however, is not essential to the DNMM philosophy of safeguards control. Rather, the DNMM program of safeguards control is predicated on the philosophy that independent objective controls do not depend upon any assumption of honesty and loyalty, on the part of either individuals or companies, to achieve its objectives. Even if a philosophy prevailed that diversion might be

an organized company policy, few, if any, changes would result in the approach set forth herein. However, it should be clear that the depth of inspection would be increased to counteract the added risk of company malfeasance.

The concept that all known quantities of material must be subject to control, however, is most important. If all known material can be accounted for, then there is some assurance that no clandestine facilities are operating. On the other hand, if large quantities of material not subject to safeguards are known to exist, then the task of the safeguards inspectors can be considerably more difficult, perhaps even impossible.

III. Distribution of Material

The basic concept of safeguards control is, of course, independent of the financial or legal basis for ownership or physical possession. The requirements enumerated in Section B above, however, must be stated by regulation, contractual document, or mutual agreement. Thus, current authorities and responsibilities are keyed to the specific documents which authorize possession, and which define the rights of the AEC to require safeguards control procedures. The most important means by which a person may acquire special nuclear material are:

a. under the terms of an AEC cost-type contract;

? b. under the terms of an AEC contract (fixed price) which requires assumption of financial liability for losses;*

c. under the terms of an AEC Supply Agreement which requires payment of a use charge and assumption of financial liability for losses;

d. under the terms of an AEC Lease Agreement which requires payment of a use charge and assumption of financial liability for losses;*

*Both use charges and payment for losses are subject to specific waiver and in many instances are waived. For example, loss payments occasionally have been required only to the extent losses exceeded some arbitrary percentage, often 0.5 or 2.0%.

e. under the terms of an AEC Interagency Loan Agreement which requires assumption of financial liability for losses;*

f. under the terms of an AEC Educational Institution Loan Agreement which requires assumption of financial liability for losses;*

g. by production in a nuclear reactor;

h. by purchase, from the AEC or from whoever has material for sale; and

i. under a lease or sale agreement executed pursuant to U.S. bilateral or multilateral agreements, including the U.S.-Euratom agreement, and the agreement with the International Atomic Energy Agency.

Contractual documents in categories a., b., and c. define AEC's rights in regard to safeguards control, and responsibility for implementation has been assigned to DNMM.

DNMM has responsibility to accumulate and verify for financial purposes material quantity data submitted pursuant to lease/loan agreements (categories d., e., and f.), including the right to perform on-site inspections. These documents typically permit physical possession by other than the lessee, however, and inspection rights at these third party facilities are not clearly defined. Also, it should be noted that responsibility and authority for enforcing corrective action under categories b. through f. is less than clear.

DNMM has no assigned responsibilities in connection with categories g., h., and i. As a practical matter, however, production of special nuclear material in domestic reactors is verified as part of the financial quantity data inspections performed over leased material.

Special nuclear materials subject to safeguards control by DNMM are located at more than 200 different sites, with the value of the material

*Both use charges and payment for losses are subject to specific waiver and in many instances are waived. For example, loss payments occasionally have been required only to the extent losses exceeded some arbitrary percentage, often 0.5 or 2.0%.

at the individual sites ranging from a few thousand dollars to several hundred millions of dollars. The types of operations in which these materials are used include the gaseous diffusion plants; reactors for production of plutonium, trititum, U-233, and Pu-238; fabrication of weapons; fabrication of fuel elements; power reactors; chemical recovery plants for both irradiated fuel elements and cold scrap; and research and development facilities ranging from small university programs to large national laboratories.

IV. Materials Subject to Control

The Division of Nuclear Materials Management administers an information system which encompasses all AEC-owned SS material* in the United States. Privately-owned special nuclear material currently is included as a memo balance only and implementation of private ownership will result in loss of control unless existing regulations are changed. No information is available to DNMM on privately-owned source materials. The DNMM information system does not detail the location of special nuclear materials distributed abroad, but does indicate the total amounts distributed and returned, by country.

As of December 31, 1964, the total special nuclear material recorded in the DNMM information system had a dollar value of $4.65 billion. Of this total $4.49 billion was subject to DNMM safeguards control, and an additional $87 million was controlled by DNMM through the verification of financial quantity data. As of the same date, the dollar value of other SS material in the DNMM information system was $1.51 billion, of which $1.45 billion was controlled by DNMM. DNMM inventory control procedures covering these other SS materials provide assurance against significant unrecognized loss or diversion comparable to that provided for special nuclear material under safeguards control. (None of these dollar values include material transferred to the DOD pursuant to Section 91b of the AE Act, which material is not subject to AEC safeguards control.

*"SS material" is a generic term used to refer to source material (natural and depleted uranium and thorium) special nuclear material (U-233, uranium enriched in the isotope U-235, and plutonium) and other materials controlled by DNMM (enriched lithium Li-6, deuterium, tritium, and neptunium-237).

Also excluded is $19 million of special nuclear material sold/bartered to the UK which is not subject to AEC safeguards.)

V. DNMM Safeguards Control Program

A. Information System

In order for the would-be diverter to escape detection, he must create the appearance (1) that he never received the missing material, (2) that he shipped the missing material to someone else (including discard to waste), (3) that the material in question is still on inventory, or (4) that the material was discarded or lost. In all but the most highly organized diversion activities, the first two of these four modes of concealment are guarded against by a requirement that both shipper and receiver independently report the physical transfer to a safeguards control information system. Wherever feasible, both shipper and receiver are expected to measure the quantity of material transferred and to report the results of their measurement, regardless of any contractual agreement as to the data to be used for financial purposes.

Within the United States, two standard transfer forms are in use. Form AEC 101 is used to document the transfer of material between AEC contractors (see Appendix A). Form AEC 388 is used to document the transfer of material between an AEC contractor and a lessee, or between two lessees (see Appendix A). No form has yet been prescribed for the documentation of transfers of privately-owned material. Staff discussions are in process, however, to require that all transfers be documented on a revised Form AEC 101, regardless of the legal or financial conditions associated with the transaction.

These transfer forms are used by the AEC as the basis of a system of records capable of showing at all times exactly how much nuclear material should be on hand in each facility. Semi-annually as of December 31 and June 30, each facility is required to report a summary material balance showing quantities received, produced, shipped, lost or consumed, and physically on hand. Form AEC-577 (or comparable) is used by AEC contractors to report their material balances, and Form AEC-578 is used by lessees (see Appendix A). Differences between

quantities reported and those on the AEC records are reconciled.

Work is now well underway to accumulate all transfer and report data on EDP equipment at Oak Ridge.

It is not expected that the information system of itself would detect theft or diversion. However, by the insistence on independent measurement and transfer reports by both shipper and receiver the information system introduces a significant element of difficulty into any would-be diversion effort. It also serves as a basis for the office review and inspections described below.

B. Routine Office Review System

A continuing office review is made of all transfer and report data. The review would be expected to detect such an anomaly as a U-235 content which does not agree with the stated enrichment, a plutonium production which was not consistent with the known reactor power output or U-235 consumption, or a transfer involving an illogical quantity of material or an illogical second party.

Where both shipper and receiver have measured the quantity of material transferred, the shipper-receiver differences are analyzed using statistical techniques wherever appropriate. Likewise, periodic material balance reports are analyzed to determine the reasonableness of the reported normal operational losses and discards of materials and to determine that the amount of material reported as unaccounted for is not excessive. The analysis further establishes from the related composition of inventory report whether an excessive accumulation of scrap or other difficult-to-measure materials has occurred.

Any of these factors may signal the need to schedule the next inspection on an accelerated basis, or the item in question may be noted for a more thorough investigation during the next inspection. Procedure manuals and personal knowledge of the investigator as to the technical processes used at various facilities are invaluable assets in recognizing the need for further investigation of reported data.

C. Surveys or Inspections

1. Frequency. Clearly, no safeguards control system can be effective unless it includes periodic inspections of at least all significant quantities of special nuclear material. DNMM requires that major facilities subject to its control be inspected at least once every 12 months. Lesser facilities, defined as those having less than $150,000 dollar value of inventory, or flow of less than $500,000 per annum, are not exempt from inspection, but may be inspected less frequently. As a special case, nuclear power reactors are inspected on a frequency of approximately 15-18 months.

2. Team Composition. Because of the highly technical nature of such diverse and complex operations as are found at laboratories, fuel fabrication plants, reactors and spent fuels processing facilities, each inspection is performed by a team of people trained in the professions appropriate to the inspection mission, such as, reactor technologists, statisticians, physicists, chemical engineers, chemists and auditors. The actual size and professional makeup of the inspection team, the scope and the details of the various measurement, audit and statistical tests will vary with the type, size, and complexity, as well as the numbers and types of transactions performed by the facility being inspected.

3. Scope. For inspections to be effective in detecting diversion, the following elements are essential:

   a. all facilities possessing material are subject to inspection. Those possessing minimal quantities are not inspected routinely, but randomly selected facilities are checked. Facilities processing large quantities of material are subject to routine periodic inspection;

   b. inspection teams receive from the information system, and verify at the site, an up-to-date material balance;

c. inspection teams verify the site physical inventory, by observation and testing, as necessary and appropriate; and

d. for major facilities, inspection teams have available and verify by direct observation and testing, written procedures describing how materials are handled and accounted for at the facility, and in particular, describing how quantity measurements are performed. This requirement of written procedures is generally enforced at larger and more complex facilities, and is absolutely essential at major fuel fabrication and reprocessing sites.

4. Reports. The findings and recommendations resulting from each inspection are reported in some detail to AEC management, in the form of written reports. Corrective action is obtained through contract channels.

The maximum quantity which can be diverted from any given facility without detection is a function of a number of factors, an important one of which is the degree of material control exercised by that facility. DNMM places considerable emphasis on encouraging facilities to improve their internal material control. By including recommendations and suggestions for improved material control in its reports, DNMM believes that the limit of detectable diversion is gradually reduced.

VI. Field Inspection Procedures

Notwithstanding the wide variations that exist between individual inspections, certain types of examinations are always performed. A statement of the objective of each, together with a brief description used to attain the objective, is contained in the succeeding paragraphs. To ensure that no essential inspection procedure is omitted, several inspection programs or check lists have been developed for use by AEC inspection teams. (Appendix B).

It should be noted that DNMM's inspection procedures are designed to achieve the maximum assurance with a finite number of inspectors. It is true, for example, that increased inventory testing would in large part eliminate the need for a review of measurement procedures. Manpower requirements, however, would be greater. DNMM believes that it has achieved a reasonable balance between inspection team size, duration of inspections, and degree of assurance obtained.

A. Physical Inventory Verification

> The objective of the physical inventory verification is to obtain an independent opinion by inspection personnel as to the validity of stated inventory quantities, including the element and, where appropriate, the isotopic content, as distinct from merely ascertaining that containers, items, or gross weights are present.

The physical inventory verification is the most important single element in DNMM's safeguards control inspection, and considerable effort is expended to ensure that the resultant physical quantity data is as accurate as is feasible.

At the outset it should be noted that DNMM inventory verification procedures do not provide for "taking or conducting a physical inventory" in that the plutonium or uranium and U-235 values are not independently established by the AEC for all items and quantities on hand. Such actions as a practicable matter, are infeasible if not impossible except in installations where the material quantities are insignificant and the form is easily samplable.

For major facilities, DNMM attempts to schedule its inspection to coincide with the time the facility has scheduled for its physical inventory. By doing this, the AEC is able to observe the techniques used at the facility and thus to obtain additional assurance that such procedures are adequate to produce an accurate inventory.

The actual techniques used will vary from facility to facility and will depend upon many circumstances, the most important of which is the chemical or physical form of the material being inventoried. Due to the limitations of time and space, it is not possible to describe herein the precise DNMM inventory verification techniques to be followed on each inspection, nevertheless it is possible to describe the general approaches:

1. Obtain a complete listing of all material in a facility. This may be done by accepting a listing from the facility, participating in its preparation, or preparing such a listing in its entirety. Generally, it is not practicable for the AEC even to list the entire inventory except at relatively small research installations or at reactor facilities where the number of inventory line items is small and the material is relatively static. A recent physical inventory at United Nuclear -- Fuels Division was completed in a period of about 10 hours by 24 contractor personnel accompanied by 7 AEC inspectors. Subsequent inventory testing required approximately 6 additional man days of AEC effort.
2. Test selected inventory items for accuracy of quantity data. Normally a statistical sampling plan is used which will provide the degree of assurance which the inspection team leader wishes to achieve. This plan takes into account the form of material and its amenability to identification, weighing, sampling, and analysis. When materials such as fuel plates or rods are not subject to destructive sampling, nondestructive methods are available. Typically, the inspection team will:

a. verify in total or by random selection that the items on the inventory listing are represented by containers; conversely, determine that all containers in the plant are listed on the inventory.

b. where possible, check weigh, sample and analyze, both chemically and isotopically, the selected items.

c. where the material is not subject to the direct tests in b., nondestructive methods such as gamma spectroscopy are used if the material is suitable. For material in heterogeneous scrap, reactors, etc., verification is accomplished indirectly through such techniques as use of data accumulated through the review of the process and the measurement system and examination of reactor operating records. (Because a high percentage of special nuclear material is contained in these kinds of inventories, DNMM places a high degree of importance on these aspects of verification.)

