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Hanford PUREX Exercise - March 29 to 31, 1994

Special Nuclear Materials Cutoff Exercise: Issues and Lessons Learned

Volume 3 of 3: Appendixes D - J

R. A. Libby
J. E. Segal
W. D. Stanbro
C. Davis

August 1995

Prepared for the Negotiations and Analysis Division Office of Arms Control and Nonproliferation U.S. Department of Energy under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy by Battelle Memorial Institute

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Pacific Northwest Laboratory
Richland, Washington 99352

(a) U.S. Department of Energy
(b) Los Alamos National Laboratory

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U.S. IAEA Treaty

ATOMIC ENERGY

Application of Agency Safeguards in the United States

Agreement, With Protocol
Between the
UNITED STATES OF AMERICA
and the INTERNATIONAL ATOMIC
ENERGY AGENCY

Done at Vienna November 18, 1977

NOTE BY THE DEPARTMENT OF STATE

Pursuant to Public Law 89–497, approved July 8, 1966 (80 Stat. 271; 1 U.S.C. 113)—

". . . the Treaties and Other International Acts Series issued under the authority of the Secretary of State shall be competent evidence . . . of the treaties, international agreements other than treaties, and proclamations by the President of such treaties and international agreements other than treaties, as the case may be, therein contained, in all the courts of law and equity and of maritime jurisdiction, and in all the tribunals and public offices of the United States, and of the several States, without any further proof or authentication thereof."

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INTERNATIONAL ATOMIC ENERGY AGENCY

Atomic Energy: Application of Agency Safeguards in the United States

Agreement, with protocol, done at Vienna November 18, 1977;
Transmitted by the President of the United States of America to the Senate February 9, 1978 (S. Ex. B, 95th Cong., 2d Sess.);
Reported favorably by the Senate Committee on Foreign Relations June 27, 1980 (S. Ex. Rep. No. 96–42, 96th Cong., 2d Sess.);
Advice and consent to ratification by the Senate, subject to understandings, July 2, 1980;
Ratified by the President, subject to said understandings, July 31, 1980;
Proclaimed by the President December 31, 1980;
Entered into force December 9, 1980.

BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

A PROCLAMATION

CONSIDERING THAT:

The Agreement with the International Atomic Energy Agency for the Application of Safeguards in the United States of America, with Protocol, was initialed at Vienna on November 18, 1977, the text of which is hereto annexed;

The Senate of the United States of America by its resolution of July 2, 1980, two-thirds of the Senators present concurring therein, gave its advice and consent to ratification of the Agreement, with Protocol, subject to the following understandings:

1. That the President shall notify the Committee on Foreign Relations of the Senate and the Committee on Foreign Affairs of the House of Representatives of any proposed addition to the list, to be provided to the International Atomic Energy Agency pursuant to Article 1(b) of the Agreement, of nuclear facilities within the United States eligible for International Atomic Energy Agency inspections, together with an explanation of the basis upon which the determination was made that any such facility did not have a

such addition by joint resolution by reason of direct national security significance, under procedures identical to those provided for the consideration of resolutions pursuant to section 130 of the Atomic Energy Act of 1954 as amended.

2. That the President shall assure that concerned licensees within the United States are consulted in advance of, and that their views and interests are considered in, any negotiations with the International Atomic Energy Agency concerning the application to a particular facility of Subsidiary Arrangements made pursuant to Article 39 of the Agreement.

3. That the President shall establish and maintain an appropriate interagency mechanism, comprised of the relevant Executive Branch agencies, and with the participation of the Nuclear Regulatory Commission, under the chairmanship of the Department of State, for the purpose of coordinating policy, and of resolving disputes, relating to the implementation of International Atomic Energy Agency safeguards under the Agreement, and, further, that the Congress shall be kept informed of the functions and procedures of such interagency mechanism.

4. That in the event of any question of interpretation of the Agreement, the Nuclear Regulatory Commission shall seek and be bound by guidance from the President. Neither this understanding nor any other in this resolution shall in any way alter the responsibilities of the Nuclear Regulatory Commission under the Agreement or in any way limit the existing authorities and responsibilities of the Nuclear Regulatory Commission,

5. That the Agreement shall not be construed to require the communication to the International Atomic Energy Agency of "Restricted Data" controlled by the provisions of the Atomic Energy Act of 1954, as amended, including data concerning the design, manufacture, or utilization of atomic weapons.

The President of the United States of America ratified the Agreement, with Protocol, subject to the aforementioned understandings, on July 31, 1980, in pursuance of the advice and consent of the Senate;

The United States of America notified the International Atomic Energy Agency on December 9, 1980, that its constitutional and statutory requirements for entry into force of the Agreement, with Protocol, had been met;

The Agreement, with Protocol, subject to the understandings entered into force for the United States of America on December 9, 1980;

NOW, THEREFORE, I, Jimmy Carter, President of the United States of America, proclaim and make public the Agreement, with Protocol,

be observed and fulfilled with good faith on and after December 9, 1980, by the United States of America and by the citizens of the United States of America and all other persons subject to the jurisdiction thereof.

IN TESTIMONY WHEREOF, I have signed this proclamation and caused the Seal of the United States of America to be affixed.

DONE at the city of Washington this thirty-first day of December in the year of our Lord one thousand nine hundred eighty and of the Independence of the United States of America the two hundred fifth.

[SEAL]

JIMMY CARTER

By the President:
EDMUND S. MUSKIE
Secretary of State

AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE INTERNATIONAL ATOMIC ENERGY AGENCY FOR THE APPLICATION OF SAFEGUARDS IN THE UNITED STATES OF AMERICA

WHEREAS the United States of America (hereinafter referred to as the "United States") is a Party to the Treaty on the Non-Proliferation of Nuclear Weapons (hereinafter referred to as the "Treaty") which was opened for signature at London, Moscow and Washington on 1 July 1968 and which entered into force on 5 March 1970;[1]

WHEREAS States Parties to the Treaty undertake to co-operate in facilitating the application of International Atomic Energy Agency (hereinafter referred to as the "Agency") safeguards on peaceful nuclear activities;

WHEREAS non-nuclear-weapon States Parties to the Treaty undertake to accept safeguards, as set forth in an agreement to be negotiated and concluded with the Agency, on all source or special fissionable material in all their peaceful nuclear activities for the exclusive purpose of verification of the fulfilment of their obligations under the Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices;

WHEREAS the United States, a nuclear-weapon State as defined by the Treaty, has indicated that at such time as safeguards are being generally applied in accordance with paragraph 1 of Article III of the Treaty, the United States will permit the Agency to apply its safeguards to all nuclear activities in the United States—excluding only those with direct national security significance—by concluding a safeguards agreement with the Agency for that purpose;

WHEREAS the United States has made this offer and has entered into this agreement for the purpose of encouraging widespread adherence to the Treaty by demonstrating to non-nuclear-weapon States that they would not be placed at a commercial disadvantage by reason of the application of safeguards pursuant to the Treaty;

WHEREAS the purpose of a safeguards agreement giving effect to this offer by the United States would thus differ necessarily from the purposes of safeguards agreements concluded between the Agency and non-nuclear-weapon States Party to the Treaty;

WHEREAS it is in the interest of Members of the Agency, that, without prejudice to the principles and integrity of the Agency's safeguards system, the expenditure of the Agency's financial and other resources for implementation of such an agreement not exceed that necessary to accomplish the purpose of the Agreement;

WHEREAS the Agency is authorized, pursuant to Article III of the Statute of the International Atomic Energy Agency[2] (hereinafter referred to as the "Statute"), to conclude such a safeguards agreement;

[1] TIAS 6839; 21 UST 483.
[2] Done Oct. 26, 1956. TIAS 3873, 5284, 7668; 8 UST 1095; 14 UST 135; 24 UST 1637.

NOW, THEREFORE, the United States and the Agency have agreed as follows:

PART I

ARTICLE 1

(a) The United States undertakes to permit the Agency to apply safeguards, in accordance with the terms of this Agreement, on all source or special fissionable material in all facilities within the United States, excluding only those facilities associated with activities with direct national security significance to the United States, with a view to enabling the Agency to verify that such material is not withdrawn, except as provided for in this Agreement, from activities in facilities while such material is being safeguarded under this Agreement.

(b) The United States shall, upon entry in force of this Agreement, provide the Agency with a list of facilities within the United States not associated with activities with direct national security significance to the United States and may, in accordance with the procedures set forth in Part II of this Agreement, add facilities to or remove facilities from that list as it deems appropriate.

(c) The United States may, in accordance with the procedures set forth in this Agreement, withdraw nuclear material from activities in facilities included in the list referred to in Article 1(b).

ARTICLE 2

(a) The Agency shall have the right to apply safeguards, in accordance with the terms of this Agreement, on all source or special fissionable material in all facilities within the United States, excluding only those facilities associated with activities with direct national security significance to the United States, with a view to enabling the Agency to verify that such material is not withdrawn, except as provided for in this Agreement, from activities in facilities while such material is being safeguarded under this Agreement.

(b) The Agency shall, from time to time, identify to the United States those facilities, selected from the then current list provided by the United States in accordance with Article 1(b), in which the Agency wishes to apply safeguards, in accordance with the terms of this Agreement.

(c) In identifying facilities and in applying safeguards thereafter on source or special fissionable material in such facilities, the Agency shall proceed in a manner which the Agency and the United States mutually agree takes into account the requirement on the United States to avoid discriminatory treatment as between United States commercial firms similarly situated.

ARTICLE 3

(a) The United States and the Agency shall co-operate to facilitate the implementation of the safeguards provided for in this Agreement.

(b) The source or special fissionable material subject to safeguards under this Agreement shall be that material in those facilities which shall have been identified by the Agency at any given time pursuant to Article 2(b).

(c) The safeguards to be applied by the Agency under this Agreement on source or special fissionable material in facilities in the United States shall be implemented by the same procedures followed by the Agency in applying its safeguards on similar material in similar facilities in non-nuclear-weapon States under agreements pursuant to paragraph 1 of Article III of the Treaty.

ARTICLE 4

The safeguards provided for in this Agreement shall be implemented in a manner designed:

(a) To avoid hampering the economic and technological development of the United States or international co-operation in the field of peaceful nuclear activities, including international exchange of nuclear material;

(b) To avoid undue interference in peaceful nuclear activities of the United States and in particular in the operation of facilities; and

(c) To be consistent with prudent management practices required for the economic and safe conduct of nuclear activities.

ARTICLE 5

(a) The agency shall take every precaution to protect commercial and industrial secrets and other confidential information coming to its knowledge in the implementation of this Agreement.

(b) (i) The Agency shall not publish or communicate to any State, organization or person any information obtained by it in connection with the implementation of this Agreement, except that specific information relating to the implementation thereof may be given to the Board of Governors of the Agency (hereinafter referred to as "the Board") and to such Agency staff members as require such knowledge by reason of their official duties in connection with safeguards, but only to the extent necessary for the Agency to fulfill its responsibilities in implementing this Agreement.

(ii) Summarized information on nuclear material subject to safeguards under this Agreement may be published upon the decision of the Board if the United States agrees thereto.

(a) The Agency shall, in implementing safeguards pursuant to this Agreement, take full account of technological developments in the field of safeguards, and shall make every effort to ensure optimum cost-effectiveness and the application of the principle of safeguarding effectively the flow of nuclear material subject to safeguards under this Agreement by use of instruments and other techniques at certain strategic points to the extent that present or future technology permits.

(b) In order to ensure optimum cost-effectiveness, use shall be made, for example, of such means as:

(i) Containment as a means of defining material balance areas for accounting purposes;

(ii) Statistical techniques and random sampling in evaluating the flow of nuclear material; and

(iii) Concentration of verification procedures on those stages in the nuclear fuel cycle involving the production, processing, use or storage of nuclear material from which nuclear weapons or other nuclear explosive devices could readily be made, and minimization of verification procedures in respect of other nuclear material, on condition that this does not hamper the Agency in applying safeguards under this Agreement.

ARTICLE 7

(a) The United States shall establish and maintain a system of accounting for and control of all nuclear material subject to safeguards under this Agreement.

(b) The Agency shall apply safeguards in accordance with Article 3(c) in such a manner as to enable the Agency to verify, in ascertaining that there has been no withdrawal of nuclear material, except as provided for in this Agreement, from activities in facilities while such material is being safeguarded under this Agreement, findings of the accounting and control system of the United States. The Agency's verification shall include, inter alia, independent measurements and observations conducted by the Agency in accordance with the procedures specified in Part II. The Agency, in its verification, shall take due account of the technical effectiveness of the system of the United States.

ARTICLE 8

(a) In order to ensure the effective implementation of safeguards under this Agreement, the United States shall, in accordance with the provisions set out in Part II, provide the Agency with information concerning nuclear material subject to safeguards

under this Agreement and the features of facilities relevant to safeguarding such material.

(b) (i) The Agency shall require only the minimum amount of information and data consistent with carrying out its responsibilities under this Agreement.

(ii) Information pertaining to facilities shall be the minimum necessary for safeguarding nuclear material subject to safeguards under this Agreement.

(c) If the United States so requests, the Agency shall be prepared to examine on premises of the United States design information which the United States regards as being of particular sensitivity. Such information need not be physically transmitted to the Agency provided that it remains readily available for further examination by the Agency on premises of the United States.

ARTICLE 9

(a) (i) The Agency shall secure the consent of the United States to the designation of Agency inspectors to the United States.

(ii) If the United States, either upon proposal of a designation or at any other time after designation has been made, objects to the designation, the Agency shall propose to the United States an alternative designation or designations.

(iii) If, as a result of the repeated refusal of the United States to accept the designation of Agency inspectors, inspections to be conducted under this Agreement would be impeded, such refusal shall be considered by the Board, upon referral by the Director General of the Agency. (hereinafter referred to as "the Director General") with a view to its taking appropriate action.

(b) The United States shall take the necessary steps to ensure that Agency inspectors can effectively discharge their functions under this Agreement.

(c) The visits and activities of Agency inspectors shall be so arranged as:

(i) To reduce to a minimum the possible inconvenience and disturbance to the United States and to the peaceful nuclear activities inspected; and

(ii) To ensure protection of industrial secrets or any other confidential information coming to the inspectors' knowledge.

ARTICLE 10

The provisions of the International Organizations Immunities Act of the United States of America[1] shall apply to Agency inspectors performing functions in the United States under this Agreement and to any property of the Agency used by them.

[1] 59 Stat. 669; 22 U.S.C. §288 note.

ARTICLE 11

Safeguards shall terminate on nuclear material upon determination by the Agency that the material has been consumed, or has been diluted in such a way that it is no longer usable for any nuclear activity relevant from the point of view of safeguards, or has become practicably irrecoverable.

ARTICLE 12

(a) If the United States intends to exercise its right to withdraw nuclear material from activities in facilities identified by the Agency pursuant to Articles 2(b) and 39(b) other that those facilities removed, pursuant to Article 34(b)(i) from the list provided for by Article 1(b) and to transfer such material to a destination in the United States other than to a facility included in the list established and maintained pursuant to Articles 1(b) and 34, the United States shall notify the Agency in advance of such withdrawal. Nuclear material in respect of which such notification has been given shall cease to be subject to safeguards under this Agreement as from the time of its withdrawal.

(b) Nothing in this Agreement shall effect the right of the United States to transfer material subject to safeguards under this Agreement to destinations not within or under the jurisdiction of the United States. The United States shall provide the Agency with information with respect to such transfers in accordance with Article 89. The Agency shall keep records of each such transfer and, where applicable, of the re-application of safeguards to the transferred nuclear material.

ARTICLE 13

Where nuclear material subject to safeguards under this Agreement is to be used in non-nuclear activities, such as the production of alloys or ceramics, the United States shall agree with the Agency, before the material is so used, on the circumstances under which the safeguards on such material may be terminated.

ARTICLE 14

The United States and the Agency will bear the expenses incurred by them in implementing their respective responsibilities under this Agreement. However, if the United States or persons under its jurisdiction incur extraordinary expenses as a result of a specific request by the Agency, the Agency shall reimburse such expenses provided that it has agreed in advance to do so. In any case the Agency shall bear the cost of any additional measuring or sampling which inspectors may request.

ARTICLE 15

In carrying out its functions under this Agreement within the United States, the Agency and its personnel shall be covered to the same extent as nationals of the United States by any protection against third-party liability provided under the Price-Anderson Act, [1] including insurance or other indemnity coverage that may be required by the Price-Anderson Act with respect to nuclear incidents.

ARTICLE 16

Any claim by the United States against the Agency or by the Agency against the United States in respect of any damage resulting from the implementation of safeguards under this Agreement, other than damage arising out of a nuclear incident, shall be settled in accordance with international law.

ARTICLE 17

If the Board, upon report of the Director General, decides that an action by the United States is essential and urgent in order to ensure compliance with this Agreement, the Board may call upon the United States to take the required action without delay, irrespective of whether procedures have been invoked pursuant to Article 21 for the settlement of a dispute.

ARTICLE 18

If the Board, upon examination of relevant information reported to it by the Director General, determines there has been any non-compliance with this Agreement, the Board may call upon the United States to remedy forthwith such non-compliance. In the event there is a failure to take fully corrective action within a reasonable time, the Board may make the reports provided for in paragraph C of Article XII of the Statute and may also take, where applicable, the other measures provided for in that paragraph. In taking such action the Board shall take account of the degree of assurance provided by the safeguards measures that have been applied and shall afford the United States every reasonable opportunity to furnish the Board with any necessary reassurance.

ARTICLE 19

The United States and the Agency shall, at the request of either, consult about any question arising out of the interpretation or application of this Agreement.

ARTICLE 20

The United States shall have the right to request that any question arising out of the interpretation or application of this Agreement be considered by the Board. The Board shall invite the United States to participate in the discussion of any such question by the Board.

ARTICLE 21

Any dispute arising out of the interpretation or application of this Agreement, except a dispute with regard to a determination by the Board under Article 18 or an action taken by the Board pursuant to such a determination which is not settled by negotiation or another procedure agreed to by the United States and the Agency shall, at the request of either, be submitted to an arbitral tribunal composed as follows: The United States and the Agency shall each designate one arbitrator, and the two arbitrators so designated shall elect a third, who shall be the Chairman. If, within thirty days of the request for arbitration, either the United States or the Agency has not designated an arbitrator, either the United States or the Agency may request the President of the International Court of Justice to appoint an arbitrator. The same procedure shall apply if, within thirty days of the designation or appointment of the second arbitrator, the third arbitrator has not been elected. A majority of the members of the arbitral tribunal shall constitute a quorum, and all decisions shall require the concurrence of two arbitrators. The arbitral procedure shall be fixed by the tribunal. The decisions of the tribunal shall be binding on the United States and the Agency.

ARTICLE 22

The Parties shall institute steps to suspend the application of Agency safeguards in the United States under other safeguards agreements with the Agency while this Agreement is in force. However, the United States and the Agency shall ensure that nuclear material being safeguarded under this Agreement shall be at all times at least equivalent in amount and composition to that which would be subject to safeguards in the United States under the agreements in question. The detailed arrangements for the implementation of this provision shall be specified in the subsidiary arrangements provided for in Article 39, and shall reflect the nature of any undertaking given under such other safeguards agreements

ARTICLE 23

(a) The United States and the Agency shall, at the request of either, consult each other on amendments to this Agreement.

(b) All amendments shall require the agreement of the United States and the Agency.