3. Compare the results of the tests with the data recorded on the inventory list; extend and total all items; and compare total to the audited total which was supposed to be on hand.

B. Audit of Material Records and Reports

> The objective of the audit of material records and reports is to evaluate the integrity and accuracy of the materials accounting records and the correctness of the material balance reports prepared therefrom.

The records audit will include a comparison of shipments and receipts as reported in the information system with those recorded in the facility's transfer journal and general ledger. However, since both the AEC information system records and the facility's external transfer records represent essentially one set of data, an important objective of the records audit team is to establish the internal consistency and accuracy of the facility's record. Among other tests, recorded receipts or shipments are compared to internal receiving or shipping

reports prepared in the appropriate department; laboratory analytical reports are compared with reported material analyses; and internal material transfers are traced and verified. The records audit should substantiate a detailed statement, by internal material balance areas, of the quantities of nuclear material which should be on hand.

The records audit at a major processing facility generally requires 5-10 man weeks; only at those non-processing facilities where the inventory is fairly small or static is the audit completed in much less than one man-week.

C. Review of Measurement Procedures

> The objective of the review of measurement procedures is to evaluate the adequacy of the techniques of weighing, sampling, chemical and isotopic analyses, and calculations of reactor materials production and consumption.

Since the DNMM inspection relies heavily on test checks, the review of the measurement system provides valuable evidence on which to base decisions concerning levels of testing. If, for example, the facility's weighing techniques are such that large errors occur with an unacceptable frequency, then that portion of the inventory dependent upon such techniques would be subjected to an increased level of testing.

The review of measurement procedures indicates whether shipper-receiver measurement data can be accepted as evidence of the true quantity transferred. In particular, the review will indicate where the receiver is in fact not measuring the material transferred, but rather is accepting shipper's data.

The accuracy of internal measurements is reviewed as an aid to localizing losses and because such measurements normally are the basis of much of the physical inventory data. Thus evaluation of internal measurements is essential to form an opinion concerning the inventory. The review of measurement data also is essential to the elimination or reduction of biases. Biased analytical procedures

can hide the loss of large quantities of material, or can cause it to appear that large losses have occurred when in fact they have not. The following may be noted as the most commonly used reviews and tests:

1. a review of scales or other weighing equipment, not only for accuracy at the time of checking, but to determine the manner and frequency with which they are checked routinely;
2. a review of tank calibration data for accuracy, frequency, and manner of testing;
3. a review of sampling techniques;
4. a comparison of analytical procedures with those published as standard methods of known accuracy; and
5. a review of waste monitoring techniques as an adjunct to the review of losses and loss mechanisms.

The review of calculations of reactor nuclear loss and production is an especially important measurement review, because such calculations are the only basis for checking dissolver measurements at chemical processing plants. The calculations thus maintain the concept of independent measurements by both shipper and receiver.

Measurement reviews may require from a few hours to a few days to complete. Often not all measurement points are reviewed during each inspection, especially where procedures are known from past inspections.

D. Review of Internal Control Procedures

> The objective of the review of internal material control procedures is to evaluate the extent to which the facility has installed and maintains a system of checks and balances in the division of duties, designed so that the work of one person serves to verify the work of another.

The interdependence of work functions and of documents contributes the most important features of internal control. The presence or absence of these characteristics of management direction has a significant influence on the scope and depth of each inspection. The internal control review is made as early in the inspection as practicable to

achieve the maximum benefit in terms of possible modifications to the overall inspection program. During the subsequent course of the inspection each inspector is alert to variances from the internal controls required by facility management and to whether his recorded observations support the internal controls as he understood them.

Some of the more useful approaches to reviewing and evaluating internal control warrant mention. The obtaining of an organization chart is essential. Inspectors identify those in a position to influence the activities pertaining to the material. Associating individuals with positions and qualifications with individuals is helpful. Flow charts, both of nuclear materials and of related documents and records, are revealing and have an influence on the direction and scope of inspection efforts. Brief descriptions of major programs involving nuclear materials assist inspectors during their field activities.

A series of questions relating to the interdependence of facility personnel and documents is formulated to be asked of management (Appendix B). The replies are recorded and referred to during the inspection, and are compared to replies made to the same or similar questions during prior inspections.

Alert, progressive organizations will already be using many internal control techniques as tools of management. To the extent that these techniques are identified and confirmed by inspectors, the latter usually may apply less effort to those areas, thereby freeing themselves for more intensive review of those areas not bounded by suitable controls.

E. Use of Mathematical Statistics

The objective of the review of statistical procedures used by facility personnel, and of the use of the techniques of mathematical statistics by the inspection team is to define as quantitatively as possible the results of the inspection, so that consistent levels of inspection can be maintained, and so that maximum utilization can be made of the available inspection data.

Historically, considerable discussion has been devoted to the question of what constitutes a significant diversion, and to the possibility of designing a statistically controlled safeguards system which would have a stated probability of detecting diversion of that quantity while maintaining an acceptable risk of false accusation.[4,5] DNMM prefers to consider the powerful techniques of mathematical statistics to be tools to aid trained and experienced inspectors in making informed judgments. Thus while diversion of slightly less than the amount specified in such a hypothetical system would not trigger the statistical control, it undoubtedly would arouse the suspicions of the trained inspector, and would signal the need for an increased level of inspection effort.

Among the many possible statistical techniques, the following may be mentioned as being of primary value:

1. The use of sampling plans to define the levels of risk involved in performing less than 100% testing. Sampling plans are nearly always used in inventory verification; less frequently they are used in other areas of the inspection, such as in connection with sampling internal records for audit testing.
2. The use of techniques for combining limits of error for individual measurements to estimate the probable uncertainty in the total material balance.
3. The use of Shewhart control charts and related techniques to compare current data with past experience.

Mathematical statistics can also be a powerful tool to the management of complex nuclear facilities. Where such procedures are used, the DNMM inspection team reviews such use to assist in determining needed AEC tests.

(4) Bennett, C. A., et al., "Control and Inspection Systems for Plutonium Production," HW-62119, October 1959 (OUO)

(5) Drukey, D. L., "Final Report under Phase III of the Nuclear Materials Control System," Ramo-Wooldridge, Canoga Park, California (Dec. 1960).

F. Losses and Loss Mechanisms

> The objective of the review of losses and loss mechanisms is to evaluate known losses and form an opinion concerning the probable disposition of unaccounted for quantities.

Although the determination of the quantity of material lost is an essential part of any safeguards control inspection, it is not sufficient to stop with a simple evaluation of the magnitude of this loss. Equally important is the review of loss mechanisms. Any large processing plant will, from time to time, experience spills, leaks, or other process accidents which result in higher than normal losses over a short period of time. Losses may also be abnormally high during the development of new processes.

DNMM inspections include an observation of actual processing operations, to identify and evaluate potential loss mechanisms. As one example, an inspector reviewing a machining operation would inquire as to losses to the machining coolant. If the coolant is filtered and discarded, he would arrange to sample current material as an indication of the validity of recorded discards. He would also inspect the filter, attempt to estimate the amount of material accumulated therein, and establish the disposition of used filters.

Historical data is maintained on losses, including records of explanations of unusual losses, as a basis for the evaluation of current loss data. Unusually low losses are as important as unusually high losses; they sometimes signal the need for a re-examination of inventory or measurement data.

APPENDIX A

SAMPLE TRANSFER AND REPORT FORMS

Form AEC 101

Form AEC 388

Form AEC 577

Form AEC 578

Form AEC-161 (Rev. 8-66)
U.S. Atomic Energy Commission
AECM-7401

NUCLEAR MATERIAL TRANSFER DOCUMENT

1. TRANSFER NO.

4. No.	DISTRIBUTION of COPIES
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	

2. SHIPPER'S FACILITY CODE _____
Name
Address

3. RECEIVER'S FACILITY CODE _____
Name
Address
Attention

5. SHIPPED FOR ACCOUNT OF (Facility Code) _____
Name
Address

6. SHIPPED TO ACCOUNT OF (Facility Code) _____
Name
Address

7. MATERIAL TRANSFERRED IS: (Check if applicable)

	Shipper	Receiver
a. Under Supply Agreement with AEC	( )	( )

8. THIS TRANSFER:
a. Initiates or Alters Financial Liability to the AEC ( )
b. Does Not Initiate or Alter Financial Liability to the AEC ( )

10. TRANSFER AUTHORITY:

9. DOCUMENTATION (If document is classified)
a. Page ____ of ____ Pages
b. Copy ____ of ____ Copies
c. Series _____

11. MATERIAL TYPE AND DESCRIPTION

12. a.*

(Signature of Receiver's Authorized Representative)

12. TRANSFER DATA

a. The Quantities Listed Below Were Shipped On _____ 19____

(Signature of Shipper's Authorized Representative)

*FOR OTHER THAN AEC COST-TYPE CONTRACTORS, COMPLETION OF BLOCK 12. a. CONSTITUTES ACCEPTANCE OF THE DATA IN BLOCK 12. IF THE RECEIVER INTENDS TO CONTEST THE DATA, BLOCK 12. a. SHOULD NOT BE COMPLETED AND THE SHIPPER SO NOTIFIED.

AEC COST-TYPE CONTRACTORS MUST SHOW THEIR RECEIVER'S DATA IN BLOCK 13.

b. Weight Units

c. From-AEC Project No.

b. To-AEC Project No.

c. Date Material Received

d. Lot & container no.	e. Gross weight	f. Net weight	g. Element weight	h. Weight % isotope	i. Isotope weight	d. Gross weight	e. Net weight	f. Element weight	g. Weight % isotope	h. Isotope weight

890-885

U.S. GOVERNMENT PRINTING OFFICE : 1966 OF—741-488

Form AEC-388
(Rev. 11-60)
Supersedes Form AEC-388 (1-60)

UNITED STATES ATOMIC ENERGY COMMISSION

SS MATERIAL TRANSFER FORM—LEASED MATERIAL

1. Transfer Series: A. _____ (From) B. _____ (To) C. _____ (Number)

2. Shipped by (*Shipper*):
Name _____
Address _____

3. Shipped to (*Receiver*):
Name _____
Address _____

4. Shipped for Account of: Lic. No. _____
Name _____
Address _____
Lease No. _____

5. Shipped to Account of: Lic. No. _____
Name _____
Address _____
Lease No. _____ Order No. _____

6. (For AEC Use Only):
Nuclear Material Draft (Form AEC-437)
Number _____

7. SS Material (Check One):
(A) Enriched Uranium ( )
(B) Uranium-233 ( )
(C) Plutonium ( )
(D) Other _____ ( )

8. Material Description:

9. This Transfer Involves:
(A) Initiating lease responsibility ( )
(B) Transfer of lease responsibility ( )
(C) Return to AEC for credit ( )
(D) No change in lease responsibility [Transfer of material only] ( )

10. Material Quantities: A. Weight Units _____

B. Container No.	C. Piece Count	D. Gross Weight	E. Tare Weight	F. Net Weight	G. Element Weight	H. Weight % Isotope	I. Isotope Weight
Totals							

11. The Items and Quantities Listed Above Were Shipped
On _____ 19____

(Shipper's Signature)

12. The Items and Quantities Listed Above Were Received
On _____ 19____

(Receiver's Signature)

Instructions to Licensees for the Preparation and Distribution of Form AEC-388
(SS Material Transfer Form—Leased Material)

GENERAL

The Form AEC-388 (Rev. 11/60) is prescribed for use by licensees to record physical transfers of materials held under lease from the Atomic Energy Commission. The completion and use of this transfer form is not to be considered as authorization to ship leased materials. The form is considered as a transfer record and receipting document necessary to support the Form AEC-570 (Material Status Report) which is required of licensees.

Upon initiating a shipment of material, the shipping licensee will prepare Form AEC-388 in the manner indicated below:

1. A—Enter the license number of the shipping licensee.

   B—Enter the license number of the licensee receiving physical custody of the material, or the SS station symbol of the AEC facility receiving physical custody of the material.

   C—Enter the shipper's number identifying the shipment. Numbers should be assigned in consecutive order by shipments so that any misplaced shipping form will be evidenced by a break in the series of numbers.
2. Enter the name and address of the shipping licensee.
3. Enter the name and address of organization facilitating physical custody of the material.
4. Enter name, address, and lease number of licensee that has lease responsibility for the material being shipped.
5. Enter name, address, license number, and lease number of organization assuming lease responsibility for the material being shipped; also the applicable order (Form OR-640) number, if available.
6. Do not make entry in this block.
7. Self-explanatory.
8. Enter concise description of material, using chemical formulae. When material is being returned to the AEC for credit in a nonstandard form or specification, the licensee must include in this block a reference to the AEC election to accept such material for credit.
9. Do not make entry under 9A. Item B, C, or D should be filled out by licensee as applicable.
10. Complete items 10(A) through 10(P) as appropriate. Items 10(G) and 10(I) must be completed in metric units, showing the weight of contained element and isotope based on the weight percent isotope shown in item 10(H).
11. Self-explanatory.

Distribution of Form AEC-388—By Shipper:

Copies 1, 2, 3, and 4: Mail to Receiver.

Copy 5: Mail to AEC Material Leasing Office
Oak Ridge Operations Office
U.S. Atomic Energy Commission
Oak Ridge, Tenn.

Copy 6: To be retained by Shipper.

Upon receiving a shipment of material, the receiving licensee will insert the date of receipt of the material and sign all copies of the form in the space indicated in item 12.

Distribution of Form AEC-388—By Receiver:

Copy 1: Mail to AEC Material Leasing Office
Oak Ridge Operations Office
U.S. Atomic Energy Commission
Oak Ridge, Tenn.

Copy 2: Mail to Division of Licensing and Regulation
U.S. Atomic Energy Commission
Washington 25, D.C.

Copy 3: Mail to Shipper.

Copy 4: To be retained by Receiver.

Notes: 1. If the receiver proposes to contest the accuracy of the data appearing on the Form AEC-388, Item 12 should not be completed. In such cases, the receiver should immediately notify the shipper and the AEC, Material Leasing Office of the claimed discrepancy.

2. Licensees are not required to report transfers of special nuclear material to another licensee or to the Commission, for disposal, if the material is contained in waste and if the material has been declared to the Commission as "consumed" by a licensee. Licensees are required to report all other transfers of special nuclear material, even though the Commission may have been paid the full value therefor. In such cases the following statement should be inserted in Item 8: "Full value paid to AEC."

U.S. GOVERNMENT PRINTING OFFICE 16—70823-2

Form AEC-877
Rev. 4-63
PREVIOUS EDITIONS ARE OBSOLETE

U.S. ATOMIC ENERGY COMMISSION
MATERIAL BALANCE REPORT

(SS Material) (Symbol) (Unit)

MONTH OF 19 (SS Station or Field Office Name) FISCAL YEAR TO DATE

(Total Element)	(Isotope)		(Total Element)	(Isotope)
		1. Beginning Inventory		
		RECEIPTS		
		2. Procurement—Raw Materials		
		3. —Other		
		4. Production		
		5. DOD Returns—Use A		
		6. —Use B		
		7. —Other Uses		
		8. From Other SS Material Balances		
		9.		
		10. Field Office —Albuquerque		
		11. —Brookhaven		
		12. —Chicago		
		13. —Cleveland SMPO		
		14. —Division of International Affairs		
		15. —Division of Nuclear Materials Mgt.		
		16. —Division of Raw Materials		
		17. —Grand Junction		
		18. —Idaho		
		19. —Materials Leasing Office, ORO		
		20. —New York		
		21. —Oak Ridge		
		22. —Pittsburgh Naval Reactors		
		23. —Richland		
		24. —San Francisco		
		25. —Savannah River		
		26. —Schenectady Naval Reactors		
		27.		
		28. TOTAL RECEIVED		
		29. TOTAL TO ACCOUNT FOR		
		REMOVALS		
		30.		
		31. Expended in Space Programs		
		32. Sales		
		33. DOD—Use A		
		34. —Use B		
		35. —Other Uses		
		36. Expended in AEC Tests		
		37. Routine Tests (Albuquerque and San Francisco)		
		38. Nuclear Loss		
		39. Decay		
		40. Shipper-Receiver Difference		
		41. To Other SS Material Balances		
		42.		
		43. Field Office—Albuquerque		
		44. —Brookhaven		
		45. —Chicago		
		46. —Cleveland SMPO		
		47. —Division of International Affairs		
		48. —Division of Nuclear Materials Mgt.		
		49. —Division of Raw Materials		
		50. —Grand Junction		
		51. —Idaho		
		52. —Materials Leasing Office, ORO		
		53. —New York		
		54. —Oak Ridge		
		55. —Pittsburgh Naval Reactors		
		56. —Richland		
		57. —San Francisco		
		58. —Savannah River		
		59. —Schenectady Naval Reactors		
		60. Accidental Losses, Normal Opnl. Losses, Write-offs & MUF		
		61. TOTAL REMOVALS		
		62. ENDING INVENTORY		
		63. TOTAL ACCOUNTED FOR		

Prepared by (Signature) Date Approved by (Signature) Date

☆ U.S. GOVERNMENT PRINTING OFFICE : 1965 OF—685369

Form AEC-578
(Revised 1-59)

UNITED STATES ATOMIC ENERGY COMMISSION

MATERIAL STATUS REPORT

Form Approved
Budget Bureau
No. 38-R114

FOR SPECIAL NUCLEAR MATERIALS HELD UNDER LICENSE
PREPARE A SEPARATE REPORT FOR EACH LICENSE

1. REPORTING LICENSEE:
   a. Name _____ c. License No. _____
   b. Address _____ d. Period Ending _____

2. MATERIAL: *(Prepare separate report for each material)*	3. WEIGHT UNIT	4. TOTAL QUANTITY AND ISOTOPE DATA	
		a. GRAMS	b. ISOTOPE
5. BEGINNING INVENTORY:			
6. RECEIPTS:			
From	Shipper's License No.		
7. TOTAL RECEIPTS			
8. PRODUCTION			
9. MATERIAL TO BE ACCOUNTED FOR *(Total of lines 5, 7, and 8).*			
10. SHIPMENTS:			
To	Consignee's License No.		
11. TOTAL SHIPMENTS			
12. PROCESSING LOSSES, DISCARDS, ETC.:			
a. MATERIAL FOR WHICH THE REPORTING LICENSEE IS FINANCIALLY RESPONSIBLE			
b. MATERIAL FOR WHICH THE REPORTING LICENSEE IS NOT FINANCIALLY RESPONSIBLE			
13. BURN-UP			
14. ENDING INVENTORY			
15. MATERIAL ACCOUNTED FOR *(Total of lines 11, 12a, 12b, 13 and 14).*			
16. DETAIL OF ENDING INVENTORY:			
a. MATERIAL ON HAND FOR WHICH REPORTING LICENSEE IS FINANCIALLY RESPONSIBLE TO THE AEC UNDER ABOVE LICENSE.			
b. MATERIAL ON HAND FOR WHICH SOMEONE OTHER THAN REPORTING LICENSEE IS FINANCIALLY RESPONSIBLE TO THE AEC *(Detail below)*			
Name	License No.		
c. Total of a. and b.			
17. MATERIAL IN POSSESSION OF OTHERS FOR WHICH REPORTING LICENSEE IS FINANCIALLY RESPONSIBLE TO THE AEC UNDER ABOVE LICENSE *(Detail below)*			
Name	Possessor's License No.		
TOTAL			

COMPOSITION OF ENDING INVENTORY

FORM OF MATERIAL	ELEMENT	% OF ISOTOPE CONTAINED	ISOTOPE	REMARKS
18. COMPOSITION OF ITEM 14a.				
TOTAL				
19. COMPOSITION OF ITEM 14b.				
TOTAL				
20. TOTAL INVENTORY ON HAND *(Total of Items 18 and 19).*				
21. COMPOSITION OF ITEM 17.				
TOTAL				

22. TO THE BEST OF MY KNOWLEDGE AND BELIEF THE INFORMATION GIVEN ABOVE AND IN THE ATTACHED SCHEDULES, IF ANY, IS TRUE, COMPLETE, AND CORRECT.

(Date) *(Signature and Title)*

18 U.S.C., SECTION 1001; ACT OF JUNE 25, 1948, 62 STAT. 749; MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

APPENDIX B

SAMPLE INSPECTION PROGRAMS, QUESTIONNAIRES AND CHECK LISTS

Safeguards Control Survey Program

Survey Program (Nuclear Reactors - Initial Survey)

Inventory Questionnaire

Inventory Listing

Test Result Data Sheet

Sampling Data Sheet

Audit Program

Scale and Balance Check List

Internal Control Questionnaire

Procedure Manual Check List

SAFEGUARDS CONTROL SURVEY PROGRAM

Facility Surveyed _____

Reporting Identification Symbol _____ Survey No. _____

Period Covered _____ Date of Survey _____

	Name	Working Paper Reference
Part I - Survey Planning		
A. General - Arrange in writing with the appropriate facility personnel for the survey dates, inventory dates and plans, initial meeting of facility personnel with survey team, and completion by facility personnel of ICQ. Notify the facility of the period covered by the survey and personnel on survey team and request information on specific aspects that facility personnel believe should be given special attention during the survey. Arrange for a preliminary visit if such is needed.		
B. Personnel Assignment - Prepare a schedule of survey personnel and the specific survey assignments for each. Each survey team member should sign off on the assignment schedule after preparing a list or schedule of his assignments or obtaining a copy of the master schedule.		
C. Document Review - Each member of the survey team shall review prior survey working papers, suspense files, material balance or status reports, and other documents pertinent to his assigned portions of the survey and shall prepare a schedule or schedules of items for investigation which pertain to his assignment.		
D. Review of Contracts and Agreements - Review pertinent data from all contracts, leases, and other agreements concerned with SS material for all such agreements in effect during the survey period. Note terms and conditions relative to SS material financial responsibility, discards, commingling, scrap recovery, shipper-receiver differences, quality control, etc.		

	Name	Working Paper Reference
E. Inventory		
1. Review the facility procedure manual and other instructions pertaining to the facility's inventory plans and procedures.		
2. Using the most current inventory data available, prepare the inventory plans, inventory questionnaire, master data sheet, and sampling data sheets similar to those of Exhibits B, C, and D, and as discussed in Part I, Section B, Paragraph 4 of this handbook.		
3. Make personnel assignments and prepare specific inventory instructions for the survey team members.		
F. Records and Reports - Complete Audit Program, Exhibit E, Part I - Planning.		
G. Measurements System Review		
1. Review facility procedure manuals, prior working papers, special reports, and other information sources to update prior or to prepare new measurement system material flow charts or measurement tabulations such as Exhibits H and I.		
2. Based on the data in Item 1, select the areas of the measurement system to be given special emphasis and those to be given less emphasis or not to be reviewed and make personnel assignments.		
H. Statistics Review - Review measurements system and associated reliability data, and other documents and reports pertaining to measurement reliability and statistical controls. Note problem areas and items to be given special emphasis.		
I. Internal Control Review		
1. Review the facility procedure manual and other documents pertaining to the facility's SS material control procedures. Complete the procedure manual check list, Exhibit J.		
2. Review the ICQ completed by field office or facility personnel to note obvious discrepancies and areas requiring special review.		
J. Initial Meetings		
1. Prepare notes for an initial meeting with facility management responsible for SS material control to outline the scope of the survey, note any areas which will be given special attention and request of the management any areas they believe need attention.		

	Name	Working Paper Reference
2. Prepare notes for an initial meeting with supervisory personnel directly responsible for SS material control to discuss detailed plans for conduct of the survey.		

Part II - Conducting the Survey

A. Initial Meetings

1. Discuss with facility management the general aspects and scope of the survey.		
2. Discuss details of the survey and the facility with facility SS material control personnel.		
3. Through the SS material control personnel arrange meetings with other facility personnel to discuss and verify procedures and observe practices related to SS material control.		

B. Inventory

1. Review detailed inventory plans with appropriate facility personnel.		
2. Observe and test inventory as planned. Note changes from stated plans along with reasons for the changes.		
3. Document observations, and complete inventory questionnaire for each area.		
4. Inventory Summarization and Reconciliation		
a. Check facility prepared data, extensions, footings, conversions, etc., using factors established or verified in measurements review.		
b. Trace selected items to final inventory listings and selected listings to the items.		
c. Prepare inventory summaries and reconcile with reported inventories by project, contract, lease, etc., and by total facility.		

C. Records and Reports - Complete Audit Program, Exhibit E, Part II - Conducting the Audit.		

	Name	Working Paper Reference
D. Measurements System Review		
1. Review the measurements system with appropriate facility personnel to determine that the written procedures are valid and what changes have been made.		
2. Observe those areas selected in planning and as a result of the discussions in 1, to establish actual measurement practices. Complete check lists and questionnaires as appropriate for the measurement system and individual measurement points. Note all changes and differences between written procedures and actual practice.		
3. Evaluate the measurement system quantitatively and qualitatively as indicated on the Measurement Point Data Sheets.		
4. Establish validity of all factors used to convert net weights to SS and isotopic weights.		
E. Statistics Review		
1. Review and evaluate statistical bases for measurement reliability of individual measurement points, procedures, factors, etc., as noted on the Measurement Point Data Sheets.		
2. Determine that the procedures for determining and controlling the reliability of measurements include:		
a. Appropriate and accurate sampling and measurement methods for generating data on which to base reliability statements.		
b. Valid statistical methods for determining the precision and accuracy of sampling and measurement methods.		
c. Adequate controls on the submission of "known" and "disguised" control samples within the laboratory.		
d. Specific procedures for determining and minimizing sampling and analytical biases within the facility's laboratory or between different laboratories.		
e. Adequate analytical statistical control programs. Exhibits H and I may be used to assist in this review and evaluation.		