ARTICLE 24

This Agreement or any amendments thereto shall enter into force on the date on which the Agency receives from the United States

[1] 71 Stat. 576; 42 U.S.C. §2210.

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written notification that statutory and constitutional requirements of the United States for entry into force have been met.[1]

ARTICLE 25

The Director General shall promptly inform all Member States of the Agency of the entry into force of this Agreement, or of any amendments thereto.

ARTICLE 26

The Agreement shall remain in force as long as the United States is a party to the Treaty except that the Parties to this Agreement shall, upon the request of either of them, consult and, to the extent mutually agreed, modify this Agreement in order to ensure that it continues to serve the purpose for which it was originally intended. If the Parties are unable after such consultation to agree upon necessary modifications, either Party may, upon six months' notice, terminate this Agreement.

PART II

ARTICLE 27

The purpose of this part of the Agreement is to specify the procedures to be applied in the implementation of the safeguards provisions of Part I.

ARTICLE 28

The objective of the safeguards procedures set forth in this part of the Agreement is the timely detection of withdrawal, other than in accordance with the terms of this Agreement, of significant quantities of nuclear material from activities in facilities while such material is being safeguarded under this Agreement.

ARTICLE 29

For the purpose of achieving the objective set forth in Article 28, material accountancy shall be used as a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures.

ARTICLE 30

The technical conclusion of the Agency's verification activities shall be a statement, in respect of each material balance area, of the amount of material unaccounted for over a specific period, and giving the limits of accuracy of the amounts stated.

ARTICLE 31

Pursuant to Article 7, the Agency, in carrying out its verification activities, shall make full use of the United States' system of accounting for and control of all nuclear material subject to safeguards under this Agreement and shall avoid unnecessary duplication of the United States' accounting and control activities.

[1] Dec. 9, 1980.

ARTICLE 32

The United States' system of accounting for and control of all nuclear material subject to safeguards under this Agreement shall be based on a structure of material balance areas, and shall make provision, as appropriate and specified in the Subsidiary Arrangements, for the establishment of such measures as:

(a) A measurement system for the determination of the quantities of nuclear material received, produced, shipped, lost or otherwise removed from inventory, and the quantities on inventory.

(b) The evaluation of precision and accuracy of measurements and the estimation of measurement uncertainty;

(c) Procedures for identifying, reviewing and evaluating differences in shipper/receiver measurements;

(d) Procedures for taking a physical inventory;

(e) Procedures for the evaluation of accumulations of unmeasured inventory and unmeasured losses;

(f) A system of records and reports showing, for each material balance area, the inventory of nuclear material and the changes in that inventory including receipts into and transfers out of the material balance area;

(g) Provisions to ensure that the accounting procedures and arrangements are being operated correctly; and

(h) Procedures for the provision of reports to the Agency in accordance with Articles 57 through 63 and 65 through 67.

ARTICLE 33

Safeguards under this Agreement shall not apply to material in mining or ore processing activities.

ARTICLE 34

The United States may, at any time, notify the Agency of any facility or facilities to be added to or removed from the list provided for in Article 1(b):

(a) In case of addition to the list, the notification shall specify the facility or facilities to be added to the list and the date upon which the addition is to take effect;

(b) In the case of removal from the list of a facility or facilities then currently identified pursuant to Articles 2(b) or 39(b):

(i) The Agency shall be notified in advance and the notification shall specify: the facility or facilities being removed, the date of removal, and the quantity and composition of the nuclear material contained therein at the time of notification. In exceptional circumstances, the United States may remove facilities without giving advance notification;

(ii) Any facility in respect of which notification has been given in accordance with sub-paragraph (i) shall be removed from the list and the nuclear material contained therein shall cease to be subject to safeguards under this Agreement in accordance with and at the time specified in the notification by the United States.

(c) In the case of removal from the list of a facility or facilities not then currently identified pursuant to Articles 2(b) or 39(b), the notification shall specify the facility or facilities being removed and the date of removal. Such facility or facilities shall be removed from the list at the time specified in the notification by the United States.

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ARTICLE 35

(a) Safeguards shall terminate on nuclear material subject to safeguards under this Agreement, under the conditions set forth in Article 11. Where the conditions of that Article are not met, but the United States considers that the recovery of safeguarded nuclear material from residues is not for the time being practicable or desirable, the United States and the Agency shall consult on the appropriate safeguards measures to be applied.

(b) Safeguards shall terminate on nuclear material subject to safeguards under this Agreement, under the conditions set forth in Article 13, provided that the United States and the Agency agree that such nuclear material is practicably irrecoverable.

ARTICLE 36

At the request of the United States, the Agency shall exempt from safeguards nuclear material, which would otherwise be subject to safeguards under this Agreement, as follows:

(a) Special fissionable material, when it is used in gram quantities or less as a sensing component in instruments;

(b) Nuclear material, when it is used in non-nuclear activities in accordance with Article 13, if such nuclear material is recoverable; and

(c) Plutonium with an isotopic concentration of plutonium-238 exceeding 80%.

ARTICLE 37

At the request of the United States, the Agency shall exempt from safeguards nuclear material that would otherwise be subject to safeguards under this Agreement, provided that the total quantity of nuclear material which has been exempted in the United States in accordance with this Article may not at any time exceed:

(a) One kilogram in total of special fissionable material, which may consist of one or more of the following:

(i) Plutonium;

(ii) Uranium with an enrichment of 0.2 (20%) and above, taken account of by multiplying its weight by its enrichment; and

(iii) Uranium with an enrichment below 0.2 (20%) and above that of natural uranium, taken account of by multiplying its weight by five times the square of its enrichment;

(b) Ten metric tons in total of natural uranium and depleted uranium with an enrichment above 0.005 (0.5%);

(c) Twenty metric tons of depleted uranium with an enrichment of 0.005 (0.5%) or below; and

(d) Twenty metric tons of thorium;

or such greater amounts as may be specified by the Board for uniform application.

ARTICLE 38

If exempted nuclear material is to be processed or stored together with nuclear material subject to safeguards under this Agreement, provision shall be made for the re-application of safeguards thereto.

ARTICLE 39

(a) The United States and the Agency shall make Subsidiary Arrangements which shall:

(i) contain a current listing of those facilities identified by the Agency pursuant to Article 2(b) and thus containing nuclear material subject to safeguards under this Agreement; and

(ii) specify in detail, to the extent necessary to permit the Agency to fulfil its responsibilities under this Agreement in an effective and efficient manner, how the procedures laid down in this Agreement are to be applied.

(b) (i) After entry into force of this Agreement, the Agency shall identify to the United States, from the list provided in accordance with Article 1(b), those facilities to be included in the initial Subsidiary Arrangements listing;

(ii) The Agency may thereafter identify for inclusion in the Subsidiary Arrangements listing additional facilities from the list provided in accordance with Article 1(b) as that list may have been modified in accordance with Article 34.

(c) The Agency shall also designate to the United States those facilities to be removed from the Subsidiary Arrangements listing which have not otherwise been removed pursuant to notification by the United States in accordance with Article 34. Such facility or facilities shall be removed from the Subsidiary Arrangements listing upon such designation to the United States.

(d) The Subsidiary Arrangements may be extended or changed by agreement between the Agency and the United States without amendment to this Agreement.

ARTICLE 40

(a) With respect to those facilities which shall have been identified by the Agency in accordance with Article 39(b)(i), such Subsidiary Arrangements shall enter into force at the same time as, or as soon as possible after, entry into force of this Agreement. The United States and the Agency shall make every effort to achieve their entry into force within 90 days after entry into force of this Agreement; an extension of that period shall require agreement between the United States and the Agency.

(b) With respect to facilities which, after the entry into force of this Agreement, have been identified by the Agency in accordance with Article 39(b)(ii) for inclusion in the Subsidiary Arrangements listing, the United States and the Agency shall make every effort to achieve the entry into force of such Subsidiary Arrangements within ninety days following such identification to the United States; an extension of that period shall require agreement between the Agency and the United States.

(c) Upon identification of a facility by the Agency in accordance with Article 39(b), the United States shall provide the Agency promptly with the information required for completing the Subsidiary Arrangements, and the Agency shall have the right to apply the procedures set forth in this Agreement to the nuclear material listed in the inventory provided for in Article 41, even if the Subsidiary Arrangements have not yet entered into force.

ARTICLE 41

The Agency shall establish, on the basis of the initial reports referred to in Article 60(a) below, a unified inventory of all nuclear material in the United States subject to safeguards under this Agreement, irrespective of its origin, and shall maintain this inventory on the basis of subsequent reports concerning those facilities, of the initial reports referred to in Article 60(b), of subsequent reports concerning

the facilities listed pursuant to Article 39(b)(ii), and of the results of its verification activities. Copies of the inventory shall be made available to the United States at intervals to be agreed.

ARTICLE 42

Pursuant to Article 8, design information in respect of facilities identified by the Agency in accordance with Article 39(b)(i) shall be provided to the Agency during the discussion of the Subsidiary Arrangements. The time limits for the provision of design information in respect of any facility which is identified by the Agency in accordance with Article 39(b)(ii) shall be specified in the Subsidiary Arrangements and such information shall be provided as early as possible after such identification.

ARTICLE 43

The design information to be provided to the Agency shall include, in respect of each facility identified by the Agency in accordance with Article 39(b), when applicable:

(a) The identification of the facility, stating its general character, purpose, nominal capacity and geographic location, and the name and address to be used for routine business purposes;

(b) A description of the general arrangement of the facility with reference, to the extent feasible, to the form, location and flow of nuclear material and to the general layout of important items of equipment which use, produce or process nuclear material;

(c) A description of features of the facility relating to material accountancy, containment and surveillance; and

(d) A description of the existing and proposed procedures at the facility for nuclear material accountancy and control, with special reference to material balance areas established by the operator, measurements of flow and procedures for physical inventory taking.

ARTICLE 44

Other information relevant to the application of safeguards shall also be provided to the Agency in respect of each facility identified by the Agency in accordance with Article 39(b), in particular on organizational responsibility for material accountancy and control. The United States shall provide the Agency with supplementary information on the health and safety procedures which the Agency shall observe and with which the inspectors shall comply at the facility.

ARTICLE 45

The Agency shall be provided with design information in respect of a modification relevant for safeguards purposes, for examination,

and shall be informed of any change in the information provided to it under Article 44, sufficiently in advance for the safeguards procedures to be adjusted when necessary.

ARTICLE 46

The design information provided to the Agency shall be used for the following purposes:

(a) To identify the features of facilities and nuclear material relevant to the application of safeguards to nuclear material in sufficient detail to facilitate verification;

(b) To determine material balance areas to be used for Agency accounting purposes and to select those strategic points which are key measurement points and which will be used to determine flow and inventory of nuclear material; in determining such material balance areas the Agency shall, inter alia, use the following criteria:

(i) The size of the material balance area shall be related to the accuracy with which the material balance can be established;

(ii) In determining the material balance area, advantage shall be taken of any opportunity to use containment and surveillance to help ensure the completeness of flow measurements and thereby to simplify the application of safeguards and to concentrate measurement efforts at key measurement points;

(iii) A number of material balance areas in use at a facility or at distinct sites may be combined in one material balance area to be used for Agency accounting purposes when the Agency determines that this is consistent with its verification requirements; and

(iv) A special material balance area may be established at the request of the United States around a process step involving commercially sensitive information;

(c) To establish the nominal timing and procedures for taking of physical inventory of nuclear material for Agency accounting purposes;

(d) To establish the records and reports requirements and records evaluation procedures;

(e) To establish requirements and procedures for verification of the quantity and location of nuclear material; and

(f) To select appropriate combinations of containment and surveillance methods and techniques at the strategic points at which they are to be applied.

The results of the examination of the design information shall be included in the Subsidiary Arrangements.

ARTICLE 47

Design information shall be re-examined in the light of changes in operating conditions, of developments in safeguards technology or of experience in the application of verification procedures, with a view to modifying the action the Agency has taken pursuant to Article 46.

ARTICLE 48

The Agency, in co-operation with the United States, may send inspectors to facilities to verify the design information provided to the Agency pursuant to Article 42 through 45, for the purposes stated in Article 46.

ARTICLE 49

In establishing a national system of materials control as referred to in Article 7, the United States shall arrange that records are kept in respect of each material balance area determined in accordance with Article 46(b). The records to be kept shall be described in the Subsidiary Arrangements.

ARTICLE 50

The United States shall make arrangements to facilitate the examination of records referred to in Article 49 by inspectors.

ARTICLE 51

Records referred to in Article 49 shall be retained for at least five years.

ARTICLE 52

Records referred to in Article 49 shall consist, as appropriate, of:

(a) Accounting records of all nuclear material subject to safeguards under this Agreement; and

(b) Operating records for facilities containing such nuclear material.

ARTICLE 53

The system of measurements on which the records used for the preparation of reports are based shall either conform to the latest international standards or be equivalent in quality to such standards.

ARTICLE 54

The accounting records referred to in Article 52(a) shall set forth the following in respect of each material balance area determined in accordance with Article 46(b):

(a) All inventory changes, so as to permit a determination of the book inventory at any time;

(b) All measurement results that are used for determination of the physical inventory; and

(c) All adjustments and corrections that have been made in respect of inventory changes, book inventories and physical inventories.

ARTICLE 55

For all inventory changes and physical inventories the records referred to in Article 52(a) shall show, in respect of each batch of nuclear material: material identification, batch data and source data. The records shall account for uranium, thorium and plutonium separately in each batch of nuclear material. For each inventory change, the date of the inventory change and, when appropriate, the originating material balance area and the receiving material balance area or the recipient shall be indicated.

ARTICLE 56

The operating records referred to in Article 52(b) shall set forth, as appropriate, in respect of each material balance area determined in accordance with Article 46(b):

(a) Those operating data which are used to establish changes in the quantities and composition of nuclear material;

(b) The data obtained from the calibration of tanks and instruments and from sampling and analyses, the procedures to control the quality of measurements and the derived estimates of random and systematic error;

(c) A description of the sequence of the actions taken in preparing for, and in taking, a physical inventory, in order to ensure that it is correct and complete; and

(d) A description of the actions taken in order to ascertain the cause and magnitude of any accidental or unmeasured loss that might occur.

ARTICLE 57

The United States shall provide the Agency with reports as detailed in Articles 58 through 67 in respect of nuclear material subject to safeguards under this Agreement.

ARTICLE 58

Reports shall be made in English.

ARTICLE 59

Reports shall be based on the records kept in accordance with Articles 49 through 56 and shall consist, as appropriate, of accounting reports and special reports.

ARTICLE 60

The United States shall provide the Agency with an initial report on all nuclear material contained in each facility which becomes listed in the Subsidiary Arrangements in accordance with Article 39(b):

(a) With respect to those facilities listed pursuant to Article 39(b)(i), such reports shall be dispatched to the Agency within thirty days of the last day of the calendar month in which this Agreement enters into force, and shall reflect the situation as of the last day of that month.

(b) With respect to each facility listed pursuant to Article 39(b)(ii), an initial report shall be dispatched to the Agency within thirty days of the last day of the calendar month in which the Agency identifies the facility to the United States and shall reflect the situation as of the last day of that month.

ARTICLE 61

The United States shall provide the Agency with the following accounting reports for each material balance area determined in accordance with Article 46(b):

(a) Inventory change reports showing all changes in the inventory of nuclear material. The reports shall be dispatched as soon as possible and in any event within thirty days after the end of the month in which the inventory changes occurred or were established; and

(b) Material balance reports showing the material balance based on a physical inventory of nuclear material actually present in the material balance area. The reports shall be dispatched as soon as possible and in any event within thirty days after the physical inventory has been taken.

The reports shall be based on data available as of the date of reporting and may be corrected at a later date, as required.

ARTICLE 62

Inventory change reports submitted in accordance with Article 61(a) shall specify identification and batch data for each batch of nuclear material, the date of the inventory change, and, as appropriate, the originating material balance area and the receiving material balance area or the recipient. These reports shall be accompanied by concise notes:

(a) Explaining the inventory changes, on the basis of the operating data contained in the operating records provided for under Article 56(a); and

(b) Describing, as specified in the Subsidiary Arrangements, the anticipated operational programme, particularly the taking of a physical inventory.

ARTICLE 63

The United States shall report each inventory change, adjustment and correction, either periodically in a consolidated list or individually. Inventory changes shall be reported in terms of batches. As specified in the Subsidiary Arrangements, small changes in inventory of nuclear materials, such as transfers of analytical samples, may be combine in one batch and reported as one inventory change.

ARTICLE 64

The Agency shall provide the United States with semi-annual statements of book inventory of nuclear material subject to safeguards under this Agreement, for each material balance area, as based on the inventory change reports for the period covered by each such statement.

ARTICLE 65

Material balance reports submitted in accordance with Article 61(b) shall include the following entries, unless otherwise agreed by the United States and the Agency:

(a) Beginning physical inventory;

(b) Inventory changes (first increases, then decreases);

(c) Ending book inventory;

(d) Shipper/receiver differences;

(e) Adjusted ending book inventory;

(f) Ending physical inventory; and

(g) Material unaccounted for.

A statement of the physical inventory, listing all batches separately and specifying material identification and batch data for each batch, shall be attached to each material balance report.

ARTICLE 66

The United States shall make special reports without delay:

(a) If any unusual incident or circumstances lead the United States to believe that there is or may have been loss of nuclear material subject to safeguards under this Agreement that exceeds the limits specified for this purpose in the Subsidiary Arrangements; or

(b) If the containment has unexpectedly changed from that specified in the Subsidiary Arrangements to the extent that unauthorized removal of nuclear material subject to safeguards under this Agreement has become possible.

ARTICLE 67

If the Agency so requests, the United States shall provide it with amplifications or clarifications of any report submitted in accordance

with Articles 57 through 63, 65 and 66, in so far as relevant for the purpose of safeguards.

ARTICLE 68

The Agency shall have the right to make inspections as provided for in Articles 69 through 82.

ARTICLE 69

The Agency may make ad hoc inspections in order to:

(a) Verify the information contained in the initial reports submitted in accordance with Article 60;

(b) Identify and verify changes in the situation which have occurred since the date of the relevant initial report; and

(c) Identify and if possible verify the quantity and composition of the nuclear material subject to safeguards under this Agreement in respect of which the information referred to in Article 89(a) has been provided to the Agency.

ARTICLE 70

The Agency may make routine inspections in order to:

(a) Verify that reports submitted pursuant to Articles 57 through 63, 65 and 66 are consistent with records kept pursuant to Articles 49 through 56;

(b) Verify the location, identity, quantity and composition of all nuclear material subject to safeguards under this Agreement; and

(c) Verify information on the possible causes of material unaccounted for, shipper/receiver differences and uncertainties in the book inventory.

ARTICLE 71

Subject to the procedures laid down in Article 75, the Agency may make special inspections:

(a) In order to verify the information contained in special reports submitted in accordance with Article 66; or

(b) If the Agency considers that information made available by the United States, including explanations from the United States and information obtained from routine inspections, is not adequate for the Agency to fulfil its responsibilities under this Agreement.

An inspection shall be deemed to be special when it is either additional to the routine inspection effort provided for in Articles 76 through 80, or involves access to information or locations in addition to the access specified in Article 74 for ad hoc and routine inspections, or both.

ARTICLE 72

For the purposes specified in Articles 69 through 71, the Agency may:

(a) Examine the records kept pursuant to Articles 49 through 56;

(b) Make independent measurements of all nuclear material subject to safeguards under this Agreement;

(c) Verify the functioning and calibration of instruments and other measuring and control equipment;

(d) Apply and make use of surveillance and containment measures; and

(e) Use other objective methods which have been demonstrated to be technically feasible.