	Name	Working Paper Reference
3. Review and evaluate controls and surveillance maintained over shipper-receiver differences including validity of limits of error on transfer documents, normal operational losses, material unaccounted for, and other material control indicators.		
F. Internal Control Review		
1. Review notes from various reviews comparing practices with written procedures and determine adequacy of procedure manual with respect to:		
a. reflecting current practices,		
b. complete coverage of SS material control procedures.		
2. Complete ICQ or verify answers given by facility personnel. Use notes and data collected during conduct of various observations and discussions in all phases of the survey performance.		
Part III - Reporting Survey Results		
A. Coordination of Findings		
1. The survey team leader should discuss survey results with the survey team to:		
a. determine adequacy of overall material control at the facility.		
b. determine adequacy of major aspects of facility material control.		
c. determine facility action on prior recommendations and suggestions.		
d. determine areas in which improvement is needed and develop recommendations and/or suggestions to accomplish the improvements.		
e. develop points for discussion with facility management and facility SS material control personnel.		
B. Final Meetings		
1. Arrange to discuss detailed findings, recommendations and suggestions with facility NMM personnel prior to reporting to facility management.		

	Name	Working Paper Reference
2. Discuss with facility management significant findings including recommendations and significant suggestions that will appear in the survey report.		
C. Prepare and issue written report as promptly as possible.		
Part IV - Survey Working Papers		
A. Complete and tie-in all working papers.		
B. Check to determine that date, initial and title are on all working papers.		
C. Index and cross-reference all working papers to:		
1. other working papers		
2. permanent file		
3. survey report		
4. office files.		
D. Bring permanent file up-to-date.		
E. Have survey working papers reviewed by supervisory personnel, preferably not a survey participant.		

SURVEY PROGRAM

Nuclear Reactors - Initial Survey

	Done By	Ref
Part I - Preliminary Office Activities		
A. Planning and Logistic Preparation		
1. Advise reactor operator of desired survey dates, and arrange for an initial meeting. When the reactor is not at the same location as the company offices, determine where the data needed for the survey is kept.	____	____
2. Establish survey team composition, and assign general areas of responsibility.	____	____
3. For surveys of power reactors operating on leased special nuclear material, request copies of all Material Status Reports for the survey period, together with transactions subsequent to the last report period.	____	____
4. Make necessary travel and hotel arrangements.	____	____
B. Working Paper Preparation		
1. Prepare a survey working paper folder, inserting a survey program, general index, etc.	____	____
2. Prepare a brief summary description of the reactor, noting fuel composition, power levels, etc. In particular, note best available values for α (capture to fission ratio), ϵ (fast fission factor), and C.R. (plutonium conversion ratio).	____	____
3. From forms AEC-577 or 578, as appropriate, prepare lead schedule for each SS material, using the format to be used in preparing the audited Material Balance Statement.	____	____
4. Prepare summary schedules of nuclear loss and plutonium or U-233 production. Sub-total by core discharge for comparison with heat balance data.	____	____
5. Examine nuclear loss and production data for general consistency. If significant differences are noted, advise the reactor operator, requesting that corrected data be prepared for review by the survey team.	____	____
6. Prepare notes for an initial meeting with the reactor operator's management, outlining the purpose of the survey, and the tests planned, and particularly noting any anticipated problems.	____	____
7. Prepare notes for more detailed discussions with the reactor operator's engineers, covering the planned review and audit of:		
a. power generation data	____	____
b. nuclear loss and production calculations	____	____
8. Develop a tentative master plan for taking or testing the nuclear materials inventory.	____	____

SURVEY PROGRAM

Nuclear Reactors - Initial Survey

	Done By	Ref
Part II - Survey Field Work		
A. Audit of Lease Material Records		
1. Trace quantities on the lead schedules to the reactor operator's records.	____	____
2. Verify the accuracy of the records by:		
a. footing journals and ledgers	____	____
b. reconciling books of final entry with books of original entry	____	____
c. test-checking extensions, postings, and footings of transfer documents	____	____
3. Detail any adjusting entries made necessary by the survey, and arrange for their inclusion in the next report. (For lessee's, a supplemental report to coincide with the survey cut-off date is preferable.)	____	____
B. Physical Inventory Verification		
1. Review the tentative master inventory plan, make changes as necessary, and develop a firm plan for inventory verification.	____	____
2. Following the master plan, verify the reactor physical inventory.	____	____
3. Using transfer documents for unused elements and reactor calculation data for spent elements or elements in the reactor, develop a physical inventory total for each SS material, and insert in the records audit lead schedules.	____	____
4. If the reactor operator did not take a physical inventory during the survey field work, determine when the last physical inventory was taken, or what plans exist to take one in the future. If possible, review the data and results of the last physical inventory.	____	____
C. Power Generation		
1. Determine the method and equipment used to measure or calculate reactor thermal power, including such factors as the frequency of measurement, and/or conversion and the manner in which data and calculations are documented.	____	____
2. Review the gauges and other equipment used in the power generation measurements. Where possible, review or obtain data as to accuracy and precision, frequency of calibration, etc. In all cases, record at least a qualitative opinion as to the validity of the source data.	____	____
3. Review secondary heat sources and sinks to determine that their effect on the recorded reactor thermal power has been considered.	____	____
4. Prepare an audited schedule of reactor thermal power, and compare with data used by the reactor operator in nuclear loss and production calculations.	____	____
5. Verify the data in the power generation summary schedule by preparing sub-schedules for at least one month, taking data from daily operating logs and repeating or checking the calculations.	____	____

SURVEY PROGRAM

Nuclear Reactors - Initial Survey

	Done By	Ref
Part II - Survey Field Work (cont)		
D. Nuclear Loss and Production		
1. Determine how nuclear loss and production is calculated, by the reactor operator, including the computer basis for the calculations, and any reconciliation of empirical data with computer predicted values.	____	____
2. Using the power data previously obtained, calculate nuclear loss and production for each report period, and compare with that reported.	____	____
3. Determine how individual fuel element factors are derived, and if possible, test the accuracy of the factors.	____	____
4. Verify the core loading data as determined during the audit, using data developed in the steps above.	____	____
5. Using best available values for the essential parameters, show that reported nuclear loss and production quantities are consistent with basic nuclear theory.	____	____
Part III - Final Office Activities		
A. Write a survey report, addressed to the appropriate AEC Field Office.	____	____
B. Prepare a draft letter to the reactor operator, for issuance by the appropriate AEC Field Office, summarizing the survey findings.	____	____
C. Assemble, bind, index, and cross-reference the working papers.	____	____
D. Review the completed survey, making notes on actions to be taken prior to or during the next survey.	____	____

INVENTORY QUESTIONNAIRE

Reporting Identification Symbol _____ Survey No. _____ Date _____

SS Material _____

Location _____ Custodian _____

Survey Team Observer _____

	Answer and/or Working Paper Reference
1. Was the material arranged in such a manner as to expedite inventory taking?	_____
2. Were proper cut-off procedures used?	_____
3. Was the inventory taken in a systematic and accurate manner?	_____
4. Approximately what portion of the inventory was taken by the following methods:	
a. piece count?	_____
b. weight?	_____
c. item or container identification?	_____
d. bulk measurement, sample, and analysis?	_____
e. calculation from measured parameters?	_____
f. other (specify)?	_____
5. Were the methods of determining the SS material quantities adequate?	_____
6. Were scales, balances or instruments calibrated properly before use in making inventory measurements?	_____
7. Were descriptions, labeling and specifications of materials adequate for inventory control?	_____
8. What inventory records does the custodian maintain (e.g., inventory issues, inventory worksheets, kardex, single or double entry books, etc.)?	_____
9. Were transfer and receipt documents on hand to support the inventory of record?	_____
10. Does the custodian have and follow written inventory procedures?	_____
11. Were there any differences between written inventory procedures and actual inventory practices?	_____
12. Were those practices that differed from procedures adequate for a proper inventory?	_____
13. Are the material storage facilities adequate from the standpoint of ease of taking inventory?	_____
14. Was the physical inventory on hand in agreement with the custodian record inventory?	_____

INVENTORY LISTING

Reporting Identification Symbol _____ Survey No. _____

Location (e.g., MBA) _____

Material Type _____

Description of Material	Identification (Number)	Gross Weight	Net Weight	Element Weight	Weight % Isotope	Isotope Weight

Comments (cross-references to sampling data sheets, etc.):

Initials _____ Others _____

Date _____

TEST RESULT DATA SHEET

Reporting Identification Symbol _____ Survey No. _____

Master Data Sheet Reference _____

Sample Data Sheet Reference _____

Inventory Identification _____

Sample Identification	Test Results		Difference Facility - Survey Team	Disposition Remarks and References
	Facility	Survey Team		

Survey Team Member _____

Date _____

SAMPLING DATA SHEET

Facility Surveyed _____ Survey No. _____

A. Description of Material:

	Check Weigh	Analysis U	Analysis U-235	Observation	Other
B. Population Size					
1. Process Inventory Estimate					
2. Estimate of σ					
C. Criteria of Acceptability					
D. Sampling Plans					
1. MIL-STD-105D					
2. Other attribute plan					
3. MIL-STD-414					
4. Other variable plan					
E. Inspection level (normal, reduced, tightened)					
F. Sample size code letter					
G. Method of sampling (single, double, sequential)					
H. Protection level (AQL, LTPD, AOQ, AOQL)					
I. Sample size(s)					
J. Acceptance/Rejection numbers					
K. Computed Process Average					
L. Computed σ					
M. Inventory accepted/rejected					

Survey Team Member _____

Date _____

AUDIT PROGRAM

Reporting Identification Symbol _____ Survey No. _____

Period Covered _____ Date of Survey _____

	Name	Working Paper Reference
Part I - Planning the Audit		
A. Document Review - Review documents and contracts as indicated in the Survey Program, Part I, C and D and note items pertinent to records and reports examination.		
1. Review contract data for terms and conditions under which SS material is held.	_____	_____
2. Review facility reports (or suspense file notes from routine review) for:		
a. date and proper signature,	_____	_____
b. proper form, including subschedules,	_____	_____
c. basis for inventory,	_____	_____
d. explanation of MUF,	_____	_____
e. timely receipt.	_____	_____
3. Review receiving and shipping documents (or suspense file notes prepared from routine review) for preparation and issuance in accordance with requirements and regulations.	_____	_____
4. Review backup documents and authorizations for NOL's and write-offs.	_____	_____
5. Prepare notes in working papers of specific items to investigate.	_____	_____
B. Procedure Manuals and Internal Control		
1. Review procedure manual, Internal Control Questionnaires and associated documents to become re-acquainted with facility with regards to records and reports.	_____	_____
2. Prepare notes on specific items to be investigated.	_____	_____
C. Trial Balances		
1. Schedule all receipts and removals including separate schedules for sales and procurement, nuclear loss and production, and, MBR Line 60 items, as appropriate, using either the facility material balance reports and/or material status reports or the field office or leasing office transfer journals.	_____	_____

	Name	Working Paper Reference
2. Using the schedules prepared in C.1, set up pro-forma trial balances for each material and material type showing total facility balances in all cases and balances for each contract or lease in the case of fixed-price contractors and lessees.		
D. Sampling Plans		
1. Prepare master data sheet and sampling plans for audit tests to be performed on statistical sampling basis. Preliminary plans and sampling plan criteria can be established prior to survey based on data from prior surveys and reports and general knowledge of facility.		
Part II - Conducting the Audit		
A. At initial meetings with facility personnel:		
1. Discuss information developed in audit planning;		
2. Review audit plans where necessary;		
3. Discuss any changes in facility procedures that affect records and reports; and		
4. Arrange for necessary assistance and availability of records and reports.		
B. Review general and subsidiary ledgers and list and investigate any unusual items occurring in journal vouchers or posting media.		
C. Receipts		
1. Procurement		
a. Using invoices as bases, trace quantities to permanent records.		
b. Test internal data supporting receipts (e.g., by use of receiving reports, measurement results, etc.) using statistical samples where appropriate.		
c. Review purchase orders and payment vouchers to determine quantities of material purchased agree with invoices.		
d. Test-check extensions, footings, and postings of invoices and/or other documents supporting quantities procured using statistical sampling plans where appropriate.		

	Name	Working Paper Reference
2. Nuclear Production		
a. Check reactor operating data for material produced and trace to records.		
b. Check extensions, additions, and calculations of production.		
3. From other SS Categories - Check bases of transfer and reconcile with corollary account under "Removals".		
4. DOD Returns - Check data, letters, receipts, etc., 100% to quantities in records.		
5. AEC Transfer Documents - Test-check postings of Forms AEC-101 and AEC-388 to the records using statistical sampling plans where appropriate.		
D. Removals		
1. Normal Operational Losses, Write-Offs, and Material Unaccounted For.		
a. From material balance reports, prepare schedules of each account for the survey period.		
b. Trace schedule to ledgers.		
c. Examine supporting evidence for posting documents.		
d. Test-check postings of source documents to ledger using statistical sampling plans where appropriate.		
e. Check footings, extensions, descriptions of data on source documents to ascertain correctness and propriety of data.		
2. Sales		
a. Check sales authorizations.		
b. Check sales slips and/or invoice quantities to ledgers.		
c. Check footings, extensions, etc., of posting documents.		
d. Trace postings to ledgers.		
3. DOD Transfers - Check data, letters, receipts, etc., 100% to quantities in records.		

	Name	Working Paper Reference
4. Nuclear Losses or Burnup (These steps may be done in connection with step C.2 above).		
a. Check reactor operating data for burnup and trace to records.	_____	_____
b. Check extensions, additions, and burnup calculations.	_____	_____
5. Decay - Check calculations on the basic posting documents and trace postings to records.	_____	_____
6. To Other SS Categories - Check bases of transfer and reconcile with corollary account under "Receipts".	_____	_____
7. AEC Transfer Documents		
a. Test-check postings of Forms AEC-101 and AEC-388 to the records using statistical sampling plans where appropriate.	_____	_____
E. Internal Transfers		
1. Trace documents supporting internal transfers (e.g., production notices, laboratory reports, weight tallies, transfer forms) to records.	_____	_____
2. Check footings, postings, and extensions of intra-area supporting documents.	_____	_____
3. Review internal transfer documents for propriety and numerical sequence of intra-area transfer forms.	_____	_____
4. Reconcile records of internal transfers to books of final entry.	_____	_____
F. Measurement Records - Trace on a selected basis using statistical sampling plans when appropriate:		
1. Quantities from records to laboratory workbooks.	_____	_____
2. Results in laboratory workbooks to quantities in records.	_____	_____
3. Check extensions, footings, descriptions, as applicable.	_____	_____
G. Summarize findings to be discussed with other team members, facility personnel and management and to be included in report.	_____	_____

SCALE AND BALANCE CHECK LIST

Reporting Identification Symbol _____ Survey No. _____ Date _____

		Answer and Working Paper Reference
1.	Are written calibration and use procedures available?	_____
2.	Is calibration performed properly and at satisfactory intervals?	_____
3.	Are calibrations traceable to NBS standards?	_____
4.	Are regular inspections, testing, and service performed?	_____
5.	Are gage cards available?	_____
6.	Are inspection stickers on equipment?	_____
7.	Is there a training or qualification program for operators, supervisors?	_____
8.	Are working standards available and satisfactory?	_____
9.	Are working standards checked? How often?	_____
10.	Are working standards accurate, handled with lifters or gloved hands, kept under cover when not used?	_____
11.	Is the equipment sufficiently accurate for the intended use?	_____
12.	Are control charts or other statistical media maintained for scale and balance precision and accuracy?	_____
13.	Is statistical determination of precision and accuracy (weighing limits of error) performed?	_____
14.	Are weights handled carefully - not slid in place, etc.?	_____
15.	Are temperature and air current effects taken into consideration in the procedures and in practice?	_____
16.	Is proper action taken to correct weighing errors?	_____
17.	Are only approved scales used?	_____
18.	Are scales checked before each use?	_____
19.	Are scales permanently identified?	_____
20.	Are red tags applied to scales out of order? Do these tags show reason why they are not used that calibration is required after repair, signature, followup action?	_____
21.	Are weights verified by more than one person (or printed tape) for shipments, receipts, scrap, etc.?	_____
22.	Is responsibility for scales assigned?	_____

References: Weights and Measures Administration - National Bureau of Standards Handbook 82, Issued June 22, 1962

Reviewed by _____

INTERNAL CONTROL QUESTIONNAIRE

Facility Surveyed _____

Reporting Identification Symbol _____ Survey No. _____

Date of Survey _____

	Answer and W/P Reference
A. General	
1. Has the Facility's Nuclear Materials Management Group a material flow chart of the station? If not - have one prepared and submitted to the field office prior to survey.	_____
2. Has the Facility's Nuclear Materials Management Group a material records flow chart of the station? If not - have one prepared and submitted to the field office prior to survey.	_____
3. Has the Facility's Nuclear Materials Management Group an organization chart of the station? If not - have one prepared and submitted to the field office prior to survey.	_____
4. Has an internal audit been performed in all material balance areas within the last 12 months?	_____
5. Who performs internal audits (list names, titles, and organization)?	_____
6. Do facility internal auditors render written reports on SS material accounting and control?	_____

Notes and Comments:

B. Organization	
1. Is the Nuclear Materials Management Group organizationally independent of the operating and storage departments?	_____
2. Does the group include (or have available) personnel qualified in:	
a. Accounting?	_____
b. Chemistry?	_____
c. Statistics?	_____
3. Can the group cross organizational lines to enforce policy?	_____
4. Are the analytical and assay measurement laboratories organizationally independent of the operating and storage departments?	_____

Notes and Comments:

Answer and W/P Reference

C. Records and Reports

1. Is the facility's material accounting system so designed that it will clearly delineate responsibility for the materials? _____

2. Is the facility's subdivision into internal material balances commensurate with the need for control of the SS material? _____

3. Are double entry records maintained? _____

4. Are subsidiary accounts periodically reconciled to control accounts? _____

5. Are perpetual inventory records maintained? _____

6. Are perpetual inventory records adjusted periodically to physical inventories? _____

7. Is there written approval by a responsible employee for all adjustments to controlling accounts, subsidiary accounts, and perpetual inventory records? _____

8. Are properly designed and approved forms used for recording adjustments to prior recorded quantities? _____

9. Is provision made for accounting for all such forms? _____

10. Are all SS material measurements (e.g., production control, experiments) routinely reported to the material accounting office? _____

11. Are applicable measurements used in the preparation of accounting records? _____

12. Are serially numbered forms used to report material transfers between:

    a. Individuals? _____
    b. Material balance areas? _____

13. Is there a system (e.g. pre-numbering of forms) to account for all internal transfer forms? _____

Notes and Comments:

D. Receipts

1. Is receiving of SS material centralized at the facility? _____

2. Is receiving performed by employees other than those who keep material accounting records? _____

3. Is receipt of material acknowledged in writing by responsible employees? _____

	Answer and W/P Reference
4. Is a lot or item number assigned after receipt?	
5. Is the material identified by its assigned number on the various accounting and production forms?	
6. Are receiving reports initialed by supervisor?	
7. Are copies of receiving reports sent to the accounting office:	
a. Immediately?	
b. Directly?	
8. Is information from the receiving department compared with the quantities and description on the shipping form?	
9. Is the checking completed prior to signing the shipping form which is returned to the shipper?	
10. Is an item count made and the gross weight of material determined on receipt?	
11. Are tare and net weights determined?	
12. Is material sampled and analyzed upon receipt?	
13. Does the receiver take an independent sample (or participate in the shipper's sampling)?	

Notes and Comments:

E. Shipments

1. Are written instructions as to lots or items to be shipped issued to the shipping departments?	
2. Is notice of shipment sent directly to the materials accounting office?	
3. Is the shipping form, AEC-101, prepared from loading sheets or other evidence received from the shipping department?	
4. After preparation, is the AEC-101 checked by other than the typist, prior to signature?	
5. Are there defined procedures for processing receipted shipping forms returned by the receiver, including:	
a. Review for authorized signatures and completeness of information?	
b. Evidence on the shipping form (e.g., by employees' initials) that the required work has been done?	

	Answer and W/P Reference
6. Is the gross weight of material determined prior to shipment?	
7. Is the tare weight of each individual shipping container determined?	
8. Is each lot shipped sampled and analyzed?	
9. Are reference samples retained for a reasonable period of time?	

Notes and Comments:

F. Other Operations

1. Storage

a. Are containers labelled?	
b. Is there adequate control over material issuances?	

2. Write-Offs

a. Is field office approval obtained prior to write-off and discard of materials?	
b. Is a file maintained of approved write-offs and supporting data?	
c. Does the Nuclear Materials Management Group maintain a record showing the location of materials written off?	

3. Inventories

a. Are physical inventories performed?	
b. Frequency of physical inventories?	
c. Are inventories based on measured values?	
d. Are inventory summaries compiled from original data (tallies, listings, analytical reports) rather than from perpetual inventory records?	
e. Are the results of the physical inventory reflected in the SS accounting records and reports?	
f. Is the facility's reported inventory supported by statements signed by an authorized representative?	

4. Normal Operational Losses (NOL)

a. Are there continuing studies with respect to processing discards and residues, such as:	
(1) Their relation to production yields?	
(2) The accuracy of the measurements?	

	Answer and W/P Reference
b. Can the lots or pieces of products, secondaries and residues, be related to feed material lots or pieces put into process:	_____
c. Are control charts or limits maintained for NOL's?	_____
5. Material Unaccounted for (MUF	
a. Is MUF localized by material balance area, project or process, as applicable?	_____
b. Is there a routine procedure for investigating MUF?	_____
c. Are written explanations of circumstances which may contribute to MUF submitted by operating supervision to the SS materials accounting office?	_____
d. Are control charts maintained for MUF?	_____
e. Are there other statistical techniques applied for control of MUF?	_____
6. Shipper-Receiver Differences (S/R)	
a. Is there a routine procedure for investigation of S/R differences?	_____
b. Are written explanations prepared of circumstances which may contribute to S/R's?	_____
c. Are control charts maintained for S/R's?	_____
d. Are there other statistical techniques applied for control of S/R's?	_____

Notes and Comments:

PROCEDURE MANUAL CHECK LIST

Facility Name _____

Reporting Identification Symbol _____ Date _____

Reviewer _____

When using this check list to review a facility procedure manual, referenced supplementary documents and appendixes are to be considered a part of the manual. With this taken into consideration, does(do) the facility procedure manual(s) contain the following information and is that information in agreement with current practices:

	Answer and/or Working Paper or Procedure Manual Reference
1. General	
a. Description of the facility internal audit program?	_____
b. Description and discussion of the procedures and responsibilities for contract activities related to SS material procurement and control?	_____
c. Date of issuance or revision?	_____
2. Facility Organization	
a. Organization charts of:	
(1) the facility organization?	_____
(2) the nuclear materials management group?	_____
b. Listing, descriptions, or charts of all MBAs?	_____
c. Basis for establishment of MBAs?	_____
d. Statements of responsibility and authority for:	_____
(1) the central NMM group?	_____
(2) MBA custodians?	_____
(3) others concerned with NMM?	_____
3. Facility Operations	
a. Functional statement of the facility operations and processes?	_____
b. Material flow description:	
(1) by charts?	_____
(2) by narrative?	_____
(3) including material composition or type at significant points?	_____
(4) including usual or normal material quantities?	_____

	Answer and/or Working Paper or Procedure Manual Reference
4. Receiving, Shipping and Other Receipts and Removals	
a. Description of shipping and receiving points?	_____
(1) notation of these points on material flow chart?	_____
(2) description of the receiving and shipping procedures at each point?	_____
b. Procedures for review, evaluation, and resolution of shipper-receiver differences?	_____
c. Description of and procedures for determining reporting and recording other additions to or removals from inventory?	_____
d. Procedures for evaluation and control of removals from inventory such as MUF and NOL?	_____
e. Statements of receiving and shipping responsibilities?	_____
5. Inventory	
a. Procedures by MBA?	_____
b. Statements of inventory timing and frequency?	_____
c. Cut-off and plant shutdown procedures?	_____
d. Inventory measurement procedures?	_____
e. Description of general inventory techniques?	_____
f. Supplemental inventory instructions?	_____
g. Statement of inventory responsibilities?	_____
6. Storage and Internal Transfers	
a. Description of procedures and mechanisms for segregation of SS material:	
(1) by material type?	_____
(2) by project, contract, lease, etc.?	_____
b. Specific SS material labeling procedures?	_____
c. Description of storage facilities?	_____
d. Description of burial grounds including location records?	_____
e. Description of procedures, documents, and document flows for internal transfers of SS material?	_____
f. Methods of determining SS material quantities transferred or stored?	_____
g. Statement of storage and internal transfer responsibilities?	_____

	Answer and/or Working Paper or Procedure Manual Reference
7. Measurements and Statistical Controls	
a. Description of SS material sampling and measurement points:	
(1) by process or material flow chart?	_____
(2) by narrative description?	_____
(3) for all material streams?	_____
b. Description of methods and techniques used at each sampling and measurement point including:	
(1) weight or volume measurements?	_____
(2) sampling procedures?	_____
(3) special equipment for sampling or measurements?	_____
(4) analytical procedures?	_____
(5) measurements for calculation of quantities related to nuclear loss or production, cascade inventory, or factors?	_____
c. Description of supporting programs:	
(1) scale and balance program?	_____
(2) calibration programs?	_____
(3) quality control programs?	_____
(4) analytical control programs?	_____
d. Description of the techniques, methodology and programs employed to determine the measurements system reliability?	_____
e. Description of the flow and use of measurement data?	_____
f. Procedures and techniques for statistical evaluation of:	
(1) shipper-receiver differences?	_____
(2) material unaccounted for?	_____
(3) normal operational losses?	_____
(4) transfer document limits of error?	_____
(5) other?	_____
g. Statements of responsibility for measurements and statistical controls?	_____

	Answer and/or Working Paper or Procedure Manual Reference
8. Records and Reports	
a. Chart of accounts?	
(1) general ledger accounts?	
(2) subsidiary accounts?	
(3) plant and MBA accounts?	
(4) control accounts?	
b. Document flow chart?	
(1) physical flow of documents?	
(2) posting points?	
(3) retention points?	
c. Description of the system:	
(1) posting procedures?	
(2) sample forms including instructions?	
(3) description and basis of reports?	
(4) method of compiling reports from records?	