ARTICLE 73

Within the scope of Article 72, the Agency shall be enabled:

(a) To observe that samples at key measurement points for material balance accountancy are taken in accordance with procedures which produce representative samples, to observe the treatment and analysis of the samples and to obtain duplicates of such samples;

(b) To observe that the measurements of nuclear material at key measurement points for material balance accountancy are representative, and to observe the calibration of the instruments and equipment involved;

(c) To make arrangements with the United States that, if necessary:

(i) Additional measurements are made and additional samples taken for the Agency's use;

(ii) The Agency's standard analytical samples are analysed;

(iii) Appropriate absolute standards are used in calibrating instruments and other equipment; and

v) Other calibrations are (icarried out;

(d) To arrange to use its own equipment for independent measurement and surveillance, and if so agreed and specified in the Subsidiary Arrangements to arrange to install such equipment;

(e) To apply its seals and other identifying and tamper-indicating devices to containments, if so agreed and specified in the Subsidiary Arrangements; and

(f) To make arrangements with the United States for the shipping of samples taken for the Agency's use.

ARTICLE 74

(a) For the purposes specified in Article 69 (a) and (b) and until such time as the strategic points have been specified in the Subsidiary Arrangements, Agency inspectors shall have access to any location where the initial report or any inspections carried out therewith indicate that nuclear material subject to safeguards under this Agreement is present.

(b) For the purposes specified in Article 69(c), the inspectors shall have access to any facility identified pursuant to Articles 2(b) or 39(b) in which nuclear material referred to in Article 69(c) is located.

(c) For the purposes specified in Article 70 the inspectors shall have access only to the strategic points specified in the Subsidiary Arrangements and to the records maintained pursuant to Articles 49 through 56; and

(d) In the event of the United States concluding that any unusual circumstances require extended limitations on access by the Agency, the United States and the Agency shall promptly make arrangements with a view to enabling the Agency to discharge its safeguards responsibilities in the light of these limitations. The Director General shall report each such arrangement to the Board.

ARTICLE 75

In circumstances which may lead to special inspections for the purposes specified in Article 71 the United States and the Agency shall consult forthwith. As a result of such consultations the Agency may:

(a) Make inspections in addition to the routine inspection effort provided for in Articles 76 through 80; and

(b) Obtain access, in agreement with the United States, to information or locations in addition to those specified in Article 74. Any disagreement concerning the need for additional access shall be resolved in accordance with Articles 20 and 21; in case action by the United States is essential and urgent, Article 17 shall apply.

ARTICLE 76

The Agency shall keep the number, intensity and duration of routine inspections, applying optimum timing, to the minimum consistent with the effective implementation of the safeguards procedures set forth in this Agreement, and shall make the optimum and most economical use of inspection resources available to it.

ARTICLE 77

The Agency may carry out one routine inspection per year in respect of facilities listed in the Subsidiary Arrangements pursuant to Article 39 with a content or annual throughput, whichever is greater, of nuclear material not exceeding five effective kilograms.

ARTICLE 78

The number, intensity, duration, timing and mode of routine inspections in respect of facilities listed in the Subsidiary Arrangements pursuant to Article 39 with a content or annual throughput of nuclear material exceeding five effective kilograms shall be determined on the basis that in the maximum or limiting case the inspection regime shall be no more intensive than is necessary and sufficient to maintain continuity of knowledge of the flow and inventory of nuclear material, and the maximum routine inspection effort in respect of such facilities shall be determined as follows:

(a) For reactors and sealed storage installations the maximum total of routine inspection per year shall be determined by allowing one sixth of a man-year of inspection for each such facility;

(b) For facilities, other than reactors or sealed storage installations, involving plutonium or uranium enriched to more than 5%, the maximum total of routine inspection per year shall be determined by allowing for each such facility 30 x $\sqrt{E}$ man-days of inspection per year, where E is the inventory or annual throughput of nuclear material, whichever is greater, expressed in effective kilograms. The maximum established for any such facility shall not, however, be less than 1.5 man-years of inspection; and

(c) For facilities not covered by paragraphs (a) or (b), the maximum total of routine inspection per year shall be determined by allowing for each such facility one third of a man-year of inspection plus 0.4 x E man-days of inspection per year, where E is the inventory or annual throughput of nuclear material, whichever is greater, expressed in effective kilograms.

The United States and the Agency may agree to amend the figures for the maximum inspection effort specified in this Article, upon determination by the Board that such amendment is reasonable.

ARTICLE 79

Subject to Articles 76 through 78 the criteria to be used for determining the actual number, intensity, duration, timing and mode of routine inspections in respect of any facility listed in the Subsidiary Arrangements pursuant to Article 39 shall include:

(a) The form of the nuclear material, in particular, whether the nuclear material is in bulk form or contained in a number of separate items; its chemical composition and, in the case of uranium, whether it is of low or high enrichment; and its accessibility;

(b) The effectiveness of the United States' accounting and control system, including the extent to which the operators of facilities

are functionally independent of the United States' accounting and control system; the extent to which the measures specified in Article 32 have been implemented by the United States; the promptness of reports provided to the Agency; their consistency with the Agency's independent verification; and the amount and accuracy of the material unaccounted for, as verified by the Agency;

(c) Characteristics of that part of the United States fuel cycle in which safeguards are applied under this Agreement, in particular, the number and types of facilities containing nuclear material subject to safeguards under this Agreement, the characteristics of such facilities relevant to safeguards, notably the degree of containment; the extent to which the design of such facilities facilitates verification of the flow and inventory of nuclear material; and the extent to which information from different material balance areas can be correlated;

(d) International interdependence, in particular the extent to which nuclear material, safeguarded under this Agreement, is received from or sent to other States for use or processing; any verification activities by the Agency in connection therewith; and the extent to which activities in facilities in which safeguards are applied under this Agreement are interrelated with those of other States; and

(e) Technical developments in the field of safeguards, including the use of statistical techniques and random sampling in evaluating the flow of nuclear material.

ARTICLE 80

The United States and the Agency shall consult if the United States considers that the inspection effort is being deployed with undue concentration on particular facilities.

ARTICLE 81

The Agency shall give advance notice to the United States of the arrival of inspectors at facilities listed in the Subsidiary Arrangements pursuant to Article 39, as follows:

(a) For ad hoc inspections pursuant to Article 69(c), at least 24 hours; for those pursuant to Article 69(a) and (b), as well as the activities provided for in Article 48, at least one week;

(b) For special inspections pursuant to Article 71, as promptly as possible after the United States and the Agency have consulted as provided for in Article 75, it being understood that notification of arrival normally will constitute part of the consultations; and

(c) For routine inspections pursuant to Article 70 at least twenty-four hours in respect of the facilities referred it in Article 78(b) and sealed storage installations containing plutonium or uranium enriched to more than 5% and one week in all other cases.

Such notice of inspections shall include the names of the inspectors and shall indicate the facilities to be visited and the periods during which they will be visited. If the inspectors are to arrive from outside the United States the Agency shall also give advance notice of the place and time of their arrival in the United States.

ARTICLE 82

Notwithstanding the provisions of Article 81, the Agency may, as a supplementary measure, carry out without advance notification a portion of the routine inspections pursuant to Article 78 in accordance with the principle of random sampling. In performing any unannounced inspections, the Agency shall fully take into account any operational programme provided by the United States pursuant to Article 62(b). Moreover, whenever practicable, and on the basis of the operational programme, it shall advise the United States periodically of its general programme of announced and unannounced inspections, specifying the general periods when inspections are foreseen. In carrying out any unannounced inspections, the Agency shall make every effort to minimize any practical difficulties for the United States and facility operators bearing in mind the relevant provisions of Articles 44 and 87. Similarly the United States shall make every effort to facilitate the task of the inspectors.

D.16

ARTICLE 83

The following procedures shall apply to the designation of inspectors:

(a) The Director General shall inform the United States in writing of the name, qualifications, nationality, grade and such other particulars as may be relevant, of each Agency official he proposes for designation as an inspector for the United States;

(b) The United States shall inform the Director General within thirty days of the receipt of such a proposal whether it accepts the proposal;

(c) The Director General may designate each official who has been accepted by the United States as one of the inspectors for the United States, and shall inform the United States of such designations; and

(d) The Director General, acting in response to a request by the United States or on his own initiative, shall immediately inform the United States of the withdrawal of the designation of any official as an inspector for the United States.

However, in respect of inspectors needed for the activities provided for in Article 48 and to carry out ad hoc inspections pursuant to Article 69(a) and (b) the designation procedures shall be completed if possible within thirty days after the entry into force of this Agreement. If such designation appears impossible within this time limit, inspectors for such purposes shall be designated on a temporary basis.

ARTICLE 84

The United States shall grant or renew as quickly as possible appropriate visas, where required, for each inspector designated for United States.

ARTICLE 85

Inspectors, in exercising their functions under Article 48 and 69 to 73, shall carry out their activities in a manner designed to avoid hampering or delaying the construction, commissioning or operation of facilities, or affecting their safety. In particular inspectors shall not operate any facility themselves or direct the staff of a facility to carry out any operation. If inspectors consider that in pursuance of paragraphs 72 and 73, particular operations in a facility should be carried out by the operator, they shall make a request therefor.

ARTICLE 86

When inspectors require services available in the United States, including the use of equipment, in connection with the performance of inspections, the United States shall facilitate the procurement of such services and the use of such equipment by inspectors.

ARTICLE 87

The United States shall have the right to have inspectors accompanied during their inspections by its representatives, provided that inspectors shall not thereby be delayed or otherwise impeded in the exercise of their functions.

ARTICLE 88

The Agency shall inform the United States of:

(a) The results of inspections, at intervals to be specified in the Subsidiary Arrangements; and

(b) The conclusions it has drawn from its verification activities in the United States, in particular by means of statements in respect of each material balance area determined in accordance with Article 46(b) which shall be made as soon as possible after a physical inventory has been taken and verified by the Agency and a material balance has been struck.

ARTICLE 89

(a) Information concerning nuclear material exported from and imported into the United States shall be provided to the Agency in accordance with arrangements made with the Agency as, for example, those set forth in INFCIRC/207.

(b) In the case of international transfers to or from facilities identified by the Agency pursuant to Articles 2(b) and 39(b) with respect to which information has been provided to the Agency in accordance with arrangements referred to in paragraph (a), a special report, as envisaged in Article 66, shall be made if any unusual incident or circumstances lead the United States to believe that there is or may have been loss of nuclear material, including the occurrence of significant delay, during the transfer.

DEFINITIONS

ARTICLE 90

For the purposes of this Agreement:

A Adjustment means an entry into an accounting record or a report showing a shipper/receiver difference or material unaccounted for.

B Annual throughput means, for the purposes of Articles 77 and 78, the amount of nuclear material transferred annually out of a facility working at nominal capacity.

C Batch means a portion of nuclear material handled as a unit for accounting purposes at a key measurement point and for which the composition and quantity are defined by a single set of specifications or measurements. The nuclear material may be in bulk form or contained in a number of separate items.

D Batch data means the total weight of each element of nuclear material and, in the case of plutonium and uranium, the isotopic composition when appropriate. The unit sof account shall be as follows:

(a) Grams of contained plutonium;

(b) Grams of total uranium and grams of contained uranium-235 plus uranium-233 for uranium enriched in these isotopes; and

(c) Kilograms of contained thorium, natural uranium or depleted uranium.

For reporting purposes the weights of individual items in the batch shall be added together before rounding to the nearest unit.

E Book inventory of a material balance area means the algebraic sum of the most recent physical inventory of that material balance area and of all inventory changes that have occurred since that physical inventory was taken.

F Correction means an entry into an accounting record or a report to rectify an identified mistake or to reflect an improved measurement of a quantity previously entered into the record or report. Each correction must identify the entry to which it pertains.

G Effective kilogram means a special unit used in safeguarding nuclear material. The quantity in effect kilograms is obtained by taking:

(a) For plutonium, its weight in kilograms;

(b) For uranium with an enrichment of 0.01 (1%) and above, it weight in kilograms multiplied by the square of its enrichment;

(c) For uranium with an enrichment below 0.01 (1%) and above 0.005 (0.5%), its weight in kilograms multiplied by 0.0001; and

(d) For depleted uranium with an enrichment of 0.005 (0.5%) or below, and for thorium, its weight in kilograms multiplied by 0.00005.

H Enrichment means the ratio of the combined weight of the isotopes uranium-233 and uranium-235 to that of the total uranium in question.

I Facility means:

(a) A reactor, a critical facility, a conversion plant, a fabrication plant, a reprocessing plant, an isotope separation plant or a separate storage installation; or

(b) Any location where nuclear material in amounts greater than one effective kilogram is customarily used.

J Inventory change means an increase or decrease, in terms of batches, of nuclear material in a material balance area; such a change shall involve one of the following:

(a) Increases:

(i) Import;

(ii) Domestic receipt: receipts from other material balance areas, receipts from a non-safeguarded activity or receipts at the starting point of safeguards;

(iii) Nuclear production: production of special fissionable material in a reactor; and

(iv) De-exemption: reapplication of safeguards on nuclear material previously exempted therefrom on account of its use or quantity.

(b) Decreases:

(i) Export;

(ii) Domestic shipment: shipments to other material balance areas or shipments for a non-safeguarded activity;

(iii) Nuclear loss: loss of nuclear material due to its transformation into other element(s) or isotope(s) as a result of nuclear reactions;

(iv) Measured discard: nuclear material which has been measured, or estimated on the basis of measurements, and disposed of in such a way that it is not suitable for further nuclear use;

(v) Retained waste: nuclear material generated from processing or from an operational accident, which is deemed to be unrecoverable for the time being but which is stored;

(vi) Exemption: exemption of nuclear material from safeguards on account of its use or quantity; and

(vii) Other loss: for example, accidental loss (that is, irretrievable and inadvertent loss of nuclear material as the result of an operational accident) or theft.

K Key measurement point means a location where nuclear material appears in such a form that it may be measured to determine material flow or inventory. Key measurement points thus include, but are not limited to, the inputs and outputs (including measured discards) and storages in material balance areas.

L Man-year of inspection means, for the purposes of Article 78, 300 man-days of inspection, a man-day being a day during which a single inspector has access to a facility at any time for a total of not more than eight hours.

M Material balance area means an area in or outside of a facility such that:

(a) The quantity of nuclear material in each transfer into or out of each material balance area can be determined; and

(b) The physical inventory of nuclear material in each material balance area can be determined when necessary in accordance with specified procedures,

in order that the material balance for Agency safeguards purposes can be established.

N Material unaccounted for means the difference between book inventory and physical inventory.

O Nuclear material means any source or any special fissionable material as defined in Article XX of the Statute. The term source material shall not be interpreted as applying to ore or ore residue. Any determination by the Board under Article XX of the Statute after the entry into force of this Agreement which adds to the materials considered to be source material or special fissionable material shall have effect under this Agreement only upon acceptance by the United States.

P Physical inventory means the sum of all the measured or derived estimates of batch quantities of nuclear material on hand at a given time within a material balance area, obtained in accordance with specified procedures.

Q Shipper/receiver difference means the difference between the quantity of nuclear material in a batch as stated by the shipping material balance area and as measured at the receiving material balance area.

R Source data means those data, recorded during measurement or calibration or used to derive empirical relationships, which identify nuclear material and provide batch data. Source data may include, for example, weight of compounds, conversion factors to determine weight of element, specific gravity, element concentration, isotopic ratios, relationship between volume and manometer readings and relationship between plutonium produced and power generated.

S Strategic point means a location selected during examination of design information where, under normal conditions and when combined with the information from all strategic points taken together, the information necessary and sufficient for the implementation of safeguards measures is obtained and verified; a strategic point may include any location where key measurements related to material balance accountancy are made and where containment and surveillance measures are executed.

PROTOCOL

ARTICLE 1

This Protocol specifies the procedures to be followed with respect to facilities identified by the Agency pursuant to Article 2 of this Protocol.

ARTICLE 2

(a) The Agency may from time to time identify to the United States those facilities included in the list, established and maintained pursuant to Articles 1(b) and 34 of the Agreement, of facilities not associated with activities having direct national security significance to the United States, other than those which are then currently identified by the Agency pursuant to Articles 2(b)

and 39(b) of the Agreement, to which the provisions of this Protocol shall apply.

(b) The Agency may also include among the facilities identified to the United States pursuant to the foregoing paragraph, any facility which had previously been identified by the Agency pursuant to Articles 2(b) and 39(b) of the Agreement but which had subsequently been designated by the Agency pursuant to Article 39(c) of the Agreement for removal from the Subsidiary Arrangements listing.

(c) In identifying facilities pursuant to the foregoing paragraphs and in the preparation of Transitional Subsidiary Arrangements pursuant to Article 3 of this Protocol, the Agency shall proceed in a manner which the Agency and the United States mutually agree takes into account the requirement on the United States to avoid discriminatory treatment as between United States commercial firms similarly situated.

ARTICLE 3

The United States and the Agency shall make Transitional Subsidiary Arrangements which shall:

(a) contain a current listing of those facilities identified by the Agency pursuant to Article 2 of this Protocol;

(b) specify in detail how the procedures set forth in this Protocol are to be applied.

D.19

ARTICLE 4

(a) The United States and the Agency shall make every effort to complete the Transitional Subsidiary Arrangements with respect to each facility identified by the Agency pursuant to Article 2 of this Protocol within ninety days following such identification to the United States.

(b) With respect to any facility identified pursuant to Article 2(b) of this Protocol, the information previously submitted to the Agency in accordance with Articles 42 through 45 of the Agreement, the results of the examination of the design information and other provisions of the Subsidiary Arrangements relative to such facility, to the extent that such information, results and provisions satisfy the provisions of this Protocol relating to the submission and examination of information and the preparation of Transitional Subsidiary Arrangements, shall constitute the Transitional Subsidiary Arrangements for such facility, until and unless the United States and the Agency shall otherwise complete Transitional Subsidiary Arrangements for such facility in accordance with the provisions of this Protocol.

ARTICLE 5

In the event that a facility currently identified by the Agency pursuant to Article 2(a) of this Protocol is identified by the Agency pursuant to Articles 2(b) and 39(b) of the Agreement, the Transitional Subsidiary Arrangements relevant to such facility shall, to the extent that such Transitional Subsidiary Arrangements satisfy the provisions of the Agreement, be deemed to have been made part of the Subsidiary Arrangements to the Agreement.

ARTICLE 6

Design information in respect of each facility identified by the Agency pursuant to Article 2 of this Protocol shall be provided to the Agency during the discussion of the relevant Transitional Subsidiary Arrangements. The information shall include, when applicable:

(a) The identification of the facility, stating its general character, purpose, nominal capacity and geographic location, and the name and address to be used for routine business purpose;

(b) A description of the general arrangement of the facility with reference, to the extent feasible, to the form, location and flow of nuclear material and to the general layout of important items of equipment which use, produce or process nuclear material;

(c) A description of features of the facility relating to material accountancy, containment and surveillance; and

(d) A description of the existing and proposed procedures at the facility for nuclear material accountancy and control, with special reference to material balance areas established by the operator, measurements of flow and procedures for physical inventory taking.

ARTICLE 7

Other information relevant to the application of the provisions of this Protocol shall also be provided to the Agency in respect of each facility identified by the Agency in accordance with Article 2 of this Protocol, in particular on organizational responsibility for material accountancy and control. The United States shall provide the Agency with supplementary information on the health and safety procedures which the Agency shall observe and with which inspectors shall comply when visiting the facility in accordance with Article 11 of this Protocol.

ARTICLE 8

The Agency shall be provided with design information in respect of a modification relevant to the application of the provisions of this Protocol, for examination, and shall be informed of any change in the information provided to it under Article 7 of this Protocol,

sufficiently in advance for the procedures under this Protocol to be adjusted when necessary.

ARTICLE 9

The design information provided to the Agency in accordance with the provisions of this Protocol, in anticipation of the application of safeguards under the Agreement, shall be used for the following purposes:

(a) To identify the features of facilities and nuclear material relevant to the application of safeguards to nuclear materialin sufficient detail to facilitate verification;

(b) To determine material balance areas to be used for Agency accounting purposes and to select those strategic points which are key measurement points and which will be used to determine flow and inventory of nuclear material; in determining such material balance areas the Agency shall, inter alia, use the following criteria;

(i) The size of the material balance area shall be related to the accuracy with which the material balance can be established;

(ii) In determining the material balance area, advantage shall be taken of any opportunity to use containment and surveillance to help ensure the completeness of flow measurements and thereby to simplify the application of safeguards and to concentrate measurement efforts at key measurement points;

(iii) A number of material balance areas in use at a facility or at distinct sites may be combined in one material balance area to be used for Agency accounting purposes when the Agency determines that this is consistent with its verification requirements; and

(iv) A special material balance area may be established at the request of the United States around a process step involving commercially sensitive information;

(c) To establish the nominal timing and procedures for taking of physical inventory of nuclear material for Agency accounting purposes;

(d) To establish the records and reports requirements and records evaluation procedures;

(e) To establish requirements and procedures for verification of the quantity and location of nuclear material; and

(f) To select appropriate combinations of containment and surveillance methods and techniques and the strategic points at which they are to be applied.

The results of the examination of the design information shall be included in the relevant Transitional Subsidiary Arrangements.

ARTICLE 10

Design information provided in accordance with the provisions of this Protocol shall be re-examined in the light of changes in operating conditions, of developments in safeguards technology or of experience in the application of verification procedures, with a view to modifying the action taken pursuant to Article 9 of this Protocol.

ARTICLE 11

(a) The Agency, in co-operation with the United States, may send inspectors to facilities identified by the Agency pursuant to Article 2 of this Protocol to verify the design information provided to the Agency in accordance with the provisions of this Protocol, for the purposes stated in Article 9 of this Protocol or for such other purposes as may be agreed between the United States and the Agency.

(b) The Agency shall give notice to the United States with respect to each such visit at least one week prior to the arrival of inspectors at the facility to be visited.

ARTICLE 12

In establishing a national system of materials control as referred to in Article 7(a) of the Agreement, the United States shall arrange that records are kept in respect of each material balance area determined in accordance with Article 9(b) of this Protocol. The records to be kept shall be described in the relevant Transitional Subsidiary Arrangements.

ARTICLE 13

Records referred to in Article 12 of this Protocol shall be retained for at least five years.

ARTICLE 14

Records referred to in Article 12 of this Protocol shall consist, as appropriate, of:

(a) Accounting records of all nuclear material stored, processed, used or produced in each facility; and

(b) Operating records for activities within each facility.

ARTICLE 15

The system of measurements on which the records used for the preparation of reports are based shall either conform to the latest international standards or be equivalent in quality to such standards.

ARTICLE 16

The accounting records referred to in Article 14(a) of this Protocol shall set forth the following in respect of each material balance area determined in accordance with Article 9(b) of this Protocol:

(a) All inventory changes, so as to permit a determination of the book inventory at any time;

(b) All measurement results that are used for determination of the physical inventory; and

(c) All adjustments and corrections that have been made in respect of inventory changes, book inventories and physical inventories.

ARTICLE 17

For all inventory changes and physical inventories the records referred to in Article 14(a) of this Protocol shall show, in respect of each batch of nuclear material: material identification, batch data and source data. The records shall account for uranium, thorium and plutonium separately in each batch of nuclear material. For each inventory change, the date of the inventory change and, when appropriate, the originating material balance area and the receiving material balance area or the recipient, shall be indicated.

ARTICLE 18

The operating records referred to in Article 14(b) of this Protocol shall set forth, as appropriate, in respect of each material balance area determined in accordance with Article 9(b) of this Protocol:

(a) Those operating data which are used to establish changes in the quantities and composition of nuclear material;

(b) The data obtained from the calibration of tanks and instruments and from sampling and analyses, the procedures to control the quality of measurements and the derived estimates of random and systematic error;

(c) A description of the sequence of the actions taken in preparing for, and in taking, a physical inventory, in order to ensure that it is correct and complete; and

(d) A description of the actions taken in order to ascertain the cause and magnitude of any accidental or unmeasured loss that might occur.

ARTICLE 19

The United States shall provide the Agency with accounting reports as detailed in Articles 20 through 25 of this Protocol in respect of nuclear material in each facility identified by the Agency pursuant to Article 2 of this Protocol.

ARTICLE 20

The accounting reports shall be based on the records kept in accordance with Articles 12 to 18 to this Protocol. They shall be made in English.

ARTICLE 21

The United States shall provide the Agency with an initial report on all nuclear material in each facility identified by the Agency pursuant to Article 2 of this Protocol. Such report shall be dispatched to the Agency within thirty days of the last day of the calendar month in which the facility is identified by the Agency and shall reflect the situation as of the last day of that month.

ARTICLE 22

The United States shall provide the Agency with the following accounting reports for each material balance area determined in accordance with Article 9(b) of this Protocol:

(a) Inventory change reports showing all changes in the inventory of nuclear material. The reports shall be dispatched as soon as possible and in any event within thirty days after the end of the month in which the inventory changes occurred or were established; and

(b) Material balance reports showing the material balance based on a physical inventory of nuclear material actually present in the material balance area. The reports shall be dispatched as soon as possible and in any event within thirty days after the physical inventory has been taken.

The reports shall be based on data available as of the date of reporting and may be corrected at a later date, as required.

ARTICLE 23

Inventory change reports submitted in accordance with Article 22(a) of this Protocol shall specify identification and batch data for each batch of nuclear material, the date of the inventory change, and, as appropriate, the originating material balance area and the receiving material balance area or the recipient. These reports shall be accompanied by concise notes:

(a) Explaining the inventory changes, on the basis of the operating data contained in the operating records provided for in Article 18(a) of this Protocol; and

(b) Describing, as specified in the relevant Transitional Subsidiary Arrangements, the anticipated operational programme, particularly the taking of a physical inventory.

ARTICLE 24

The United States shall report each inventory change, adjustment and correction, either periodically in a consolidated list or individually. Inventory changes shall be reported in terms of batches. As specified in the relevant Transitional Subsidiary Arrangements, small changes in inventory of nuclear material, such as transfers of analytical samples, may be combined in one batch and reported as one inventory change.

ARTICLE 25

Material balance reports submitted in accordance with Article 22(b) of this Protocol shall include the following entries, unless otherwise agreed by the United States and the Agency:

(a) Beginning physical inventory;

(b) Inventory changes (first increases, then decreases);

(c) Ending book inventory;

(d) Shipper/receiver differences;

(e) Adjusted ending book inventory;

(f) Ending physical inventory; and

(g) Material unaccounted for.

A statement of the physical inventory, listing all batches separately and specifying material identification and batch data for each batch, shall be attached to each material balance report.

D.22

ARTICLE 26

The Agency shall provide the United States with semi-annual statements of book inventory of nuclear material in facilities identified pursuant to Article 2 of this Protocol, for each material balance area, as based on the inventory change reports for the period covered by each such statement.

ARTICLE 27

(a) If the Agency so requests, the United States shall provide it with amplifications or clarifications of any report submitted in accordance with Article 19 of this Protocol, in so far as consistent with the purpose of the Protocol.

(b) The Agency shall inform the United States of any significant observations resulting from its examination of reports received pursuant to Article 19 of this Protocol and from visits of inspectors made pursuant to Article 11 of this Protocol.

(c) The United States and the Agency shall, at the request of either, consult about any question arising out of the interpretation or application of this Protocol, including corrective action which, in the opinion of the Agency, should be taken by the United

States to ensure compliance with its terms, as indicated by the Agency in its observations pursuant to paragraph (b) of this Article.

ARTICLE 28

The definitions set forth in Article 90 of the Agreement shall apply, to the extent relevant, to this Protocol.

DONE in Vienna on the eighteenth day of November 1977, in duplicate, in the English language.

For the UNITED STATES OF AMERICA:

GRS 18 November 1977

For the INTERNATIONAL ATOMIC ENERGY AGENCY:

D.K.V.V. 18th November 1977

Appendix E

DOE Order 1270.2B

U.S. Department of Energy

Washington, D.C.

- ORDER

DOE 1270.2B

6-23-92

SUBJECT: SAFEGUARDS AGREEMENT WITH THE INTERNATIONAL ATOMIC ENERGY AGENCY

1. PURPOSE. To prescribe policies and responsibilities of the Department of Energy (DOE) for compliance with the agreement, including the associated protocol, between the Government of the United States of America (U.S.) and the International Atomic Energy Agency (IAEA) for the application of safeguards in the U.S. (hereinafter designated the "agreement" and the "protocol").

2. CANCELLATION. DOE 1270.2A, SAFEGUARDS AGREEMENT WITH THE INTERNATIONAL ATOMIC ENERGY AGENCY, of 7-29-83.

3. SCOPE. The provisions of this Order apply to all Departmental Elements and to all contractors and subcontractors who perform work for the Department and possess or are responsible for nuclear materials subject to the agreement, and as provided by contract and/or law.

4. AUTHORITY. The agreement with its protocol is a treaty ratified by the President on 12-9-80. Copies are available in a Department of State publication (Treaties and Other International Acts, TIAS, Number 9889) which is available by DOE purchase order from the Superintendent of Documents, 044-000-92998-8, at a price of $3.

5. REFERENCES.

   a. Atomic Energy Act of 1954, as amended, section 142, establishes policy for controlling the classification and declassification of restricted data.

   b. DOE 5633.4, NUCLEAR MATERIALS TRANSACTIONS: DOCUMENTATION AND REPORTING, of 2-9-88, which identifies policies, objectives, standards and criteria, authorities, and responsibilities for the Department's nuclear explosive and weapon safety program.

   c. DOE 5633.3, CONTROL AND ACCOUNTABILITY OF NUCLEAR MATERIALS, of 2-3-88, which contains the basic definitions, principles, and requirements for control and accountability of nuclear materials.

   d. "U.S. Agency Procedures for Implementation of the Agreement Between the United States of America and the International Atomic Energy Agency for the Application of Safeguards in the United States of America, with Protocol," (the agreement or the protocol), published in the Federal Register of 6-2-81 (46 FR 29578).

DISTRIBUTION:

All Departmental Elements

INITIATED BY:

Office of Arms Control and Nonproliferation

6. DEFINITIONS.

a. Safeguards. Those measures applied, pursuant to the agreement and protocol, to enable the IAEA to detect possible diversion of nuclear material.

b. Subsidiary Arrangements. Documents setting forth details that have been mutually agreed between the U.S. and the IAEA for implementing the agreement and protocol. Subsidiary arrangements are required by the agreement and transitional subsidiary arrangements are required by the protocol. The subsidiary arrangements include a general part applicable to those facilities in the United States identified by the IAEA for the application of safeguards in accordance with the agreement and protocol. The general part identifies the substance of communications to be made, the format of documents, procedures to be followed, and time limits for various actions. A separate facility attachment is prepared for each such facility identified by the IAEA for the application of safeguards, containing all other necessary arrangements, specified in sufficient detail to permit the IAEA to fulfill its responsibilities in an effective and efficient manner.

c. Facility. As defined under the agreement: (1) a reactor, a critical facility, a conversion plant, a fabrication plant, a reprocessing plant, an isotope separation plant, or a separate storage installation; or (2) any location where nuclear material in amounts greater than one effective kilogram is customarily used.

d. Effective Kilogram. A special unit for quantities of nuclear material defined under the agreement as: (1) for plutonium, its weight in kilograms; (2) for uranium with an enrichment of 0.01 (1 percent) and above, its weight in kilograms multiplied by the square of its enrichment; (3) for uranium with an enrichment below 0.01 (1 percent) and above 0.005 (0.5 percent), its weight in kilograms multiplied by 0.0001; and (4) for depleted uranium with an enrichment of 0.005 (0.5 percent) or below, and for thorium, its weight in kilograms multiplied by 0.00005.

e. List of Eligible Facilities. A list, provided to the IAEA by the U.S., of all facilities within the U.S. not associated with activities of direct national security significance.

f. Design Information Questionnaire. An IAEA form used in accordance with the agreement or the protocol for providing to the IAEA information on facilities selected by the IAEA. There are different forms for different types of facilities.

g. Interagency Steering Group for International Safeguards. An interagency group that coordinates U.S. policy for all of its safeguards relationships with the IAEA. It coordinates U.S.

assistance to help improve IAEA safeguards effectiveness and resolves interdepartmental issues relating to the agreement or the protocol. The Interagency Steering Group is composed of representatives from the Departments of State and Energy, the Nuclear Regulatory Commission, the Arms Control and Disarmament Agency, and the staff of the National Security Council. The Interagency Steering Group is chaired by the Deputy Assistant Secretary of State for Nuclear Energy and Energy Technology, or such other official as may be designated by the Secretary of State.

h. Safeguards Agreement Working Group. A team established by the Interagency Steering Group for International Safeguards to monitor implementation of the agreement.

i. U.S. Negotiating Team. A team established by the Interagency Steering Group for International Safeguards which includes one permanent member from the Department of Energy. It is chaired by the Department of State and shall include such additional participants from DOE as the DOE determines necessary. The U.S. negotiating team negotiates with an IAEA negotiating team to arrive at mutually agreed subsidiary arrangements to the agreement or protocol.

j. Nuclear Materials Management and Safeguards System. The national data base and information support system for nuclear materials controlled by the U.S. Government, created to support national safeguards and management objectives in the domestic and foreign utilization of nuclear resources. The system stores data on nuclear material transactions and inventories, and produces a wide range of printed reports for use by DOE and the Nuclear Regulatory Commission. The system is used to satisfy the U.S. nuclear materials information requirements of agreements between the U.S. and foreign entities. In addition, the system provides the reporting interface between facilities selected under the provisions of the agreement and the IAEA. The system uses a centralized computer data base linked via direct data communication lines and the secure automated communications network (SACNET) to a number of facilities, DOE organizations, and Nuclear Regulatory Commission offices in the U.S.

k. Restricted Data. As defined in the Atomic Energy Act of 1954, includes all data concerning: (1) the design, manufacture, or utilization of atomic weapons; (2) the production of special nuclear material; and (3) the use of special nuclear material in the production of energy; but does not include data declassified or removed from the restricted data category pursuant to section 142 of the Atomic Energy Act of 1954.

l. Formerly Restricted Data. Classified information jointly determined by the Assistant Secretary for Defense Programs and the Department of Defense to be related primarily to the military utilization of atomic weapons, and removed by the Assistant Secretary for Defense Programs from the category of restricted data pursuant to section 142(d) of the Atomic Energy Act.

m. National Security Information. Information pertaining to the national defense and foreign relations of the United States, and classified in accordance with an Executive order.

7. POLICY AND OBJECTIVES.

a. All nuclear activities in the U.S. are eligible for IAEA safeguards pursuant to the agreement, excluding only those of direct national security significance.

b. Procedures in this Order for establishing and changing the list of eligible facilities apply to all facilities participating in DOE programs and possibly eligible for safeguards under the agreement, including both DOE-owned and contractor-owned facilities that are either exempt from or subject to requirements for licensing by the U.S. Nuclear Regulatory Commission. Procedures in this Order, other than those related to establishing and changing the list of eligible facilities, apply to DOE-owned facilities that are exempt from requirements for licensing by the U.S. Nuclear Regulatory Commission. These latter procedures include, for example, negotiating subsidiary arrangements, and reporting information to the IAEA to carry out inspections.

c. DOE facilities, selected by the IAEA pursuant to the agreement or protocol, shall comply with the provisions of the agreement or protocol.

d. Information classified as restricted data or formerly restricted data shall not be transmitted to the IAEA.

e. Nuclear materials transaction, material balance, and inventory information shall be transmitted to the IAEA pursuant to the agreement or protocol and shall include national security information on a controlled basis, as necessary to comply with the agreement or protocol.

f. Implementation activities required pursuant to terms of the agreement or protocol and the subsidiary arrangements shall avoid unnecessary interference in the operation of facilities, be consistent with prudent management practices, and incur minimal costs.

8. RESPONSIBILITIES.

a. Director of Arms Control and Nonproliferation (AN-1).

(1) Represents the Department before the Department of State, the Congress, and the IAEA on matters pertaining to the agreement.

(2) Approves plans and procedures developed by the Director of Export Control and International Safeguards for implementing the agreement and the protocol.

(3) Participates in resolution of proposed changes to the list of eligible facilities, where agreement has not been achieved by responsible Heads of Headquarters Elements, as provided by the procedures on page 12, paragraph 9.

(4) Participates or designates representatives to participate with the Department of State and the Director of Export Control and International Safeguards in policy development and decisionmaking related to areas where the agreement or protocol can affect programs and facilities under its cognizance.

(5) Maintains the option to concur on all notifications to offices external to DOE, where implementation of the agreement or protocol can affect programs under its cognizance.

(6) Ensures that DOE Field Offices and contractors under their cognizance fulfill the terms of the agreement or protocol.

b. Director of Export Control and International Safeguards (AN-30).

(1) Serves as a member of the Interagency Steering Group for International Safeguards. Provides a senior staff officer to serve as a member of the safeguards agreement working group.

(2) Provides guidance on international policy as required by other Departmental Elements for implementation of the agreement or protocol.

(3) Participates with the Department of State in policy development and decisionmaking related to the agreement or protocol, including designation and acceptance of IAEA inspectors.

(4) Establishes channels for transmission to the Department of State, for the IAEA, of DOE documents and reports including design information questionnaires, draft facility

attachments, and nuclear material transaction, material balance, and inventory reports, including special reports, amplifications, and clarifications as required under the agreement and protocol.

(5) Ensures that appropriate arrangements are made with the IAEA and other countries, as appropriate and when required for compliance with article 22 of the agreement, which provide for suspension of safeguards in the U.S. under other U.S.-IAEA agreements while safeguards are in force under this agreement.

(6) Serves as the initial DOE point of contact with other U.S. Agencies (Department of State, Arms Control and Disarmament Agency, and Nuclear Regulatory Commission) and the IAEA.

(7) Notifies Program Secretarial Officer (PSO) responsible for relevant DOE facilities about IAEA actions under the agreement, including IAEA selections and changes in selections of DOE facilities for the application of safeguards.

(8) Routinely informs the Department of State and, as appropriate, the Nuclear Regulatory Commission of changes in eligibility of DOE license-exempt facilities or facilities licensed by the Nuclear Regulatory Commission.

(9) Participates with appropriate Heads of Headquarters Elements, and the Chief Financial Officer (CFO) in the development of arrangements for recovery of costs at selected facilities resulting from IAEA requests.

(10) Ensures the opportunity for the Office's participation in interagency policy meetings and IAEA negotiations and, as appropriate, for PSOs and Managers of DOE Field Offices responsible for the facilities involved.

c. Director of International Safeguards (AN-30).