ANNEX "D"

U. S. Atomic Energy Commission
Division of International Affairs

SAFEGUARDS

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THE TECHNICAL BASIS AND BACKGROUND OF SAFEGUARDS

In the technical sense, safeguards--as used here--means a system of controls designed to detect any diversion of materials or equipment committed to the peaceful uses of atomic energy to any military purpose. Safeguards, therefore, in the direct sense detect, rather than prevent, diversion. Their effectiveness in preventing diversion is derived indirectly from the deterrent effect which the consequences of detection may exert on the would-be diverter. Hence the aim of safeguards is to detect diversion to any military purpose. Many possible types of violations are of interest to the safeguard system--for example, the use of a reactor to undertake research on reactors for military purposes. However, the most serious and important type of violations is the diversion of fissionable material to research on or use in atomic weapons. The fissionable material subject to safeguards and, thus susceptible to diversion may be either that supplied directly from one country to another or that produced from the use of a reactor or materials supplied under safeguards.

Early Development

The idea of controls to avoid the military use of atomic energy is nearly as old as atomic energy itself. In the Baruch plan that was presented immediately after World War II, the emphasis was on full ownership and operation of at least all critical atomic energy facilities by the controlling authority. With the failure

of the Baruch plan to be accepted and with the development of national military programs in the U. K. and the Soviet Union, the emphasis shifted to the development of controls which could be applied to militarily-oriented national programs to assure that they were no longer being used for military purposes; that is, to disarmament controls. In contrast to the Baruch plan, disarmament studies were concentrated on control systems in the strict sense of the word; that is, systems under which the operation of the facilities would continue to be undertaken by national operating authorities, with a control organization superimposed to determine the utilization of all material and equipment. These studies indicated that such systems could be devised and that if the systems were of sufficient intensity they could have an effectiveness in terms of detecting diversion approaching the accuracy of the various measurement methods. This was generally considered to be in the range of two or three percent. Most studies showed that to be of such high effectiveness, the system would have to be rather elaborate and involve the use of numerous personnel with their associated equipment. For systems of less intensity, the chance of detecting diversions of this magnitude of course, decreased. No system short of complete operation of the facility by the control authority--and perhaps not even that--could give one-hundred percent assurance at the technical level that any diversion would be detected.

During the same time period, important progress was made in the application and development of control systems and techniques through the vigorous program of materials accountability or nuclear materials management which was carried out in the United States atomic energy program and, presumably in other national programs as well. The domestic program provided an important and valuable basis for the development of safeguards systems designed for control of material abroad. Since both systems have as their objective the detection of diversion of material to unauthorized uses, many of the same elements and techniques can and do appear in both systems.

There are, however, important differences between a control system designed to be applied nationally and one designed to be applied internationally. In the national context there is a strong presumption that the management and the vast majority of the personnel employed in the operation of atomic energy facilities will be guided by national policy and will not divert material from the uses specified by the government. Any attempted diversion, therefore, is most likely to be on a small scale and the act of only one or a few people. In the international context, while diversions of this type cannot be ruled out, the system must be designed primarily to cope with the possible situation that a diversion might be attempted by the operating nation itself with the cooperation and support of the facility management and all of the facility personnel. This basic difference places substantially different requirements on the control systems and leads to a

different emphasis on the various elements which go to make up a system. Another factor to be taken into consideration in the international program is that these controls are based on solemn sovereign guarantee given by the cooperating nation. Except for the U. K., Canada and the international organizations - Euratom and the IAEA, such guarantees are verified by actual on-site inspection by U. S. representatives. This is a feature unprecedented in international affairs.

National control or materials management systems may have, in addition to the detection of diversion, the important subsidiary objective of helping to assure the economic use and management of nuclear material. The achievement of this objective requires the acquisition of knowledge not only of whether any material has been diverted, but also how much and what kind of material has been produced, used, or is present in various parts of the system. A safeguards system, on the other hand, need determine only whether material has been diverted, and if it can do so without requiring information on how much material remains in the authorized peaceful channels, it has fulfilled its objective.

With the passage of the Atomic Energy Act of 1954 and the subsequent development of an extensive program of international cooperation, the need for the development of a safeguards system to be applied to materials distributed abroad became immediate. The first agreements calling for the export of reactors and fissionable material abroad were executed in 1955. These early agreements were limited to the export of research reactors and small quantities of material with a maximum of 20% enrichment.

To a degree, therefore, they contain a self-implementing safeguards system. They reduced the safeguards problem by limiting the kinds of assistance to those which were inherently of little or no military significance. These limitations were possible because there was no immediate requirement for cooperation of a kind where a more comprehensive safeguards system which would clearly be needed.

Despite these limitations even the earliest agreements contained provisions which gave the United States the right to observe from time to time the research reactors and fuel provided for them to determine that they were still being employed for the maintained purposes. In practice, these limited rights have been entirely adequate to apply the kinds of safeguards required for materials and equipment of this nature.

Safeguard Rights

The Atoms-for-Peace Program contemplated from the outset that assistance would be given and materials would be distributed for use in the generation of power by nuclear reactors. This meant that large quantities of plutonium would result from the cooperative activities and the development of a safeguards system to accommodate this problem was therefore pursued.

It was recognized that the application of an effective safeguards system would depend on the acquisition of ample rights on behalf of the inspecting authority to enable him to undertake the necessary control measures. Thus, the first step was the formulation of this system of rights. If these rights could be

made sufficiently broad, the development of the detailed techniques of control could continue over a longer period, since the actual construction and operation of reactors producing large amounts of plutonium was several years away. Indeed, it can be said that a safeguards system consists of both the rights vested in the controlling authority and the actual measures by which these rights are implemented. The existence of the rights themselves, so long as the possibility of their implementation is maintained through the activities of the inspectorate, is an important element in the total effectiveness of the system.

The system of rights included in U. S. comprehensive bilateral agreements beginning in 1956 and, in almost identical words, in the statute of the IAEA, are an impressive and unprecedented step in international relations. They provide the inspecting authority, that is, the United States in the case of bilateral safeguards and the IAEA in the case of Agency arrangements, with the right to send into the recipient country inspectors who shall have access at all times and to all places and data as necessary to account for material and to determine that the commitment to peaceful uses is being observed. This right of access is the central right on which the United States and the IAEA systems are based. It has proven to be sufficiently broad so that any reasonably conceivable safeguard system required by practice can be fitted within it. There are supplementary but important rights -- again quite comparable in both U. S. bilaterals and the Agency statute. These include the

right to approve the design of facilities from the standpoint of whether effective safeguards can be applied, the right to require the maintenance of satisfactory records, and the right to approve the means for reprocessing material from the standpoint of effective application of safeguards. Neither United States bilaterals nor the Agency statute are broad enough to deprive a country of the right to use any plutonium which it has produced under safeguards, so long as this plutonium is used for peaceful purposes under continuing safeguards. Both United States bilaterals and the Agency statute, however, do have mechanisms for the transfer of any plutonium produced under safeguards which is excess to its needs for peaceful purposes. Both the bilaterals and the statute also contain the important concept of "pursuit"; that is, the principle that safeguards apply not only to materials and equipment supplied in the first instance, but also to any material produced as a result of the use of safeguarded material or equipment through each successive generation.

Safeguards Procedures

In application, a safeguards system depends upon two principal elements. First, the maintenance and review of records showing the receipt, production, consumption, transfer and present location of all nuclear material. Secondly, the undertaking of actual on-site inspections designed to determine the validity of these records and, therefore, the compliance with the

commitment to peaceful uses. A summary description of how safeguards are undertaken in the U. S. bilateral program is given in "United States Bilateral Safeguards Inspections".

The effectiveness of a record keeping system as an element in a safeguards system requires some comment. Where material is transferred from facility to facility and particularly where these various facilities fall under different national jurisdictions, a record keeping system can be an important and effective means of control in its own right. Where material remains under the national control of a single country, the effectiveness of a records system as a means of control as contrasted merely with a source of information on which to base inspections, is greatly reduced. The atomic energy authority of a nation involved in a deliberate effort to divert material could, and presumably would have to, devise and maintain a set of false records designed to obscure its activities.

On-site inspections are the second and crucial element of a safeguards system. The inspections, in turn, may consist of elements of two kinds. First are the steps involved in conducting a physical inventory of material at a given installation to determine whether it complies with the reported figures. The second are the measures of a physical security nature; that is, measures to determine directly whether there has been any unauthorized removal of material. The seals placed by the Agency on the Yankee reactor, and their inspection, are an example of this kind of measure. Particularly in situations where resident

inspection is called for and applied, measures in this category may become an extremely important part of the over all safeguards system. While it is difficult to place numerical limits on their effectiveness, this effectiveness may be quite high.

The application of physical security measures of this nature may permit a substantial reduction in the intensity of inventory control techniques with a resultant over all simplification of the system. This is because, as noted previously, the sole objective of safeguards, as opposed to a national accountability system, is to determine whether any material has been removed from the system to unauthorized uses. If the question of diversion can be determined with assurance, it is of no particular importance to the inspector to determine how much material being properly employed remains within the system.

Experience to Date

Most of the inspection experience acquired to date both by the AEC and by the IAEA has involved comparatively small facilities and amounts of materials. It has also been confined largely to reactors. The material has often, though not always, been delivered in fuel element form and it is also often returned in the same form. With an increase in the performance of fabrication and reprocessing abroad, new safeguards problems will be presented.

Diversion from a reactor can occur in two different ways. First, by the diversion either before or after irradiation, of material known to have been supplied for use in the reactor, or secondly,

by the irradiation in the reactor of fertile material not declared or reported as having been charged to the reactor. This can be thought of as the diversion of neutrons. For reactors operating on natural or slightly enriched uranium and producing plutonium, the principal safeguards problem, reduced to its simplest terms, is to assure that any material irradiated in the reactor, regardless of its origin, is delivered to a controlled reprocessing facility. If this assurance can be obtained, it makes no difference whether the power output and plutonium production of the reactor are known or not. In practice, because these assurances may not be absolute, it makes sense to develop a system with as many cross-checks as possible. For this reason, information on reactor operation leading to a knowledge of a flow of material through the reactor and estimates of plutonium production are a desirable feature of the safeguards system applied to reactors.

For research reactors without substantial plutonium production capability, the safeguards problem is one of determining that the material supplied for the reactor remains in the reactor or in other controlled channels. This is particularly important where, as is often the case, the research reactor is fueled with highly enriched material, itself suitable for weapons utilization. The size and simplicity of research reactors is such that in many cases the fuel can be physically observed and counted. Moreover, any significant removal of fuel from a reasearch reactor

will often prevent its operation. The analysis of the discharged fuel elements of a research reactor when they are reprocessed, completes the material balance and provides a final effective check as to whether any diversion has occurred.

The problems of safeguarding power reactors vary among reactor types. Relevant factors include the presence or absence of on-power charge-discharge machines, the enrichment of the fuel, the time required for removal of the head and fuel, the design of the fuel storage facilities, and others.

Comparatively, little experience has been accumulated so far in the safeguarding of facilities other than reactors. The principal types of facilities in these categories are fuel fabrication plants and reprocessing plants. From the safeguards point of view these facilities share the characteristic of handling fissionable material in dispersed, easily transportable form, as contrasted with the fabricated fuel elements present at a reactor. This fact increases the opportunity for diversion at fuel fabrication and reprocessing plants. On the other hand, it also permits the application of sampling and analytical techniques of materials accountability which are difficult if not impossible to apply to reactors and to their costly fabricated fuel elements.

Probably the central fact of safeguards is that controls must be applied at each step of the fuel cycle. This is essential not only because opportunities for diversion exist in every operation, but because controls applied in this way reinforce each other and

supply cross-checks on the effectiveness of the controls applied to the preceding and subsequent operations. As noted earlier, where these operations occur in different countries under independent national control, the cross-checks can be particularly valuable.

Effectiveness of Safeguards

The question of the effectiveness of safeguards is frequently raised. Unfortunately, there is no clear-cut technical answer to this question. Quantitative limits of accuracy can be placed on the various measurements and analyses required to determine the amount of material at each point in a nuclear complex. These measurements and analyses, if performed independently by the inspecting authority, provide one approach to determing the effectiveness of a safeguard system. However, this statistical approach ignores two factors -- first, the physical security measures which may be employed to permit actual or inferential observation of diversion and, second, the deterrent effect that the over all safeguards system exerts on the would-be-diverter. In the final analysis, the effectiveness of a safeguards system in preventing diversion is a political question. If the probability of detection is high, it is likely that the probability of prevention is nearly total.

Instrumentation

One aspect of safeguards which deserves special mention is the possibility of using instruments to reduce or eliminate

physical inspections by inspection personnel. In the broad sense of course, instruments are employed in the present system both those installed in facilities by the operator and those under the control of inspectors. Power level and related measuring instruments at reactors could, in theory, provide a measure of plutonium output that would serve as the input measurement to a reprocessing plant and greatly simplify the need for direct surveillance of the reactor. In practice, however, this approach suffers from two drawbacks -- the fact that power level measurements are not convertible with high precision to plutonium production, and the fact that the instruments are under the control of the operator and are, therefore, subject to deliberately induced error. Instruments of this type, while not useless in a safeguards system -- particularly if they are subject to checking and calibration by the inspectors -- are of only limited value as a subsidiary means of data for cross-checking purposes.

It was recognized early in the development of safeguards systems, however, that instruments could be of substantially greater value if they were "tamper-proof"; that is, not subject to manipulation by the operator. The work that has been done to date on tamper-proofing indicates that it is not easy to achieve. Moreover, tamper-proofing overcomes only one of the shortcomings of instruments noted above so far as measurement instruments in the usual sense of the word are concerned. On the other hand, instruments in the broad sense, particularly including those

intended simply to indicate whether a particular operation -- such as removal of a reactor closure -- has or has not taken place, can perform a valuable service in the simplication of a safeguard system. This, too, is an area where further study is called for.

The IAEA Safeguards System

Even as the U. S. was negotiating and implementing its bilateral agreements and applying its safeguards thereunder, concerted efforts were being made to bring about the development and adoption of a safeguards system by the IAEA. This was recognized as the first step in achieving acceptance of IAEA safeguards by a number of countries.

The reason why it was necessary to formally develop an IAEA safeguards system requires some comment. It has already been noted that the IAEA statute contains a series of safeguard rights expressed in very broad terms designed to enable the application of virtually any conceivable safeguards system.

The IAEA membership and particularly those nations who might potentially come under the system, have felt a need for a fairly detailed definition of the scope and intensity of the safeguards system which the Agency would actually apply in the implementation of its safeguards rights.

Discussions with other Agency members convinced the United States that there was no possibility of obtaining Agency approval of a complex safeguards system covering the whole range of

possible activities that might ultimately come under Agency safeguards. Consequently, the U. S. decided to adopt an evolutionary approach to the development of an Agency system, seeking approval for various parts of it as the need arose. The first step, was the development of a system for reactors of less than 100 megawatts and for related small research and development activities.

One of the most controversial points in developing the Agency safeguards system for reactors under 100 megawatts was, as anticipated, the frequency of inspection. While it can be argued that the intensity of each inspection may be as important as the frequency of inspections in determing the impact of the system on the facility and country involved, the fact is that inspection frequency has come to be regarded as the principal measure of the intensity of an inspection system. A U. S. proposal during the development of the original system for small reactors was successful in achieving agreement on the question of inspection frequency. Under this proposal, the inspection frequency varies with the productive capacity of the reactors, rising to a maximum of six inspections per year at 100 megawatts thermal or equivalent. This approach, developed with the help of the Pacific Northwest Laboratories, assumes that the maximum inspection frequency should be such as to permit the detection of diversions of 200 grams of fissionable material in the interim between inspections.

In 1963, development of an extension of the Agency system to reactors of greater than 100 megawatts thermal was undertaken. While many points were debated, the principal issue again was that of inspection frequency. It was recognized that with larger reactors, particularly of certain types, continuous or resident inspection might be required. Extension of the system was agreed upon and following a review of the system in 1964, specific agreement was obtained on the principle of resident inspection, as well as the principle of inspection without advance notice. Both of these techniques may be necessary for the effective safeguarding of large reactors and other large and complex facilities, such as reprocessing plants. The latest version of the Agency system containing these principles was given final approval in September 1965.

The development of an Agency safeguards system is only a step toward the end objective of bringing about the actual application of this system in all countries receiving external nuclear assistance. The United States is now steadfastly committed to the widespread adoption of this system as soon as possible.

One concern expressed in obtaining acceptance of IAEA controls is with the nationality of the inspectors and, implicitly, the concern that inspectors of unfriendly nations will be used who might harass the inspected country's activities. Under the Agency statute as well as under its safeguards regulations, every inspected country must be consulted in connection with the appointment of inspectors. The United States strongly supports this right so as

to insure that no attempt is made to employ inspectors of a nationality which might give rise to a question of their objectivity. On the other hand, it must be recognized that no country subject to inspection by the IAEA should be entitled to limit inspections to nationals of only its closest friends and allies. The nationality of the inspectors which have been employed in the United States illustrates that, between the two extremes, there is a common sense solution to this problem.

Another issue frequently raised by countries who are asked to submit to IAEA inspection is that of compromise of trade secrets. The Agency safeguards system calls for strict protection and limitation on distribution of all information gained by inspectors in the course of their activities. When reactors are sold, particularly abroad, the information which can be acquired from observing these reactors must in any case be assumed to have been placed in the public domain. Taken together, these facts lead to the conclusion that there is no serious risk of loss of trade secrets and proprietary information through Agency inspections.

In the development of the Agency system, two kinds of questions arose. The difficulty in distinguishing between these two questions led to a great deal of difficulty in reaching agreement of the system. Not simply for historic reasons but because this distinction is still important to the development of U. S. safeguards policy, it should be explained at this point.

The first question to be considered in the establishment of a safeguards system is: What are the circumstances which give rise to the application of the system in the first place? The second question is: What kind of safeguards procedures should be applied to those activities which for one reason or another, have become subject to the system? Under the Agency's statute, the Agency is authorized to apply safeguards under three circumstances: (a) where the Agency has assisted in the project, (b) where two parties to a bilateral agreement have requested the Agency to apply its safeguards, and (c) where a single nation voluntarily requests the Agency to apply its safeguards to the activity. That, of course, is the circumstance under which the Agency is applying safeguards at the Yankee reactor.

In the case where safeguards are based on assistance supplied by the Agency, the nature of the assistance which should give rise to safeguards must be determined. This same question arises in the development of national safeguards policy. There is a degree of assistance that is so remote, insignificant or generally available that it would be impracticable for a supplying country to require safeguards from a recipient country. Examples are often cited such as copper wire, nuts and bolts, concrete or steel, all of which may end up in a reactor, but whose supply can hardly be used as a basis for requiring safeguards. Thus, the question is presented of what is the nature and degree of assistance which when supplied by one country to another, or by the IAEA,

should give rise to, or "trigger", safeguards. Despite the fact that there is little likelihood that the IAEA will act as a major supplier of nuclear assistance, this question has been extensively debated in the IAEA.

The principle is now accepted in the Agency system that the nature of the safeguards to be applied to a particular project depends on the nature of the project, its productive capacity, etc., regardless of the circumstances under which the particular project came under the Agency safeguards system. Moreover, the emphasis in this system is on detecting the diversion of any fissionable material to military use -- regardless of whether the "trigger" item was material, equipment, or, perhaps, financial assistance. From the standpoint of what will trigger safeguards when supplied through the Agency, the general approach adopted is that Agency safeguards will be applied when the Agency has supplied either source or fissionable material, a reactor or substantial parts thereof, or several other specialized materials. In the case of material, exemption limits are specified. In the case of components of a reactor, the Board determines in each case whether the supply has been substantial enough to warrant the application of safeguards.

The Agency system recognizes, however, that when two parties to a bilateral arrangement request the Agency to apply its safeguards, the Agency may do so regardless of the nature of the supply arrangements between the two parties.

Since the Agency is not playing and is not expected to play a major supply role, these principles, despite the extent to which they were debated, are important primarily to the extent of the importance they may have on the policies of individual supplier countries. A major and continuing problem in the field of safeguards is the achievement of agreement on the items or activities which will form the basis for a requirement that safeguards be applied to the project being assisted. Competition among suppliers in safeguards would create a major threat to the system.

Problem Areas and Future Evolution

Safeguards to date have been applied only on a limited scale. All the indication from this experience, and from the basic technical considerations involved, are that effective safeguards can be developed and applied without undue interference to the design and operation of facilities and without significant effect on the cost of the finished product -- electric power. Nevertheless, more experience is needed. Inspection personnel must be increased many fold in number if the system is to grow with the growing application of nuclear power. The system must be expanded to encompass new types of facilities -- particularly large fabrication and reprocessing plants. The possible use of instruments to reduce manpower and inspection requirements must be further studied and exploited.

All of these are areas which are receiving active attention at the present time.

UNITED STATES BILATERAL SAFEGUARDS INSPECTIONS

Introduction

As pointed out in the paper on Technical Basis and Background of Safeguards, the safeguards system depends on two principal elements: First is the maintenance and review of records showing the receipt, production, consumption, transfer and present location of all nuclear material. The second is the undertaking of actual on-site inspections designed to determine the validity of these records and therefore the compliance with the commitment to peaceful uses. In this paper a summary description is given of the second element, inspections, as typically carried out in the U. S. bilateral program. Presentation of this summary does not set a prototype inspection. U. S. inspections have in the past varied from this description and it may be expected that in the future different procedures will be used. It should be noted particularly that most of the facilities which have been inspected so far have been research reactors and the related fuel fabrication facilities.

Planning the Inspection Schedule

Safeguards inspections are planned on a semi-annual basis. The determination of the frequency of inspection for a given facility follows the criteria adopted by the International Atomic Energy Agency. Under these criteria the frequency of inspection is a function of:

(a) The possession by the country of an irradiated fuel reprocessing facility;

(b) The nature of the reactor facility;

(c) The nature of the nuclear material used or produced in the reactor facility; and

(d) The amount of nuclear material used or produced in the reactor facility.

Inspection Preparation

The first step in preparing for an individual inspection is a detailed review of USAEC records on nuclear material and facilities subject to U. S. safeguards in a particular country. The periodic material balance reports submitted by the country are reviewed to determine nuclear material location for preparation of the inspection itinerary. The reports are also compared to USAEC records and differences, if any, are listed in the workpapers prepared for the inspection for resolution during the course of the inspection. Particular attention is paid to the country's listing of nuclear material processing and consumption losses and to the explanation for these losses. These are losses which are normal to the operation of nuclear fuel fabrication and chemical processing facilities. Of course, unusual losses are reported immediately and special inspections scheduled if necessary. Loss amounts are compared to those experienced in the past in similar processes and those, if any, that appear larger than might be expected are listed in the workpapers for investigation during the inspection. Also, included in the workpapers are descriptions, including quantity and type of material, of all U. S. nuclear material shipments to the country to be inspected.

Usually the U. S. Embassy is asked about three weeks before the scheduled beginning of the inspection to notify the host country of the planned inspection and suggested itinerary. On arriving at the country to be inspected the visit is coordinated with the control officer designated by the American Embassy or Consulate. Following this the Government Agency responsible for the implementation of the Agreement for Cooperation is usually visited to discuss inspection plans and itinerary.

Inspection Implementation

The type of inspection being described here does not include the element of physical security measures. The inspection therefore consists of:

(a) Review of reports and records;

(b) Examination of the facility and material under safeguards;

(c) Physical inventory to verify amounts of material by physical inspection, measurement and sampling;

(d) Examination and testing of measurement instruments.

If a country has a central point at which nuclear material records for the whole country are kept, the inspection is initiated with a review of these records. They are compared to the records kept by the USAEC and the differences and comments, if any, are discussed. The review at the central records station also permits the inspectors to obtain current information on material movements and the inspection itinerary is adjusted if necessary.

At each reactor, fuel fabrication plant, laboratory or other facilities, the inspection begins with a review of the records which are compared with USAEC records and also with the country's central records. At this point differences between these records and processing and operating losses are discussed. Following this, the inspection itinerary for the facility is planned so that the on-site verification of the accuracy of the records can be conducted with minimum interference with the operation of the facility.

For reactors the physical inventory usually begins with the fuel elements and other material in cold storage. Here the elements are counted and the number compared to that given in the records. In the cases where serial numbers are listed on the shipping documents these numbers are compared with those on the elements. Selected elements are then scanned with a gamma ray spectrometer to establish enriched uranium content.

Radioactive reactor fuel elements contained in hot storage are counted and Cerenkov radiation is noted when present. (Cerenkov radiation is characteristic to elements that have been used in an operating reactor.) The number of elements in hot storage is compared with the number listed in the facility records. When possible, hot elements are moved near the surface of the storage pool and the increase in radioactivity at the surface of the pool is observed. This is another qualitative indication to establish that the element had been in the operating core.