(1) Serves as the primary source of information within DOE concerning implementation of the agreement and protocol. Provides technical guidance on safeguards as required by other Departmental Elements, and provides assistance in implementation.

(2) Maintains a current list of DOE facilities eligible for safeguards and informs the Director of Export Control and International Safeguards of proposed additions or deletions.

(3) Serves as, or designates, a senior staff member with experience in international safeguards to serve as the permanent DOE representative on the U.S. negotiating team chaired by the Department of State.

(4) Advises appropriate PSOs and Managers of DOE Field Offices of actions that will be necessary to satisfy requirements of the agreement, the protocol, and subsidiary arrangements.

(5) Approves procedures for acceptance of accreditation credentials presented by IAEA inspectors and for escorting IAEA inspectors at DOE facilities.

(6) Arranges with PSOs and DOE Field Offices for IAEA inspections under the agreement.

(7) Receives from DOE Field Offices copies of safeguards documents prepared in accordance with the agreement for transmittal through the Department of State to the IAEA. These safeguards documents include draft design information questionnaires, draft facility attachments, special reports, amplifications, and clarifications. Reviews and coordinates this material with cognizant Headquarters Elements for appropriateness for release to the IAEA.

(8) Develops and maintains policy and procedures for reporting nuclear materials transaction, material balance, and inventory information to and from the nuclear materials management and safeguards system, as necessary for reporting such information obtained from facilities to the IAEA, in accordance with the provisions of the agreement or the protocol. Implementation of this responsibility is provided for in DOE 5633.3, CONTROL AND ACCOUNTABILITY OF NUCLEAR MATERIALS and 5633.4, NUCLEAR MATERIALS TRANSACTIONS: DOCUMENTATION AND REPORTING.

(9) Maintains procedures for controlled release to the IAEA of classified national security information and any other sensitive DOE information. Coordinates procedures for protecting other DOE sensitive information processed through the computer system with the Director of Administration and Human Resource Management.

(10) Monitors safeguards aspects of implementation of the agreement or protocol and ensures that potential problems are identified to responsible PSO and DOE Field Offices.

(11) Advises the Director of Export Control and International Safeguards as to the status and plans for Headquarters and field activities associated with implementation of the agreement.

(12) Ensures that material under safeguards pursuant to the agreement is at all times at least equivalent in amount and composition to any material which would be subject to IAEA safeguards in the U.S. under other suspended agreements between the U.S., the IAEA, and possible other parties.

(13) Participates with the Director of Export Control and International Safeguards, appropriate Headquarters Elements, and the CFO in developing arrangements for recovery from the IAEA of certain facility costs resulting from special requests by the IAEA.

(14) Prepares other DOE documents as required to further delineate the contents of this Order, including plans and procedures for implementation. Coordinates with Headquarters Elements where there will be a programmatic impact.

d. Program Secretarial Officers (PSOs).

(1) Oversee field implementation pursuant to the agreement or protocol to ensure that it is effective without unnecessary impact on the operation of facilities or program implementation.

(2) Participate, as necessary or desirable, in meetings of the interagency steering group or the safeguards agreement working group for technical discussions and decisions relating to activities that can significantly affect DOE programs and facilities.

(3) Participate, as necessary or desirable, with the DOE representative on the U.S. negotiating team responsible for negotiation with the IAEA of subsidiary arrangements under the agreement.

(4) When changes are being considered in the list of eligible facilities, PSOs responsible for facilities under consideration participate with the Director of Export Control and International Safeguards in determining whether a facility should be placed on or deleted from the list.

(5) Upon notification of actions by the IAEA, including the selection of a facility for implementation of IAEA safeguards, the appropriate Headquarters element, or its designee, directs the responsible DOE Field Office to implement actions required under the agreement or protocol, including timely completion of a draft design information questionnaire and draft facility attachment; and participate

and arrange for appropriate DOE Field Office staff to participate in the preliminary discussions related to facility attachments or other understandings which have a bearing on programs or facilities.

(6) Receive from DOE Field Offices copies of safeguards documents prepared in accordance with the agreement for transmittal through the Department of State to the IAEA, including draft design information questionnaires, draft facility attachments, and, to the extent they so wish, copies of all special reports, amplifications, and clarifications.

(7) Ensure that field resources are adequate for DOE responsibilities under the agreement.

(8) Advise the contracting officers at the time of initiation of a procurement request, or at any time that it is known that a contract will fall within the scope of this Order, so that appropriate provisions are included in the contracts.

e. Chief Financial Officer (CR-1). Participates with the Director of Export Control and International Safeguards and responsible Headquarters Elements in the development and dissemination of principles and procedures for recovering from the IAEA those costs eligible for recovery following special IAEA requests. In general, the U.S. shall bear the expenses incurred by the U.S. in implementing its responsibilities under the agreement. However, if DOE or its contractors incur extraordinary expenses as a result of a specific request by the IAEA, the IAEA shall reimburse such expenses provided that it has agreed in advance to do so. Facility-specific cost principles may be part of the facility attachment.

f. Managers of DOE Field Offices.

(1) Follow direction from the PSOs with responsibility for facilities that are eligible or selected under the agreement, and consider advice from the Director of Export Control and International Safeguards as to actions required under the agreement, the protocol, and subsidiary arrangements. When directed by such PSOs, designate DOE Field Office participants and, as appropriate, contractor participants to serve as a DOE Field Office team for preliminary technical negotiations, and for drafting and reviewing draft design information questionnaires and facility attachments. The DOE Field Office team will participate as appropriate in meetings of the safeguards agreement working group when invited by a PSO, including the

Director of Export Control and International Safeguards. DOE Field Offices forward their proposed draft design information questionnaires and facility attachments to the Director of International Safeguards and the appropriate Headquarters Elements.

(2) Ensure that implementation activities pursuant to the agreement are effective, avoid undue interference in the operation of facilities, are consistent with prudent management practices, and incur minimal costs.

(3) Ensure that DOE contractors with facilities excluded from the list of eligible facilities, because of activities of direct national security significance, notify the DOE Field Office when such activities terminate and the facility may be added to the list. The DOE Field Office initiates the procedure for possible addition of the facility to the list by informing the PSO with responsibility for the facility and the Director of Export Control and International Safeguards, in accordance with the procedures in paragraph 9a.

(4) Ensure that DOE contractors with facilities on the list of eligible facilities notify the DOE Field Office when negotiations or plans are initiated which could lead to the facility being judged to be engaged in activities of direct national security significance. The DOE Field Office initiates the procedure for possible removal of the facility from the list by informing the appropriate Headquarters Elements and the Director of Export Control and International Safeguards, in accordance with the procedures in paragraph 9b.

(5) Inform facilities selected by the IAEA of their responsibilities as necessary for successful implementation of the agreement.

(6) Prepare for visits by inspectors as soon as IAEA has identified facilities under the cognizance of that DOE Field Office for application of safeguards pursuant to the agreement or reporting pursuant to the protocol; keep readily available a file of current information for the identification of IAEA inspectors designated by the IAEA for inspections in the U.S., and maintain current arrangements for ready access and departure by these inspectors.

(7) Ensure that IAEA inspectors are identified properly before entering a facility and are free to carry out their duties under the agreement and subsidiary arrangements after they have entered the facility.

(8) Exercise care to ensure that classified accounting information provided to the IAEA and its inspectors is limited to information that is required to be provided to the IAEA under the terms of the agreement, protocol, and subsidiary arrangements, including facility attachments. Classified information shall be limited under ordinary circumstances to information on nuclear material accounting, including nuclear materials transactions, material balance, and inventory information, for facilities as defined on the list of eligible facilities. When questions arise as to the appropriateness of providing specific classified accounting information, the proposal for resolution shall be coordinated with the Director of International Safeguards (AN-30) and the Office of Classification (SA-20). Where classified information is provided to the IAEA and its inspectors and the information is to be protected by the IAEA under their "safeguards confidential" classification, the recipient shall be informed that the information is classified by DOE.

(9) Ensure that IAEA inspectors are escorted during inspections. Desirable background for such escorts includes:

(a) Familiarity with the facility attachment for the inspected facility.

(b) Understanding of the facility system for material control and accountability, and procedures for information reporting to the nuclear materials management and safeguards system.

(c) Familiarity with the types of bulk and assay measurement equipment used at the facility.

(d) Academic preparation in fields related to nuclear material assay and accounting, including nuclear chemistry, physics, and/or statistics.

(10) Ensure that IAEA inspectors and any IAEA staff members carrying out functions under the agreement have the benefit of safety and radiation protection measures in effect at each facility, including emergency assistance, medical care in case of accidents, and all other health and safety protection required for other individuals under U.S. laws or DOE directives, or practices.

(11) Inform the Director of Export Control and International Safeguards and the responsible PSO of unusual incidents or circumstances involving actual or possible loss of nuclear

material subject to safeguards under the agreement, where the agreement or subsidiary arrangements provide for reporting these events to the IAEA.

(12) Inform the Director of Export Control and International Safeguards and the responsible PSO prior to termination of safeguards on nuclear materials or facilities, pursuant to the agreement, or reporting pursuant to the protocol.

(13) Following action by the PSO with responsibilities for facilities selected under the agreement or the protocol, ensure the availability of resources and ensure that resources available to contractors are adequate to satisfy DOE obligations pursuant to the agreement and the protocol.

9. PROCEDURES.

a. Additions to the List of Eligible Facilities. When the Director of Export Control and International Safeguards or a PSO with responsibility for a facility believes that a facility heretofore excluded should be considered for addition to the list of eligible facilities, the directors shall confer. Where agreement is reached, the Director of Export Control and International Safeguards shall notify the Department of State; the Director of International Safeguards shall record the proposed change in the list; and the responsible Headquarters Elements shall inform the appropriate DOE Field Office. Where the Directors do not reach agreement on a proposal to add a facility, the Director of Arms Control and Nonproliferation shall seek agreement of the responsible PSO. If they do not agree, the Director of Arms Control and Nonproliferation shall refer the proposal to the Office of the Secretary for resolution.

b. Deletions from the List of Eligible Facilities. PSOs and Managers of DOE Field Offices shall inform the Director of Export Control and International Safeguards whenever a facility on the list is scheduled to be, or is reasonably expected to become, engaged in activities of direct national security significance and should, therefore, be considered for deletion from the list. The notification of the Director shall include the nature of the activity, the expected duration and commencement, the type and level of classification of the activity, the impact on national security if the facility is not deleted from the list, and any other information pertinent to a complete understanding and an objective determination as to deletion of the facility from the list. The Director shall immediately enter into discussions with the responsible PSO to determine the course of action. When a deletion from the list of eligible facilities is agreed upon, the Director of Export Control and International Safeguards shall notify the Department of State, the Director of International Safeguards shall record the proposed change in the list, and the

responsible Headquarters Element shall inform the appropriate DOE Field Office. Where the Directors do not reach agreement on a proposal to delete a facility, the Director of Arms Control and Nonproliferation shall seek agreement of the responsible PSO organizations. If they do not agree, the Director of Arms Control and Nonproliferation shall refer the proposal to the Office of the Secretary for resolution.

c. Congressional and Other Agency Role on Additions to and Deletions from the List of Eligible Facilities. In accordance with the procedures governing implementation of the agreement (see paragraphs F(a) and F(b)(1)-(2) of the reference in paragraph 5d on page 1), DOE will seek agreement to the proposed addition(s) and/or deletion(s) from the Interagency Steering Group for International Safeguards. In the case of additions, if agreement is reached and the Congress does not pass a joint resolution opposing the action within 60 days, the additions become effective and the Department of State notifies the IAEA. In the case of deletions, if agreement is denied or delayed, a final decision may be made by the President and the Department of State notifies the Congress and the IAEA.

BY ORDER OF THE SECRETARY OF ENERGY:

DOLORES L. ROZZI
Director of Administration
and Human Resource Management

THIS PAGE MUST BE KEPT WITH DOE 1270.2B, SAFEGUARDS AGREEMENT WITH THE INTERNATIONAL ATOMIC ENERGY AGENCY.

DOE 1270.2B, SAFEGUARDS AGREEMENT WITH THE INTERNATIONAL ATOMIC ENERGY AGENCY, HAS REVISED DOE 1270.2A TO REFLECT ORGANIZATIONAL TITLE, ROUTING SYMBOL, AND OTHER REVISIONS REQUIRED BY SEN-6. NO SUBSTANTIVE CHANGES HAVE BEEN MADE. DUE TO THE NUMBER OF PAGES AFFECTED BY THE REVISIONS, THE ORDER HAS BEEN ISSUED AS A REVISION.

Appendix F

Journal of Nuclear Material Article on Safeguarding Reprocessing Plants*

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Safeguarding Reprocessing Plants: Principles, Past Experience, Current Practice and Future Trends

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Abstract

Under Article 6(c) of all comprehensive International Atomic Energy Agency (IAEA) safeguards agreements, verification procedures are to concentrate on those stages in the nuclear fuel cycle involving the production, processing, use or storage of nuclear material from which nuclear weapons could readily be made. In that context, the most intensive IAEA safeguards are applied at chemical processing plants and other facilities at which separated plutonium is stored, processed or used. The principles underlying the design, implementation and evaluation of IAEA safeguards at chemical reprocessing plants are explored in this paper. The interrelation between the elements of the safeguards approach for such plants is examined, including design verification, extensive use of containment and surveillance, including operations monitoring in certain of the process areas, near-real-time accountancy and conventional accountancy measures. Reference is made to IAEA experience, and current practice is examined at length. New reprocessing plants of large throughput and/or having novel design features are under construction, and the measures currently in use will require extensive effort to provide effective and efficient safeguards implementation.

I. Introduction

The intensity of IAEA safeguards measures applied in a facility depends upon the ease with which the nuclear materials processed, stored or used in that facility could be employed for the production of nuclear weapons. Thus, of the many different types of facilities in which IAEA safeguards are applied, facilities which store, process or use highly enriched uranium, uranium-233 or plutonium separated from fission products are subject to the most intensive IAEA safeguards measures.

In this paper, we present an analysis of the factors affecting safeguards implementation in reprocessing plants, a compilation of plants where IAEA safeguards have been or will be applied, a description of current practice and the challenges foreseen for strengthening and streamlining current practice and applying safeguards at new facilities.

II. Factors Affecting Safeguards Implementation

In this section, we define a "reprocessing complex" in terms of the operations typically carried out and the chemical technology employed. Then we summarize the inspection requirements used for planning and evaluation purposes. Next, the principal factors affecting safeguards implementation in a given setting are identified. Following that, the elements of the safeguards approach for reprocessing plants are presented, establishing the principles for design and implementation of safeguards at these plants. Finally, inspector staffing requirements and deployment arrangements are described.

1. Reprocessing Plant Characteristics

A chemical reprocessing plant complex may include spent fuel transport-cask storage and unloading areas, spent fuel storage ponds, a mechanical cell for shearing fuel assemblies or a cell for chemically decladding fuel elements, dissolution and clarification cells, a chemical separations and purification area, acid and organic recovery systems, uranium and plutonium oxide conversion areas, plutonium and uranium product storage, waste storage areas and waste conditioning, and analytical and operations testing laboratories. Fuel fabrication facilities may also be sited at the same complex. Many of these activities involve separated plutonium and thus require intensive safeguards.

While a variety of reprocessing technologies have been explored over the years, the plants submitted to IAEA safeguards thus far have been based on the Purex process. In this process, fuel materials are dissolved in hot nitric acid, and

TABLE 1

SAFEGUARDS IMPLEMENTATION CRITERIA FOR REPROCESSING PLANTS (INFCIRC-153)

ACTIVITIES PERFORMED	
FLOW VERIFICATIONS	**INTERIM AND PHYSICAL INVENTORY VERIFICATION**
Frequency of Inspections: Continuous	**Frequency of Inspections: Monthly IIV/Yearly PIV**
Examination of Records and Reports	**Examination of Records and Reports**
Facility accounting records are compared with Inventory Change Reports (ICRs), Material Balance Reports (MBRs) and any other special reports provided by the State to the IAEA. Records are checked for consistency.	Itemized Inventory List is compared for consistency with the Material Balance Report and Physical Inventory Listing. Inventory Change Reports and Material Balance Reports are compared for consistency.
SPENT FUEL	
Receipts If Shipped Verified and Sealed: The Seal is verified maintaining continuity of knowledge. If Shipped unverified or unsealed: The spent fuel is item counted and verified with medium detection probability for gross defects.[1] **Shipments** If not to be verified on receipt: The spent fuel is item counted and verified with medium detection probability for gross defects and sealed. If to be verified on receipt: The spent fuel is item counted and measures taken to ensure that the cask contents are not altered before shipment. Transfers to the Mechanical Cell: All transfers are item counted and verified by serial number.	**Spent Fuel under Dual C/S** PIV: Both C/S systems are evaluated. If seals are used, verify with low detection probability. IIV (for timeliness): Only one device need be evaluated if it is conclusive positive. If seals are evaluated, verify with low detection probability. **Spent Fuel under Single C/S** PIV: Spent fuel is item counted and surveillance is evaluated or seals are verified using low detection probability. IIV (for timeliness): The C/S device is evaluated. Seals, if used, are verified with low detection probability.[1] **Spent Fuel not under C/S** PIV: Spent fuel is item counted and verified with medium detection probability for gross defects. IIV (for timeliness): Spent fuel is item counted and verified with low detection probability for gross defects.

the undissolved particles are then removed prior to chemical processing. Next, plutonium and uranium are separated from fission products through liquid-liquid interactions in which the Pu and U are transferred between aqueous solutions (nitric acid) and organic solutions (typically comprised of tributyl phosphate in a kerosene carrier). Successive separation stages provide a highly decontaminated Pu/U stream, which is subsequently partitioned into separate Pu and U streams for further purification and concentration, leading to the final solution products, typically plutonium and uranyl nitrate. These are then converted to oxide powders for storage or subsequent processing.

2. *Inspection Requirements for Reprocessing Plants*

Safeguards activities are designed and implemented so as to detect a diversion of one *significant quantity* of nuclear material either removed abruptly or in a protracted manner. For plutonium, one significant quantity (SQ) is defined to be 8 kg Pu. The timing interval related to protracted diversion possibilities is one year, for abrupt diversion of separated plutonium, one month, and for plutonium in spent fuel, three months.

The principal requirements for safeguards implementation are summarized in Table 1. These criteria have evolved over the years and reflect technical considerations against possibilities for diversion and concealment, and the verification capabilities available to the IAEA. The current criteria will be revised in 1995 for the period from 1996–2000.