The quantity of nuclear material in the core of an operating reactor usually cannot be directly determined. During the inspection various indirect indications of this quantity are observed. Information on reactor power level is usually available from the main power meter and power can be calculated from coolant water inlet and outlet temperatures and the coolant water flow rate. The reactor control rod settings may be noted for comparison with past experience. The strip chart records for selected time periods are reviewed. At each opportunity instrument calibrations are observed and special calibrations include interchange of fuel elements and observation of the effect on control rod settings. At beam ports and other experimental facilities gamma ray fields are monitored using portable instruments carried by the inspectors. Gamma fields may also be detectable at the coolant loops, heat exchangers and ion exchange columns. These gamma ray measurements are qualitative and are useful mainly in giving independent confirmation of the fact of operation at power. At swimming pool type reactors the core is usually clearly visible from above the surface of the water which serves as the reactor shield and in these reactors the number of elements in the core can be counted and the Cerenkov radiation is visible. (In addition to this information obtained during inspections, a complete analysis of the spent fuel elements is obtained when they are reprocessed in the U. S. or in a safeguarded facility overseas.)

At facilities such as laboratories and fuel fabrication plants where nuclear material is found in fuel element form and other forms such as powder, solutions, metal, etc., material inventory is verified by piece count, where possible, and by weighing. Samples are taken of material in forms amenable to sampling and removed to USAEC laboratories for analysis. Where possible, inspectors also observe analysis of samples at facility laboratories to establish uranium content. Also, selected inventory samples are scanned by a portable gamma spectrometer to establish U-235 content.

For the analysis using gamma spectrometry, a portable gamma ray spectrometer similar to one used domestically on nuclear material surveys is used. The assay method utilized is based on the detection of gamma rays characteristic to the decay of U-235. The portable gamma ray spectrometer is used to detect and measure the intensity of this characteristic gamma ray being emitted from a sample. The results are then compared to the data previously obtained from a similar sample containing a known amount of U-235 to give an indication of the U-235 content. The safeguards group has developed procedures to extend the use of this instrument to the assay of enriched uranium in plate type fuel elements, fuel plates, fuel plate cores, powders, and pellets. In addition the instrument is used to establish the presence of enriched uranium in forms difficult to assay such as in metal scrap and in UF_6 cylinders.

The presence of plutonium in a container can also be established by plotting its gamma spectrum. The results obtained from the use of this instrument during actual inspections have been consistent with those results obtained during the calibration of the instrument at domestic fuel fabrication facilities.

Finally, following the records review and inventory verification at research facilities -- research reactors and laboratories -- the programs and experiments, using facilities and nuclear material subject to safeguards, are reviewed in detail to ascertain that the research does not contribute to any military purpose.

SCOPE OF SAFEGUARDS

U. S. Safeguards:

1. Source material and special nuclear material
   (a) transferred from U. S. to other country
   (b) produced in or by use of U. S. material, equipment or devices
2. Reactors and other equipment and devices transferred from U. S. to other country.
3. Facilities, equipment and devices using, containing or processing U. S. supplied materials and equipment.
4. Tritium
5. Certain neutron generators.

Safeguards Rights Are Obtained as Result of Supply of:

1. Source material.
2. Special nuclear material.
3. Complete reactors.
4. Substantial assistance in the nuclear field including following reactor components and materials:
   (a) reactor control rods and reactor control rod drive
   (b) reactor vessels
   (c) reactor pressure tube
   (d) reactor fuel charging and discharging machine
   (e) reactor coolant pumps and blowers
   (f) heavy water, more than three tons
   (g) graphite, nuclear grade, more than 100 tons
   (h) zirconium and alloys, nuclear grade, more than 500 kgs.

PROCEDURES FOR EXPORT AND IMPORT OF SPECIAL NUCLEAR MATERIAL
UNDER AGREEMENTS FOR COOPERATION IN CIVIL USES OF ATOMIC ENERGY

Exports of special nuclear material to foreign nations or groups of nations are authorized and implemented by the USAEC pursuant to the provisions of specific contractual agreements between the USAEC and the concerned foreign nation. The material to be exported may be provided either from the inventory of a USAEC facility or, where the material is to be fabricated or otherwise prepared by a private contractor prior to its export, from the inventory of a licensee of the USAEC engaged by the foreign nation. In the latter case, the USAEC authorizes release of the material from one of its supplying offices to the licensee, unless the material is to be drawn from the licensee's inventory of material. Measurements of the special nuclear material to be exported are determined prior to the start of its transport to a port of export. If the material is supplied directly to the foreign nation from a USAEC supplying office, the measurement determinations are made by the USAEC using its procedures and facilities, unless other measurement procedures are agreed upon. Where a domestic licensee of the USAEC has been engaged by the foreign nation for fabrication or preparation of the material, the domestic licensee certifies to the USAEC the quantities and enrichments of special nuclear material in its finished product. This certification, which is subject to any reviews or analysis the USAEC may wish to make, establishes, upon its acceptance by the USAEC, the quantities and enrichments of special nuclear material in the export shipment. When the material is ready for delivery, the concerned foreign nation prepares an "Export

Declaration" (Bureau of Census Form 7525V) covering the shipment, and submits the declaration to the USAEC for approval and authorization. Upon USAEC endorsement of the export declaration, the material is released for transport to a designated port of export. Delivery of the special nuclear material to the foreign nation is made at the port of export and is evidenced by a receipt submitted by the foreign nation indicating the exact quantity of material received, and the date and place of its delivery.

Imports of special nuclear material consist of U.S. supplied material returned from abroad, most commonly pursuant to reprocessing agreements between the USAEC and a foreign nation. Ad hoc procedures, based upon the nature of the material being imported and the purpose of its importation, have been developed for the relatively few imports experienced thus far. In practice, the party desiring to effect an import is required to provide the USAEC with advance notice (normally ninety days) of all details of the shipment, including nature and quantity of the material, shipping date, port of entry, consignee, and detailed intra-U.S. transportation arrangements. Upon issuance of a specific approval by the USAEC, the foreign party proceeds with shipping arrangements. Authorization of the import is effected by the USAEC by appropriate certification to the Bureau of Customs upon arrival of the material at the port of entry. Immediately following import, the material is dispatched by common or contract carrier to the U. S. consignee, either a USAEC facility or a facility of a domestic licensee.

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Chapter II

Control of SNM of US Origin Transferred Outside the US for Civil Uses

Section 123 of the 1954 Act specifies that special nuclear materials and production or utilization facilities may not be provided any nation (or group of nations) unless an agreement for cooperation, approved by the President and submitted to the JCAE, has been executed. Each agreement for cooperation in civil uses of atomic energy is required to include a "guaranty by the cooperating party that any material to be transferred pursuant to such agreement will not be used for atomic weapons, or for research on or development of atomic weapons or for any other military purpose". Also required to be included is a "guaranty by the cooperating party that any material ... to be transferred pursuant to the agreement for cooperation will not be transferred to unauthorized persons or beyond the jurisdiction of the cooperating party, except as specified in the agreement for cooperation".

In the technical sense, safeguards--as used here--means a system of controls designed to detect any diversion of materials or equipment committed to the peaceful uses of atomic energy to any military purpose. Safeguards, therefore, in the direct sense detect, rather than prevent, diversion. Their effectiveness in preventing diversion is derived indirectly from the deterrent effect which the consequences of detection may exert on the would-be diverter. Hence the aim of safeguards is to detect diversion

to any military purpose. Many possible types of violations are of interest to the safeguard system--for example, the use of a reactor to undertake research on reactors for military purposes. However, the most serious and important type of violations is the diversion of fissionable material to research on or use in atomic weapons. The fissionable material subject to safeguards and, thus susceptible to diversion may be either that supplied directly from one country to another or that produced from the use of a reactor or materials supplied under safeguards.

The 1954 Act does not require that the US exercise any effort to assure that the specified guarantees in agreements for cooperation in peaceful uses are fulfilled by the cooperating nation. The AEC, however, as a matter of policy, has included in all "comprehensive" (i.e., not limited to research activities) agreements, (with the exception of those with Canada, the United Kingdom, Euratom and IAEA) "safeguard" provisions giving the US the right to send into the cooperating nation, US inspectors who shall have access at all times and to all places and data as necessary to account for material and to determine that the guarantees are being observed. In addition to this broad right, supplementary but important rights are provided, including the right to approve the design of facilities from the standpoint of whether effective safeguards can be applied, the right to require the maintenance of satisfactory records, and the right to approve the means for reprocessing material from the standpoint of effective application of safeguards. In recent years, as each

agreement for cooperation has been renewed, the US has sought to secure agreement with the other government that such safeguards should be implemented by the IAEA, rather than by US inspectors. That type of agreement, in which the parties agree that IAEA implement safeguards is generally referred to as a "trilateral" to distinguish it from the "bilateral" type in which the US applies the safeguards.

In the case of Canada and the UK, no safeguards rights are included in the present agreements for cooperation, although the guarantees, of course, are included.

In the case of Euratom, that organization is responsible for implementing the safeguards, but must also assure that the system employed is reasonably compatible with that used by IAEA. Euratom is also obliged to consult with AEC in formulating and implementing its safeguards system. The US has the right to verify by mutually approved scientific methods the effectiveness of the safeguards being applied by Euratom to US-supplied material.

As mentioned in Chapter I, the "trilateral" agreements provide for the US to guarantee that any SNM received from the other government would not be used to further any military purpose and for the acceptance by the US of IAEA safeguards on such material. The agreement with Euratom also provides for such a US guarantee and the right by Euratom to verify the effectiveness of controls placed by the US upon SNM supplied by Euratom.

The Division of International Affairs is responsible for administering the program of safeguards under agreements for cooperation, including (1) development of the systems to be employed, (2) implementation of the safeguards, including the maintenance of records and receipt of reports, and conducting on-site inspections, and (3) liaison with Euratom and the IAEA. An over-all effort is made to achieve comparability between the US bilaterals, Euratom and IAEA systems. DIA has recently established a Technical Advisory Panel on Peaceful Use Safeguards. DIA also calls upon the experience and knowledge of the AEC's Nuclear Materials Management organization and its Advisory Committee on Standard Materials and Method of Measurements.

The safeguards system employed by DIA depends upon two principal elements:

(a) Maintenance and review of records showing the receipt, production, consumption, transfer, and present location of all SNM.

(b) On-site inspections designed to determine the validity of those records.

The type of on-site inspection currently being carried out by DIA with respect to SNM consists of:

(a) Review of reports and records;

(b) Examination of the facility and material under safeguards;

(c) Physical inventory to verify amounts of material by physical inspection, measurement, and sampling;

(d) Examination and testing of measurement instruments.

In addition to the foregoing type of inspection related to control of materials, DIA inspections include examination of facilities and equipment, such as reactors, to assure that they are not being utilized to further any military purpose.

The frequency of inspections is determined by DIA, who follow criteria adopted by the IAEA. Those criteria consider the nature of the facilities involved, the nature and amount of materials used or produced in the facilities and the existence of reactor fuel reprocessing facilities within the country. For certain types of large facilities, the stationing of resident inspectors is not precluded, under either AEC or IAEA criteria.

The installation of tamper-proof seals or instruments is being considered for possible application as means for determining that a diversion of SNM could have taken place between inspections of certain kinds of facilities.

Further details of the safeguards employed by DIA are described in Annex D of this report. It should be noted that most of the facilities inspected to date by DIA have been research reactors and related fuel fabrication facilities involving relatively small amounts of SNM. This is also largely the case with Euratom and IAEA, although those organizations have been confronted with the necessity to safeguard some large facilities, such as operating power reactors. The development of detailed international safeguard procedures for SNM in chemical processing facilities is currently receiving attention.

It is important to bear in mind that the access provided to the US, under the "bilaterals" and to IAEA, under the "trilaterals", includes -- access at all times, to all places and to all data.

In carrying out its responsibilities for liaison with the IAEA safeguards organizations, DIA has been involved in the development of IAEA safeguards policies and procedures and continue to maintain close liaison with their organizations and their inspections.

If the present US policy of encouraging the utilization of IAEA safeguards in connection with US agreements for cooperation is completely successful, there may be no necessity, in time, for the US to maintain an independent safeguards inspection staff. It will be necessary, however, even in that event, to maintain US personnel (probably within AEC) who are conversant with international safeguards concepts and practices in order that the US may participate in the development, implementation, and evaluation of IAEA and Euratom safeguards.

The over-all effectiveness of the international or domestic procedures depends, to some extent, upon deterrents which impose substantial, but unmeasurable, inhibitions against unauthorized or unlawful diversion of SNM. Domestically, such inhibitions include criminal penalties, financial interest in the value of SNM, and risk of loss of a license. Internationally, the risk of raising questions concerning the sanctity of solemn guarantees given by a sovereign government and the consequent risk of being cut off from future supplies of power reactors and nuclear fuel, for example, impose real inhibitions upon that government.

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