3. *Factors Affecting Safeguards System Design*

IAEA safeguards at a reprocessing plant are designed and carried out in such a manner as to satisfy the criteria currently in effect. The specific arrangements employed at a given reprocessing plant depend on a range of considerations, including:

a. the type of safeguards agreement (i.e., whether it is based on a comprehensive safeguards obligation involving all nuclear facilities and materials within a state, or limited to a given project or to specific equipment or materials covering the entire facility or a specified portion or portions thereof);

b. whether or not the plant has been built or has been operated before safeguards are applied. This may occur in states which do not have comprehensive safeguards agreements, when safeguards are applied, discontinued and then reapplied when safeguarded spent fuel is to be processed. When safeguards are applied to a plant already in operation or one that has operated in the past, a significant effort is required to confirm its history;

c. the scale and specific design features of a plant (for

TABLE 1 (continued)

PLUTONIUM/URANIUM PROCESS SOLUTIONS/PRODUCT COMPOUNDS	
Dissolver Solution to Process: Each transfer is verified by volume or weight measurements, sampling and analysis for Pu and U with a capability to detect measurement biases and C/S is maintained to detect all transfers. Completion of Dissolution: Operating Records (Charts) are checked after all dissolutions to verify that dissolution was completed. Product Transfers to Storage: All transfers of Pu and HEU product material from the process are verified with the capability to detect measurement biases. Pu Transfers from facility: Material is item counted and verified with high detection probability for gross, partial and bias defects, and transfers are made under seal or inspector observation. Pu Transfers by Pipeline from facility: For transfers by pipeline, verification can be omitted if the PIVs and IIVs (for timely detection) are performed simultaneously. Uranium Transfer from facility: Transfers not under seal are item counted and: Verified with medium detection probability for gross, partial and bias defects (LEU), verified with medium detection probability for gross and partial defects (NU) and verified with medium detection probability for gross defects (DU). Transfers under seal, verified before shipment or after receipt: Seal verification is performed with low detection probability. The material is item counted and verified with medium detection probability for: Gross, partial and bias defects (LEU), gross and partial defects (NU) and gross defects (DU).	PU PIV: Verified with high detection probability for gross, partial and bias defects. IIV (Timeliness): Product material in storage not under C/S is verified with medium detection probability for gross and partial defects. In-process inventory is verified using approved facility-specific procedures. NU and LEU Verified with medium detection probability for gross and partial defects. DU Verified with medium detection probability for gross defects.
WASTE MATERIALS	
Material not under C/S: Transfers are verified with high detection probability for Pu and medium detection probability for uranium (for gross defects).	Material not under C/S PIV: Verified with high detection probability for Pu and medium detection probability for uranium (for gross defects). IIV (Timeliness): Verified with medium detection probability for gross defects. Material under C/S IIV (Timeliness): The C/S system is evaluated, items are item counted and seal verification is performed with low detection probability. NOTE: Waste material is verified to the extent that the total amount of unverified inventory changes are below 0.5 SQ per Material Balance Period for each material type.
SPECIAL NOTES	
	Unverified nuclear material cannot exceed 0.6 SQ for any material type (IIV). Unverified material for each nuclear material type cannot exceed 0.3 SQ (PIV).

example, a small plant with manual controls calls for very different safeguards arrangements than a new commercial scale plant with extensive plant computerization); and

d. the intensity of the radiation background (while introducing an element of diversion-resistant self-protection, the intense radiation imposes requirements for safeguards measures to be performed remotely, within the biologically shielded areas of the plant).

4. Elements of the Safeguards Approach

IAEA safeguards implementation at reprocessing plants consists of a combination of nuclear material accountancy and containment/surveillance measures for design verification, the verification of plant operations and the verification of inventory changes and interim and annual physical inventories.

4.1 *Design Information Examination and Physical Verification.* This process is undertaken for the following purposes:

a. to establish that the design information provided by the state is complete, accurate and consistent;

b. to verify that the facility is constructed, operated and maintained in accordance with the design information provided. The provision, examination and verification of design information begins with the conceptual design of a plant and extends over its whole life, including decommissioning. Extensive physical verification activities are carried our during plant construction, during cold and hot plant commissioning, during shut downs for plant modifications and maintenance and, to the extent practicable, during plant operations;

c. to gain an understanding of the facility to confirm its declared peaceful purpose;

d. to conclude that the facility operator will be capable of operating the facility in accordance with the information provided, specifically in relation to procedures for the control and accounting of nuclear materials;

e. to serve as the basis for the design and implementation of a safeguards approach for the plant, to detect a diversion or undeclared reprocessing activities; and

f. to serve as a reference basis for normal plant operational patterns, and for abnormal or anomalous conditions when those patterns are not observed in practice.

4.2 *Nondestructive Assay (NDA) and Containment and Surveillance (C/S) Measures.* These measures are used extensively to verify the amounts of plutonium and uranium and to maintain continuity of knowledge of the verified amounts, particularly in item-control areas of the plant for spent fuel and for plutonium oxide or mixed plutonium-uranium oxide (MOX) product.

4.3 *Plant Operations Monitoring.* Plant-specific proce-

TABLE 2. REPROCESSING PLANTS SUBJECT TO IAEA SAFEGUARDS

PLANT NAME	LOCATION	CAPACITY	OPERATIONAL STATUS	SAFEGUARDS STATUS
EUROCHEMIC	MOL, BELGIUM	0.5 t/d LWR FUEL; MTR FUEL	OPERATED FROM 1966 - 1974	SAFEGUARDS APPLIED AFTER PLANT SHUT-DOWN
RADIOCHEMICAL LABORATORY	NYONGBYONG, DEMOCRATIC PEOPLES REPUBLIC OF KOREA	CONFIDENTIAL	CONFIDENTIAL	NPT SAFEGUARDS
UP2, UP3	CAP DE LA HAGUE, FRANCE	8 t/d LWR FUEL (COMBINED)	IN OPERATION	LIMITED SAFEGUARDS NWS VOLUNTARY OFFER LASCAR INVOLVEMENT
WIEDERAUF-ARBEITUNGS ANLAGE KARLSRUHE (WAK)	KARLSRUHE, GERMANY	0.2 t/d LWR FUEL	OPERATED FROM 1971 - 1991	NPT SAFEGUARDS
WIEDERAUF-ARBEITUNGS ANLAGE WACKERSDORF (WAW)	WACKERSDORF, GERMANY	3.5 t/d LWR FUEL	CANCELLED	PLANNING, R&D LASCAR INVOLVEMENT
NO NAME GIVEN	EL THUWAITA, IRAQ	CONFIDENTIAL	DESTROYED 1991	VIOLATION
PREFRE REPROCESSING PLANT	TARAPUR, INDIA	0.5 t/d CANDU FUEL	COMMISSIONED IN 1982	ONLY WHEN SAFEGUARDED FUEL IS REPROCESSED
EUREX	SALUGGIA, ITALY	0.1 t/d LWR FUEL	SHUT-DOWN	NPT SAFEGUARDS
ITREC	ROTONDELLA, ITALY	0.02 t/d Th FUEL	SHUT-DOWN	NPT SAFEGUARDS
PETRA	ISPRA ITALY	EXPERIMENTAL: TRU WASTE R&D	AWAITING COMMISSIONING	NPT SAFEGUARDS
TOKAI REPROCESSING PLANT	TOKAI-MURA, JAPAN	0.7 t/d LWR/ATR FUEL	IN OPERATION	NPT SAFEGUARDS
ROKKASHO REPROCESSING PLANT	ROKKASHO-MURA, JAPAN	4 t/d LWR FUEL	UNDER CONSTRUCTION	NPT SAFEGUARDS LASCAR INVOLVEMENT
CHEMICAL PROCESS FACILITY	TOKAI-MURA, JAPAN	FAST REACTOR R&D REPROCESSING PLANT	1982 - 1987	NPT SAFEGUARDS
RECYCLE ENGINEERING TECHNOLOGY FACILITY (RETF)	TOKAI-MURA, JAPAN	LMR FUEL REPROCESSING	UNDER LICENCE REVIEW	NPT SAFEGUARDS
NUCLEAR FUEL SERVICES (NFS)	WEST VALLEY, USA	1.5 t/d LWR FUEL	RETIRED 1972	TRAINING + R&D
THERMAL OXIDE REPROCESSING PLANT (THORP)	SELLAFIELD, UNITED KINGDOM	6 t/d LWR FUEL	IN COMMISSIONING	LIMITED SAFEGUARDS NWS VOLUNTARY OFFER LASCAR INVOLVEMENT
FAST REACTOR FUEL REPROCESSING PLANT	DOUNREAY, UNITED KINGDOM	0.04 t/d LMR FUEL	IN OPERATION	LIMITED PERIOD (1980-82) NWS VOLUNTARY OFFER TRAINING + R&D

dures are employed to provide authenticated data for the nuclear materials accountancy measures described below, and to confirm that plant operations are consistent with operator declarations. Plant-specific systems are used particularly in the head-end process area, the chemical separations and purification process areas (especially for the contactors and evaporators), the plutonium solution storage area, the plutonium conversion area and, in the future, high-level waste-conditioning plants.

These systems may incorporate solution level, density, temperature and concentration measurements, together with engineering flow sheet analyses to provide estimates of the inventories in the chemical plant, including those in the dissolvers, clarifiers, contactors and evaporators.

4.4 *Interim Inventory Verifications (IIV).* These are carried out to meet verification timeliness requirements. They combine findings from physical inventory verifications, inventory change verifications during a material balance period, and the verification activities carried out specifically for IIV.

For medium- and large-scale plants, near-real-time accountancy (NRTA) is applied to enhance verification sensitivity and to reduce the number of IIV verification measurements required. The manner in which data are collected and the frequency for deriving NRTA balances depend on the scale of the plant. For new plants, on-line data acquisition is foreseen, which will permit balance closings whenever desired.

4.5 *Subcampaign Material Balances.* These may be computed at large plants for the contiguous reprocessing of fuels from a single reactor, permitting a shipper/receiver difference to be evaluated on a client basis.

4.6 *Annual Material Balance Evaluations.* At least once per year, plant operators are required to shut down their plants, clean out the process areas and collect all nuclear materials at specially designated measurement points. The inventory is then measured and the combined material balance over a one-year (maximum) period is evaluated and reported to the IAEA. Physical inventory verification, together with inventory change verification, enables the IAEA to verify the material-unaccounted-for (MUF) declared by the operator, and to evaluate operator and inspector errors associated with the inventory and inventory changes and the resulting MUF value.

4.7 *Cumulative Material Balances.* These are computed over the life of the facility to ensure long-term verification stability.

5. Inspector Staffing and Deployment

Reprocessing plants operate around the clock, and thus the requirement for safeguards inspectors at medium- or large-scale plants is for 24-hour coverage, seven days per week. Additional inspectors are needed to cover such activities as book auditing, camera servicing, in-plant measurements,

sample taking and preparations for sample shipments to the IAEA Safeguards Analytical Laboratory, and on-site inspection data evaluation. During shutdown periods the requirements are reduced considerably.

In addition to field activities, at IAEA headquarters inspectors (and Agency support staff) carry out detailed analyses of the inspection data to produce the inspection reports and statements to the state.

About 600 person-days[2] of inspection are needed for shift coverage, and approximately 100 person-days for additional activities, for typical medium-sized reprocessing plants operating for 200 days per year. The total number of inspectors needed to meet this commitment depends on whether those inspectors are based in Vienna, in a regional office within the country where the facility is located, or reside in the vicinity of the plant and work at an inspection center at the plant site. The trend has been towards greater decentralization.

5.1 *Inspector Expertise.* Two categories of inspectors are used at reprocessing plants, taking into account overall Agency staff utilization efficiency requirements. These may be called *reprocessing inspectors*, whose normal obligations are focused on one or more reprocessing plants, and *supplemental inspectors* assigned for one or more person days of inspection when their normal duties permit. The qualities required of *reprocessing inspectors* reflect the wide range of technologies employed. A good working team can be set up if there is an adequate mix of expertise in more than one of the following fields:

a. reprocessing chemistry, chemical engineering and related reprocessing technology (inspectors with these skills are always in need);

b. nondestructive assay and destructive laboratory assay techniques;

c. computer literacy, including limited programming skills;

d. report writing and communications skills;

e. management, training and planning skills; and

f. safeguards rules, regulations and common practice.

5.2 *Training.* A comprehensive training program is needed to establish and maintain the knowledge and skills of *reprocessing inspectors*, particularly for those inspectors who do not have industrial experience in reprocessing plants. The skills and knowledge needed by *supplemental inspectors* is less demanding, encompassing only the broader aspects of reprocessing technology and facility-specific inspection practices. Inspector scheduling is normally arranged such that there is always at least one *reprocessing inspector* in the area, available to assist *supplemental inspectors* as needs develop. The training commitment necessary to support *reprocessing and supplemental inspectors* is thus quite extensive, especially in view of the high turnover of staff. General and specialized courses are provided related to reprocessing, particularly in the United Kingdom.

TABLE 3. APPROVED MEASUREMENT METHODS/EQUIPMENT FOR REPROCESSING PLANTS

MATERIAL FORM	VERIFICATION	APPROVED METHOD
SPENT FUEL	GROSS DEFECT	ICVD (CERENKOV DETECTION) GRN1 (NEUTRON DETECTION) CPMU (CUTIE PIE) HSGM (HIGH SENSITIVY γ MON.) SFAT (SPENT FUEL ATTRIBUTE TESTER)
MEASURED DISCARDS, WASTE	GROSS DEFECT	FMCG (MCA W/ Ge DETECTOR) FMCN (MCA W/ NaI DETECTOR) DA (DESTRUCTIVE ASSAY)
DISSOLVER SOLUTION	GROSS/PARTIAL /BIAS DEFECT	ELTM (ELECTROMANOMETER OR H_2O MANOMETER) + DA (IDMS, ISOTOPE DILUTION MASS SPECTROMETRY), OR HKED (HYBRID K-EDGE DENSITOMETER)
PLUTONIUM NITRATE	GROSS/PARTIAL /BIAS DEFECT	ELTM (ELECTROMANOMETER OR H_2O MANOMETER), + KEDG (K-EDGE DENSITOMETER), OR + DA (DESTRUCTIVE ASSAY),
URANYL NITRATE	GROSS/PARTIAL /BIAS DEFECT	ELTM (ELECTROMANOMETER OR H_2O MANOMETER) + DA (DESTRUCTIVE ASSAY)
PLUTONIUM OXIDE POWDER, OR MIXED PLUTONIUM/ URANIUM OXIDE POWDER (MOX)	GROSS/PARTIAL /BIAS DEFECT	*GROSS:* HLNC (HIGH LEVEL NEUTRON COINCIDENCE ASSAY) FMCG (MCA W/ Ge DETECTOR) OR FMCN (MCA W/ NaI DETECTOR) *PARTIAL:* HLNC (HIGH LEVEL NEUTRON COINCIDENCE ASSAY) + HRGS (HIGH RESOLUTION γ ASSAY), OR INVS (INVENTORY SAMPLE COINCIDENCE ASSAY) + HRGS (HIGH RESOLUTION γ ASSAY) *BIAS:* DA (DESTRUCTIVE ASSAY)
URANIUM OXIDE POWDER	GROSS/PARTIAL /BIAS DEFECT (BIAS DEFECT FOR LEU ONLY)	*GROSS:* FMCN (MCA W/ NaI DETECTOR) FMCG (MCA W/ Ge DETECTOR) *PARTIAL:* FMCN (MCA W/ NaI DETECTOR) + EBAL (ELECTRONIC BALANCE + STANDARD IAEA WEIGHTS) *BIAS:* DA (DESTRUCTIVE ASSAY)

Note: selections among alternative methods may be determined by the availability of equipment or plant-specific factors making one choice preferable to others.

IV. Past Experience

Table 2 shows the chemical reprocessing plants where IAEA safeguards have been, are currently, or will be applied. In some cases, safeguards application has been on a partial basis, as under voluntary safeguards agreements in nuclear weapons states. In other cases, extensive safeguards-related R&D activities are underway or have been carried out.

V. Current Practice

In this section, the verification activities currently applied are summarized.[3] Measurement systems currently approved for routine inspection use in reprocessing plants are shown in Table 3. Table 4 summarizes the techniques most widely applied in the analysis of inputs to and product outputs from reprocessing plants. The measurement uncertainties are taken from a forthcoming IAEA publication.[4] They describe the measurement performance that is expected under normal conditions.

1. Design Verification

Design verification is expected to be achievable under routine verification conditions.

In reprocessing plants currently under IAEA safeguards,

TABLE 4. ANALYTICAL TECHNIQUES AND EXPECTED MEASUREMENT ERRORS

MEASUREMENT POINT	MEASUREMENT TECHNIQUE	MEASUREMENT	ERROR STD. DEV. (% REL)	
			RANDOM	SYSTEM.
INPUT SOLUTION	ISOTOPE DILUTION MASS SPEC.	PU-CONCENTRATION	0.4	0.2
		U-CONCENTRATION	0.3	0.2
		U-235 ABUNDANCE	0.3	0.2
	ISOTOPE DILUTION MASS SPEC. (USING LSD-SPIKE)[6]	PU-CONCENTRATION	0.2	0.1
		U-CONCENTRATION	0.2	0.1
		U-235 ABUNDANCE	0.2	0.2
	HYBRID K-EDGE DENSITOMETER	PU-CONCENTRATION	0.6	0.3
		U-CONCENTRATION	0.5	0.35
PU OUTPUT SOLUTION	TITRATION/COULOMETRY	PU-CONCENTRATION	0.15	0.15
	K-EDGE DENSITOMETER	"	0.20	0.20
PUO_2	TITRATION/COULOMETRY	PU-CONCENTRATION	0.15	0.15
	HLNC	TOTAL PU	1.0	0.5
U OUTPUT SOLUTION	TITRATION/COULOMETRY	U-CONCENTRATION	0.1	0.1
	K-EDGE DENSITOMETER	"	0.2	0.2
	MASS SPECTROMETRY	U-235 ABUNDANCE	0.2	0.2

the design information has been verified. Additional design verification activities should be carried out when there are plant modifications or when operator access is required inside the biological shield for repairs. Implementation arrangements for continued design verification over the life of existing plants and decommissioning are under discussion.

2. Verification of Plant Operations

2.1 *Verification of Transfers to the Mechanical Cell.* C/S is maintained to detect all transfers of spent fuel from the spent fuel pond to the mechanical cell. Observed movements are cross checked with operator declarations and in-cell gamma monitor readings. The serial number of each fuel assembly is identified in the cell prior to shearing.

2.2 *Verification of Shearing and Dissolution.* Shearing of the bottom end of each fuel assembly is monitored and visual observation of the chopped fuel assembly bottom is carried out to ensure that the assembly cannot go back to the pond without unacceptable contamination. Completion of dissolution is verified by assuring that the standard dissolver solution density is achieved, as established during plant commissioning.

2.3 *Monitoring of Operator Instrumentation.* Strip charts and data logged by operator computers are examined to confirm that operations are consistent with operator declarations. Limited authentication measures are applied.

3. Inventory Change Verification

3.1 *Verification of Spent Fuel Receipts.* All spent fuel receipts are verified by item counting and Cerenkov glow, or gross gamma detection, with random medium detection probability. Casks leaving the facility are checked before they are removed from the unloading pond to verify that they are empty.

3.2 *Verification of Input Accountancy.* Input declarations from the reactors are calculated values based on the quantities of nuclear material in the fresh fuel assemblies and nuclear loss and production calculations made over the exposure history of each fuel assembly. The calculated values are corrected for ^{241}Pu decay over the period from final discharge from the reactor core to the time that input accountability measurements are made.

Each batch of dissolver solution is verified in the input accountability tank prior to being transferred to the process. This verification consists of volume measurements and sampling for analysis of Pu (all batches) and U (random medium basis) to detect bias defects. The calibration of the input accountancy tank is checked annually and a recalibration is performed when necessary.

Sample preparations at the facility, the shipping of samples to the IAEA Safeguards Analytical Laboratory, and sample analysis and evaluation, can take up to three months. Therefore, a preliminary evaluation is made using a density correlation[5] to estimate the uranium content. The Pu/U ratio de-

TABLE 5. REPROCESSING-RELATED R&D UNDER IAEA MEMBER STATE SUPPORT PROGRAMMES

TOPIC	STATUS
TOOLS AND TECHNIQUES FOR DESIGN INFORMATION VERIFICATION	ACTIVE
MAINTAINING CONTINUITY OF KNOWLEDGE ON VERIFIED DESIGN INFORMATION	ACTIVE
WORKSHOP: VERIFICATION DURING PLANT COMMISSIONING TO CONFIRM PHYSICAL DESIGN VERIFICATION AND TO ESTABLISH REFERENCE BASIS FOR COMPARISON DURING NORMAL PLANT OPERATIONS	ACTIVE
FEASIBILITY OF ADVANCED METHODS OF MATHEMATICAL ANALYSIS APPLIED TO DESIGN VERIFICATION AND NRTA AUTHENTICATION ANALYSIS	ACTIVE
VIBRATION ANALYSIS OF SHEARING	PRE-STARTUP
FEASIBILITY OF NOBLE GAS ISOTOPE CORRELATION FOR INDEPENDENT MEASUREMENT OF PU INPUT, AND C/S MONITORING OF SHEARING	ONE ACTIVE, ONE UNDER CONSIDERATION
FEASIBILITY OF COMBINED NDA/DA OF CURIUM FOR INPUT VERIFICATION, VERIFICATION OF PU IN LEACHED HULLS, AND VERIFICATION OF PU IN CONDITIONED WASTE	UNDER CONSIDERATION
HYBRID K-EDGE/K-XRF FOR INPUT MEASUREMENTS	ACTIVE
UNATTENDED VERIFICATION OF TANK VOLUME MEASUREMENTS AND SAMPLING	ACTIVE
APPLICATION OF NRTA/ADJUSTED RUNNING BOOK INVENTORY METHOD IN HEAD-END PROCESSING AREAS OF REPROCESSING PLANTS	ACTIVE
AUTHENTICATION OF OPERATOR MONITORING SYSTEMS BY EXPERT SYSTEMS ANALYSIS	PRE-STARTUP
SOLUTION MASS VERIFICATION TECHNOLOGY	ONE ACTIVE, ONE UNDER CONSIDERATION
REPROCESSING/CONVERSION PLANT NRTA SAFEGUARDS DESIGN SPECIFICATIONS	ACTIVE
DIAGNOSTIC ANALYSIS OF NRTA ALARMS	STARTUP
ADAPTATION AND APPLICATION OF HAZOP/HAZAN METHODS TO SAFEGUARDS	ACTIVE
PROBABALISTIC ANALYSIS OF SAFEGUARDS EFFECTIVENESS FOR REPROCESSING PLANTS	ACTIVE

cleared by the shipper (the reactor), adjusted to reflect historical data for each reactor, is used to obtain a preliminary estimate of the Pu content.

Input accountability values are compared with shipper declarations. Problems exist in the SRD comparisons due to batch mixing and to inaccurate burn-up calculations, particularly for Boiling Water Reactors.

3.3 *Verification of Waste Streams.* Verification of transfers to waste or to measured discards is required for gross defects. Over a material balance period, unverified transfers must not exceed one-half of one SQ for each material type.

Waste materials must be measured and conditioned to be nonretrievable before safeguards can be terminated on the plutonium and uranium contained. At present, however, no practical verification methods exist for leached hulls and filters, and these materials are maintained as retained waste. High level liquid waste (HLLW), which contains most of the nuclear material in retained waste, also must be analyzed for the presence of plutonium.

3.4 *Verification of Plutonium Product Output.* All transfers of the final plutonium product solution (i.e., plutonium nitrate, $Pu(NO_3)_4$) from the process material balance area are verified for bias defects by volume measurement, sampling and analysis — mainly by K-edge densitometry and additionally, on a random basis, by destructive analysis.

Volume calibration of the output accountancy tank is checked each year and a recalibration is performed if necessary.

3.5 *Verification of Plutonium Product Shipments.* All transfers of plutonium product material from the plutonium nitrate storage tanks to a conversion facility are verified by volume measurement, sampling and analysis for gross, partial and bias defects, usually by X-ray fluorescence (XRF) and destructive analysis. This verification can be performed at either the shipping or receiving tanks, provided that C/S is maintained during such transfers (usually by inspector observation of tank levels).

3.6 *Verification of Uranium Solution or Product Powder Shipments.* Shipments of uranium from the facility are verified by volume measurement (for solutions) or by weighing (for oxide powders), with medium detection probability for gross and partial defects for low-enriched and natural uranium, and for gross defects for depleted uranium.

4. Interim Inventory Verification (IIV)

Interim inspection activities are carried out at a time (called the cut-off time) when the Pu product evaporator has just been emptied. During shutdown, any convenient time may be chosen.

4.1 *Examination of Records and Reports.* Facility accountancy records are examined for correctness and consistency with the operating records and supporting documents. Inventory change and material balance reports submitted by the state to the Agency are compared with the previously examined facility accountancy records.

4.2 *Spent Fuel Verification.* The spent fuel pond inventory is verified by comparing the operator's declaration of transfers to and from the pond area with that observed through surveillance.

4.3 *Verification Activities in the Head-End.* The in-process inventories in the head-end and in the process MBA are verified by an approved facility-specific method. Head-end batches present at the cut-off time are identified, tracked until their arrival in the input accountancy tank, and verified as inventory and as flow to the process MBA.

4.4 *Verification Activities in the Separations and Purification Area* . Near-real-time accountancy (NRTA) measures are applied on a monthly basis to the process MBA based on operator declarations of flow and inventory. All flows to or from the process MBA are verified. Samples are taken from the major Pu-containing inventory tanks on a random medium basis for authentication of the operator declarations. The sequence of monthly NRTA MUFs is analyzed for indications of possible losses of plutonium, which might result from innocent causes or in the event of a diversion.

4.5 *Verification Activities in the Plutonium Nitrate Storage Area.* The $Pu(NO_3)_4$ stored in product tanks is verified by volume measurement and sampling for gross and partial defects by K-edge densitometry. An NRTA analysis with authentication is also carried out for this storage.

TABLE 6. FACTORS AFFECTING SOLUTION MASS MEASUREMENTS

The accuracy of a measurement of the amount of nuclear material present in solution in a given tank or series of tanks will be influenced by the following factors:

1) Tank design and materials; supporting structures; piping for transfers of solutions, ventilation, reagent addition, air pulsation or sparging; power trains for mechanical homogenization; pneumatic lines for solution level and density measurements; and electronic cabling for temperature measurements and other types of instrumentation;

2) Tank operational procedures, including provisions for sampling, solution transfers, drainage, homogenization and ventilation;

3) Physical and chemical phenomena, including density, acidity, viscosity, surface tension, volatility/chemical reactivity, thermal expansion, polymerization, presence of undissolved solids or immiscible liquids;

4) The solution measurement system, including sensors with support utilities (e.g., dip tubes with controlled instrument air or nitrogen supply) and transducers; signal conditioning; data transmission and logging.

5) Initial tank calibrations and re-calibrations providing reliable calibration curves, including determinations of the random and systematic uncertainties associated with those determinations, including acceptance testing and normal operations.

6) Sampling systems, including provisions for assuring that samples are representative and well characterized; provisions for protecting the integrity of samples and methods, procedures and evaluations of sampling error anticipated in routine use of the tank; and

7) Sample concentration measurements to determine the elemental and isotopic composition of nuclear material species present in the solution in the tank at the time of measurement, and methods, procedures and evaluations of random and systematic uncertainties associated with the concentration measurements.

5. Physical Inventory Verification (PIV)

One PIV is carried out per calendar year at intervals not exceeding 14 months. Before the PIV, the operator cleans out the process vessels and piping by successive rinsing and flushing and transfers the recovered materials to calibrated tanks. The entire plant inventory is measured or otherwise confirmed by the operator, constituting the physical inventory taking (PIT). The result of this is a preliminary list of inventory items (LII), which serves as the basis for IAEA verification.

Upon completion of the PIT, the operator analyzes the material balance over the period from the previous PIT and subsequently submits his declaration to the national safeguards authority. The national safeguards authority, when satisfied with the material balance report, submits an official Material Balance Report to the IAEA, which includes the official Physical Inventory Listing (PIL), based on the LII.

5.1 *Examination of Records and Reports.* The facility accountancy records are examined for correctness and consistency with the operating records and supporting documents. Inventory Change and Material Balance Reports submitted by the state to the Agency are compared with the previously examined facility accountancy records.

5.2 *Spent Fuel Verification.* For PIV, the spent fuel pond inventory is verified through successful surveillance and item counting of the spent fuel assemblies, plus random low verification for gross defects. If spent fuel is stored in closed containers, two-stage sampling is applied; containers are selected with 10% detection probability ($\beta = 0.9$), and then assemblies in the selected containers are verified by identification and Cerenkov glow or gross gamma detection on a random medium basis.

5.3 *Verification of the Plutonium and Uranium Inventory.* Plutonium solutions in process vessels as well as in storage tanks are verified with high detection probability ($\beta = 0.1$) for gross, partial and bias defects. Uranium solutions and product powders are verified with medium detection probability for gross and partial defects for low enrichment and natural uranium and for gross defects for depleted uranium. Plutonium waste is verified with high detection probability for gross defects. (Note that up to 0.3 SQ of each material type, i.e., 2.4 kg Pu, may remain unverified according to present requirements.)

VI. Future Trends

Approximately one quarter of the total IAEA inspection effort is devoted to plutonium processing facilities, the amount depending from year to year on the operating schedules of the existing plants. While substantial technical progress has been realized in establishing credible safeguards systems, efforts continue to address some remaining problems. However, none of these problems has precluded inspection goals from being attained, but improvements are needed to improve the technical credibility of the safeguards applied, or to lower the costs of safeguards implementation without adversely affecting safeguards effectiveness. Some of the present problem areas are identified below:

- Measurement biases on solution measurements persist at levels in excess of 1% (i.e., 10 times the expected levels of performance).
- In some cases, it is not possible to assure that samples taken for the IAEA are not altered prior to shipment to the Agency's Safeguards Analytical Laboratory.
- Following recommendations from the IAEA board of governors, continuing verification of design information of operating plants will require significant effort and may interfere with plant schedules. Limitations caused by radiation will inhibit the extent of physical verification.
- Investigations are continuing into expanded use of unattended verification arrangements, telecommunications and resident inspector deployment as possible efficiency measures.
- Improvements are required in the analysis of shipper/receiver differences (see annex).

In addition to these activities focused on existing facilities, in the coming years, Agency safeguards will be applied at a few new reprocessing plants, particularly in Japan. Efforts related to new plants are described below.

1. Safeguards Implementation at New Reprocessing Plants

The basic concepts regarding IAEA safeguards implementation in large-scale reprocessing plants were investigated recently, under an arrangement referred to by the acronym LASCAR (for LArge SCAle Reprocessing).[7,8] France, Germany, Japan, the United Kingdom, the United States, Euratom and the IAEA examined potential verification arrangements for the spent fuel areas, the main chemical process area and the product storage areas. While LASCAR

TABLE 7: VERIFICATION MEASUREMENT METHODS FOR ON-SITE IAEA ANALYTICAL LABORATORIES

PROCESS AREA	SAMPLING POINT	INSTRUMENT OR METHOD	CONCENTRATION MEASUREMENT	SAMPLE FRACTION	GOAL ACCURACY
HEAD END	INPUT TANK	HYBRID K-EDGE DENSITOMETER (HKEDG)	Pu U	100 % 50 %	≤ 1 % ≤ 0.5 %
SEPARATION	BUFFER/FEED TANKS	ISOTOPE DILUTION MASS SPECTRO-METRY (IDMS)	Pu U	25 % 2 %	≤ 0.2 % 0.2 %
SEPARATION	SCRUB AND WASTE TANKS	Pu(VI) SPECTRO-PHOTOMETRY	Pu	< 20 %	≤ 25 %
Pu PURIFICATION	COLLECTION AND FEED TANKS	HKEDG IDMS	Pu Pu	50 % ≤ 10 %	1 % ≤ 0.2 %
	PuN TANKS	KEDG IDMS	Pu Pu	25 - 100 % 10 - 90 %	0.2 % 0.1 %
	WASTE TANKS	Pu(VI) SPECTRO-PHOTOMETRY	Pu	< 10 %	≤ 25 %
U PURIFICATION	UN TANKS	K-EDGE DENSITOM-ETER (KEDGG)	U	≤ 10 %	0.2 %
	UO_3 CANS UO_3 CANNING	NDA (MEASURE-MENTS MADE IN PLANT) KEDG	U U	≤ 10 % 1 %	< 5 % 0.2 %
MOX CONVERSION	U, Pu N TANKS	KEDG	U Pu	< 10 % 50 %	0.2 % 0.2 %
		IDMS	Pu	20 %	≤ 0.2 %
	MOX CANISTERS	NDA (MEASURE-MENTS MADE IN PLANT)	Pu	100 %	1 %
	MOX CANNING	KEDG	Pu	25 %	≤ 0.2 %

was a significant success, a considerable effort will be required to translate the recommendations into specific working arrangements for the new large scale plants. Also, reprocessing plants other than those considered by LASCAR will or may come under IAEA safeguards in the future (see Table 2).

New reprocessing facilities that are currently being designed or constructed pose challenges in the application of safeguards principally because of the large quantities of nuclear material involved, the complexity of the plants and their remote locations. Existing verification equipment or procedures may be inadequate or inappropriate or highly inefficient, especially in large-scale plants. For example, new reprocessing plants may employ continuous dissolvers, centrifugal contactors and continuous evaporators, requiring new inspection procedures. Moreover, the scale of some of the new facilities is expected to be much larger than that of existing plants subject to IAEA safeguards. In the plants addressed through LASCAR, for example, the plutonium throughput, in-process inventory and storage capacity will be 10-to-50 times that encountered in existing plants under IAEA safeguards. These facilities will require extensive Agency effort and will strain the limits of Agency verification capabilities.

2. R&D and Implementation Support Planning For New Reprocessing Plants

New safeguards techniques and equipment are required that are cost effective and eliminate anticipated vulnerabilities or shortcomings. R&D is carried out for the IAEA by Member State Support Programs. Table 5 identifies the R&D tasks currently active in Australia, Euratom, Japan, the United Kingdom and the United States, and additional R&D topics under consideration.

Our R&D planning must consider the following factors:

- implementation must be synchronized with plant construction schedules,
- current and projected inspection requirements must be met (see Table 1),
- LASCAR recommendations will be honored and
- the required sequence of tasks necessary to address each need and the resources available within Member State Sup-

port Programmes.

When a requirement is identified on the basis of reducing intrusiveness, improving cost effectiveness or addressing potential vulnerabilities, one or more tasks may be proposed to address each need. The tasks generally would follow logical stages: concept development (of one or more alternative approaches), evaluation of alternatives, technology development and evaluation, system procurement, system qualification and evaluation, training, and maintenance.

Each task must be planned in accordance with the plant construction and commissioning schedule. The relationships between tasks must be identified and progress closely monitored to ensure that when a new plant commences operations, an effective and efficient safeguards system will be in place.

3. Anticipated Problems for Safeguards Implementation in New Facilities

At the present time, the following issues remain unresolved:

- The costs for implementing safeguards at new reprocessing plants will be substantial, requiring additional resources for staff, equipment and operations.
- Solution mass measurement technology is not sufficient for the needs anticipated, noting that 0.1% of throughput may be greater than one significant quantity of plutonium. Table 6 shows the factors affecting the accuracy of solution mass measurements.
- Monitoring of process operations will be required in real-time, with comparisons of the observed operations with operator declarations and predictions of normal plant behavior. This is a more intrusive arrangement than currently employed, and one likely to require more frequent inspector enquiries than at present.
- Resident inspectors will substantially reduce the inspector staffing requirements. Basing inspectors in remote areas will require attractive arrangements.
- On-site analytical laboratories may be shared by Agency analysts and national safeguards analysts to offset the costs that both would bear if separate laboratories were established. The capabilities foreseen for on-site laboratories are shown in Table 7. Such a laboratory should be equipped to provide verification measurements of the main nuclear material streams and strata with accuracies of the order of 0.1%. These measurements will be needed to complement less accurate but more frequent measurements done by faster and simpler methods. If the accuracy is comparable to that obtained at the IAEA Safeguards Analytical Laboratory, shipments of samples to SAL will be needed infrequently for quality control and authentication purposes, and for the resolution of discrepancies, or in the event of failure of the equipment in the on-site laboratory. The working arrangements will require that the Agency analysts are able to obtain independent measurement results.
- Specialized verification systems will tax the Agency's ability to ensure reliable safeguards implementation (design, procurement, authentication, operation, maintenance).
- The policies and specific guidelines for authentication of operator instruments and for the termination of safeguards on measured discards require further development.

VII. Conclusions

In the case of safeguards as applied to a reprocessing plant, the effectiveness of IAEA technical safeguards measures is determined by the Agency's ability to detect the diversion of plutonium or uranium from the declared reprocessing plant inventories, and to detect undeclared reprocessing operations, should such a diversion or misuse occur. The effectiveness of a given safeguards application depends on the relative strengths and limitations of the measures employed, beginning with design verification and building up through the various applications of containment and surveillance and nuclear materials accountancy at the facility in question. Other possibilities are available to supplement these routine verification activities, including special inspections if suspicions warrant. Thus, no single safeguards measure, whether it be anomaly detection through containment and surveillance, or material balance evaluation involving the analysis of material-unaccounted-for, adequately represents the capability or the system to detect diversion or undeclared reprocessing.

Safeguards in new reprocessing plants will differ from current implementation arrangements in several ways. First, the emphasis on design verification will be more evident, over the entire life of a plant. Second, for large scale facilities, there will be a greater need for assuring that operations are carried out as declared, which will require extensive use of installed instrumentation. Operator instruments will be used more than at present, and authentication provisions will be incorporated from the outset. Third, with the increased data requirements and budgetary pressures limiting future staff growth, on-site inspection centers will be needed, with on-line logging of verification data and on-site data analysis and reporting capabilities. Where possible, resident inspector arrangements may be adopted to facilitate specialization and to increase inspector efficiency. And fourth, on-site analytical laboratories may be employed to minimize the number of samples requiring shipment to the IAEA Safeguards Analytical Laboratory in Seibersdorf, Austria. Such laboratories will provide improved verification sensitivity and dramatically improve verification timeliness.

The principal objective of this paper has been to describe safeguards implementation at current reprocessing plants and the complications anticipated in meeting future demands. On the whole, the safeguards provisions employed today are acceptable, with certain improvements required. For the future, the complications identified are being addressed, although the demands will certainly tax the existing conceptual base and the implementation framework.

References

1. In IAEA safeguards terminology, low, medium and high detection probability refer to the probability for committing errors of the second type, b, chosen for planning purposes to be 0.9, 0.5, and 0.1, respectively.

2. One "person day of inspection" is defined to be up to 8-hours per calendar day spent within a facility by one inspector, whether continuously or in broken intervals.

3. S. Johnson and N. Islam, "The Current IAEA Approach to Implementation of Safeguards in Reprocessing Plants," *Proceedings of the Fourth International Conference on Facility Operations - Safeguards Interface* (1991)

4. *1993 International Target Values for Uncertainty Components in Fissile Isotope and Element Accountancy for Effective Safeguards of Nuclear Materials*, IAEA publication, in preparation.

5. Ph. Cauchetier, Rapport CEA R 5322 (1985).

6. D. Donohue, et. al., *15th ESARDA Symposium on Safeguards and Nuclear Materials Management*, Vatican City (1993) (in preparation).

7. STI/PUB/922, *Report of the LASCAR Forum: Large Scale Reprocessing Plant Safeguards*, IAEA, Vienna, 1992.

8. J. Jennekens, B. Judson and H. Kuroi, "A Perspective of the IAEA on LASCAR," *INMM 33rd Annual Meeting Proceedings* 21:287-290 (1992).

Thomas Shea, Fredy Franssen, David Hope, Nural Islam, Shirley Johnson, Dean Neal and Therese Renis are International Atomic Energy Agency inspectors assigned responsibility for applying safeguards in reprocessing plants. Stein Deron, Erwin Kuhn and Gabor Laszlo are specialists providing technical support for the safeguarding efforts.

FRACTAL ANALYSIS OF SHIPPER/RECEIVER DIFFERENCE SERIES

Shipper/Receiver Difference analyses are carried out to verify the amounts of nuclear materials transferred between facilities, and thereby to detect diversion concealment through over declarations of shipments or under declarations of receipts. For spent fuels, however, the shipper is the reactor, and the amounts of plutonium and uranium in spent fuel assemblies are calculated on the basis of the initial contents and nuclear loss and production over the exposure history of the assembly in the reactor. Substantial shipper/receiver differences are observed in practice. Fractal analyses reduce the random effects and permit useful SRD analyses.

At the beginning of the century, a hydrologist named Hurst was concerned with the problem of reservoir control. To come up with an optimum discharge policy, the influx of water had to be modeled. Hurst measured how the reservoir level fluctuated around its average over time. As expected, the range of this fluctuation would change depending on the length of time used for measurement. If the series were a random walk-like sequence then the range would increase with the square root of time. To standardize the measure over time, Hurst created a dimensionless ratio - *the rescaled range* - by dividing the range by the standard deviation of observations. *Hence, the analysis of random processes and of time series with the help of the behavior of the rescaled range is called rescaled range (R/S) analysis.* Hurst found that most natural phenomena, including river discharges, follow a "biased random walk" trend with noise. The strength of the trend and the level of noise can be measured by how the rescaled range scales with an exponent (H) of time, noting that H = 0.5 corresponds to Brownian motion.

A more modern twist in Hurst's investigations is that of the connection to fractal sets. Mandelbrot studied time series, which he called fractional Brownian motion, a generalization of the classical Brownian motion. He found interesting interpretations of the Hurst exponent. For example, the fractal dimension of a time series showing a stable Hurst exponent H is equal to 1/H. Thus, the parameter H is a measure of the roughness of a series at small scales. It is also related to the correlation between two increments of the process.

A time sequence plot of almost any SRD series shows a noise-like process as if produced by some random mechanism. In analyzing an SRD series, it is first described as tersely as possible. (The Box-Jenkens analysis, for example, would attempt to describe a time series with a small number of coefficients defining a filter, which in turn transforms white noise into a series statistically identical to the underlying one.) Next, its structure, buried in its noise-like appearance, is revealed. SRD series can contain information about the various fuels and reactor types with which they are associated.

In work carried out thusfar, the R/S analysis of two SRD data sets suggests that:

- there are unique and stable Hurst coefficients for each series; and
- process campaigns and reactor fuel types seem to show distinct structures in the R/S transform.

The most useful aspect of the R/S analysis might be its discerning capability for fuel and reactor types in the SRD series.

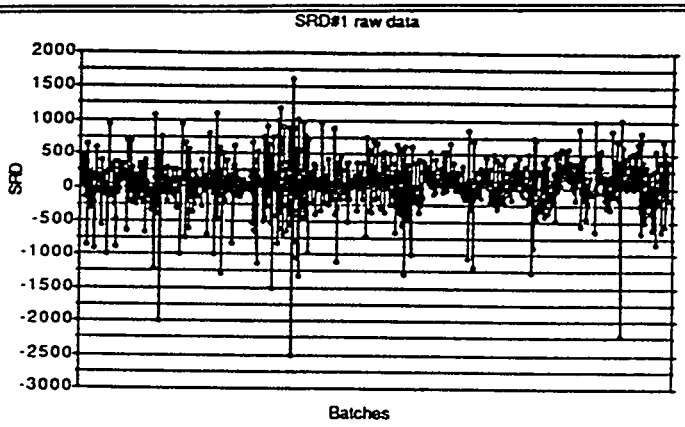


Figure 1. An unmodified SRD sequence, expressed in arbitrary units.

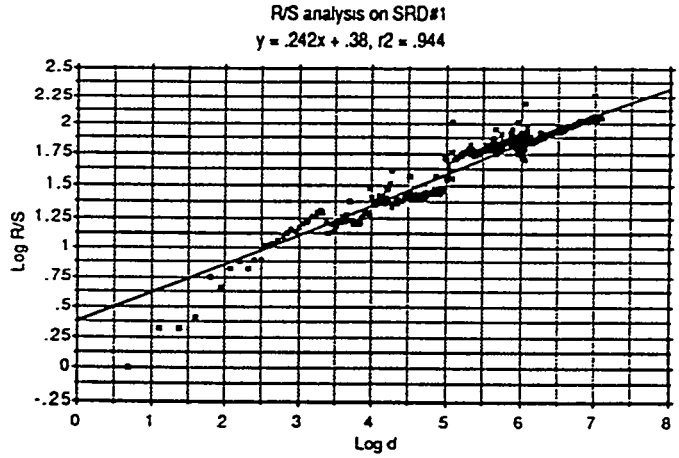


Figure 2. The R/S transform of the SRD sequence shown in Figure 1 gives an H estimate of .242, which corresponds to a fractal dimension about twice that of normal Brownian motion, or a random walk with small steps. Another SRD sequence yielded a fractal dimension of 2.36.

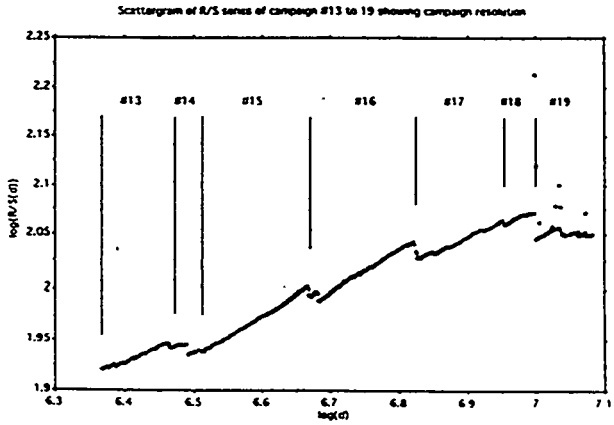


Figure 3. The ability of the R/S transform to resolve different campaigns in the original SRD sequence is shown; jumps in the R/S sequence tend to mark the beginning of a new campaign.

Appendix G

General Safeguards Discussion

Reprocessing Plant Safeguards and Some Thoughts on Verification of Plant Shutdown

E. Arnold Hakkila

Los Alamos National Laboratory

LASCAR Plenary and Working Group Meetings

Meeting	Venue/Date		Chairman
1st plenary meeting	Kyoto, Japan	17-21 October 1988	Japan
1st wg meeting wg-1 & wg-2	Sellafield, UK	27 Feb–3 March 1989	Japan France
2nd wg meeting wg-1 & wg-2	Cap La Hague Cherbourg, France	8-12 May 1989	Japan France
2nd plenary meeting	York, UK	19-23 June 1989	UK
3rd wg meeting wg-1 & wg-2A	Hannover, Germany	2-6 October 1989	Japan France
4th wg meeting wg-2B & wg-3	Tokyo, Japan	2-6 April 1990	UK Germany
3rd plenary meeting	Avignon, France	18-22 June 1990	France
5th wg meeting wg-2B & wg-3	London, UK	29 Oct-2 Nov 1990	UK Germany
6th wg meeting wg-2B & wg-3	München, Germany	15-19 April 1991	UK Germany
4th plenary meeting	Williamsburg, VA, USA	15-19 July 1991	US
Drafting committee meeting	Alpbach, Austria	27-31 January 1992	IAEA
Drafting committee meeting	Eisenstadt, Austria	23-27 M arch 1992	IAEA
5th plenary meeting	Shimoda/Tokyo, Japan	18-22 May 1992	Japan

U. S. Participation in LASCAR

Arms Control and Disarmament Agency

U. S. Department of State

U. S. Department of Energy

Nuclear Regulatory Commission

Los Alamos National Laboratory

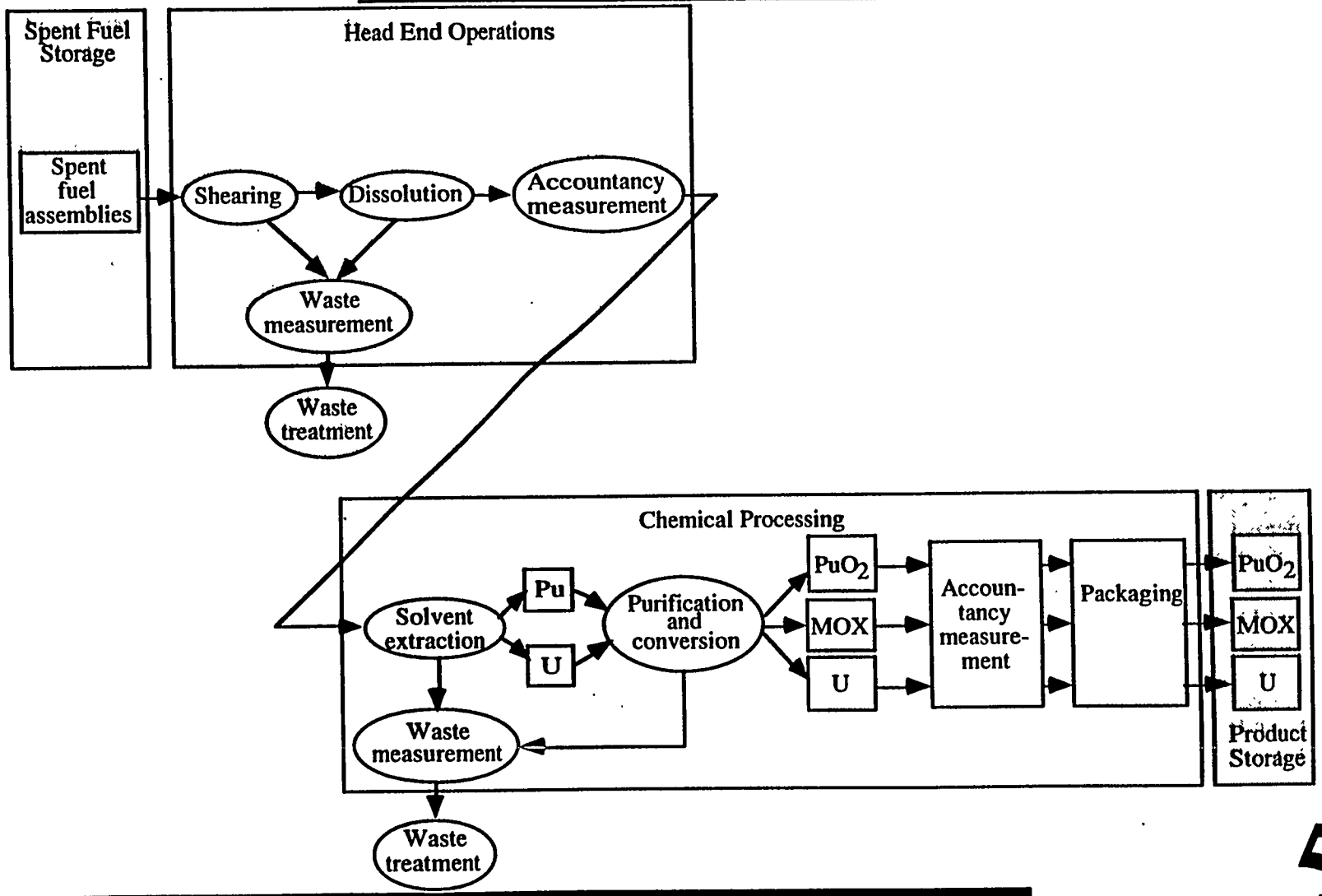
Sandia National Laboratory

CONTENTS

SECTIONS

ANNEXES

Major Areas of Reprocessing Plant



Spent Fuel Pond

- Verify that any spent fuel in the pond is not moved to reprocessing area
  - Perform periodic inventory (every three months)
  - Perform annual physical inventory (operator)
  - Annual physical inventory verification—PIV (IAEA)
- Verify all transfers into/out of spent fuel pond

Spent Fuel Pond

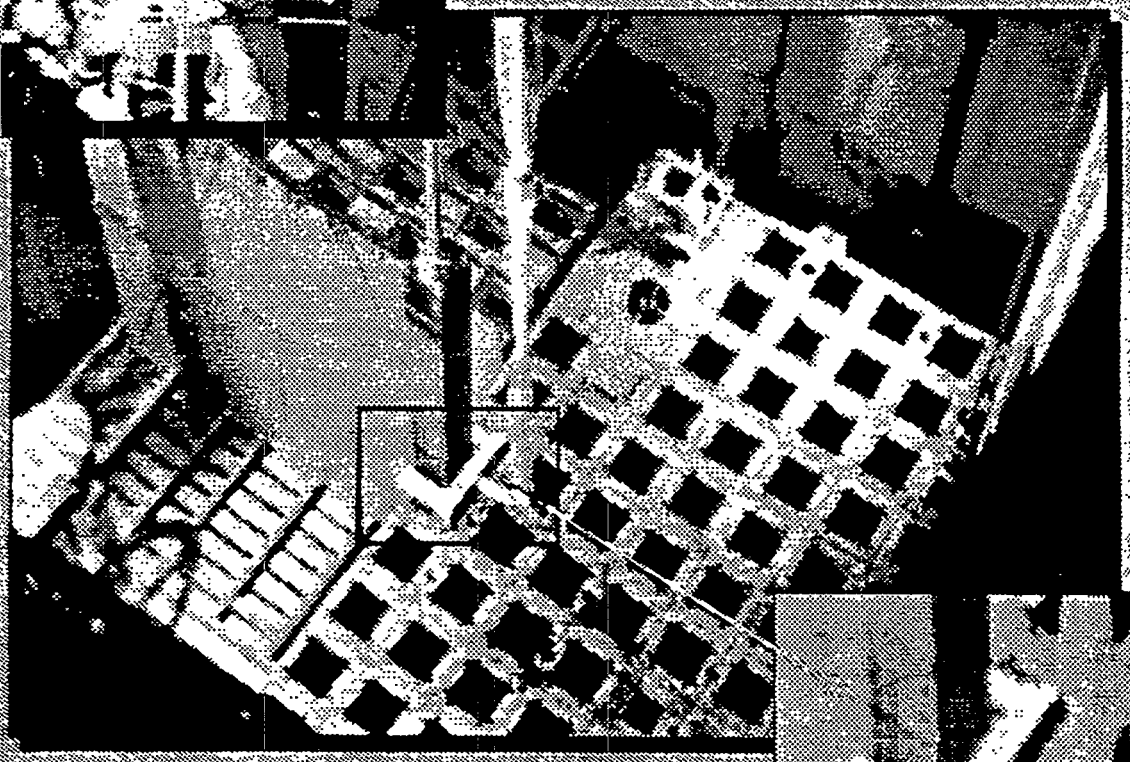
- Item accountancy
- Spent fuel measurement
  - Fork
  - Python
- Video surveillance

International Safeguards for Spent Fuel

Los Alamos

Description/Objective

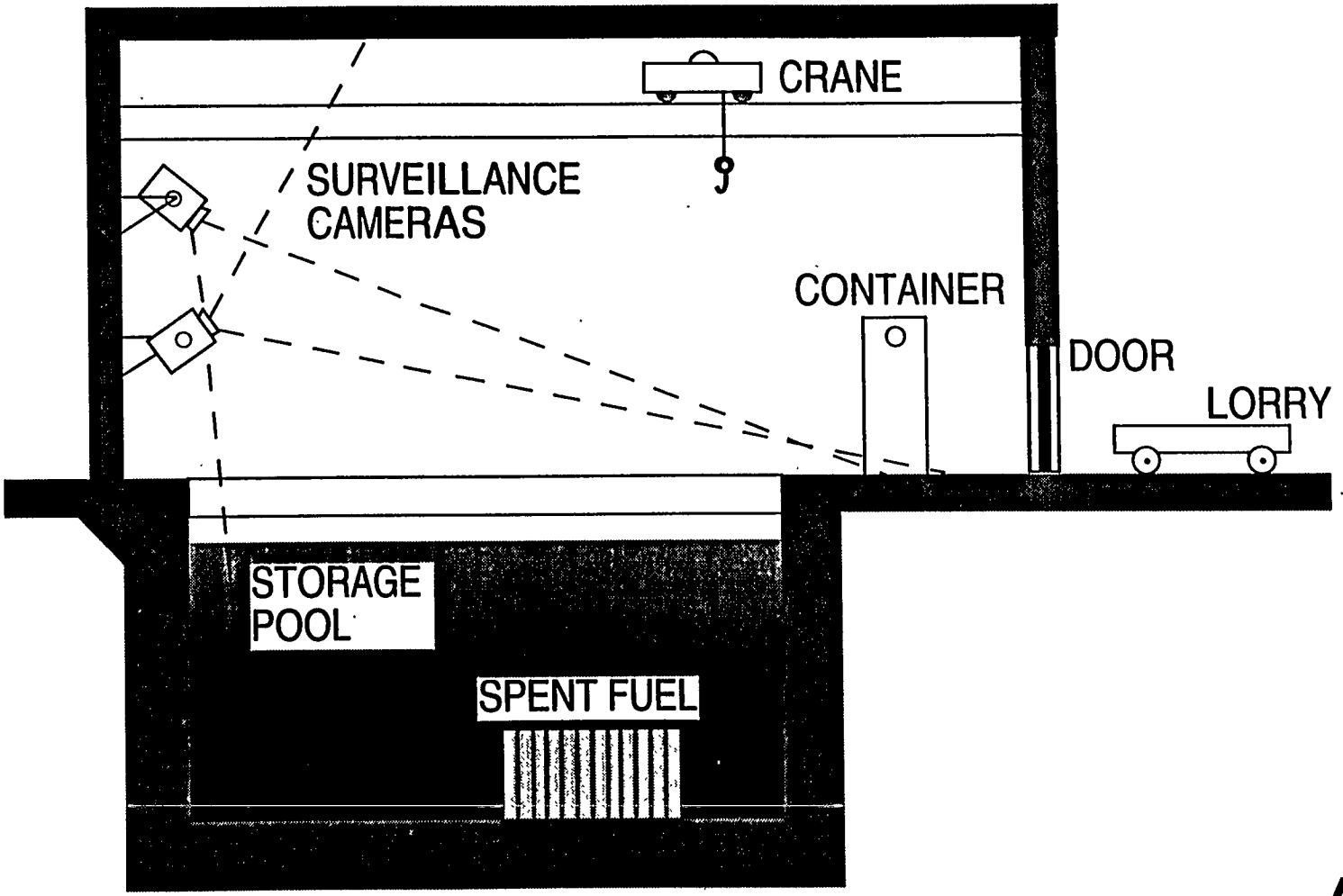
Develop a procedure for measuring characteristics of spent-fuel assemblies stored in underwater facilities. The equipment is used by safeguards inspection authorities for inventory verification and by facility operators to verify "burnup" before loading assemblies in storage or transportation casks.



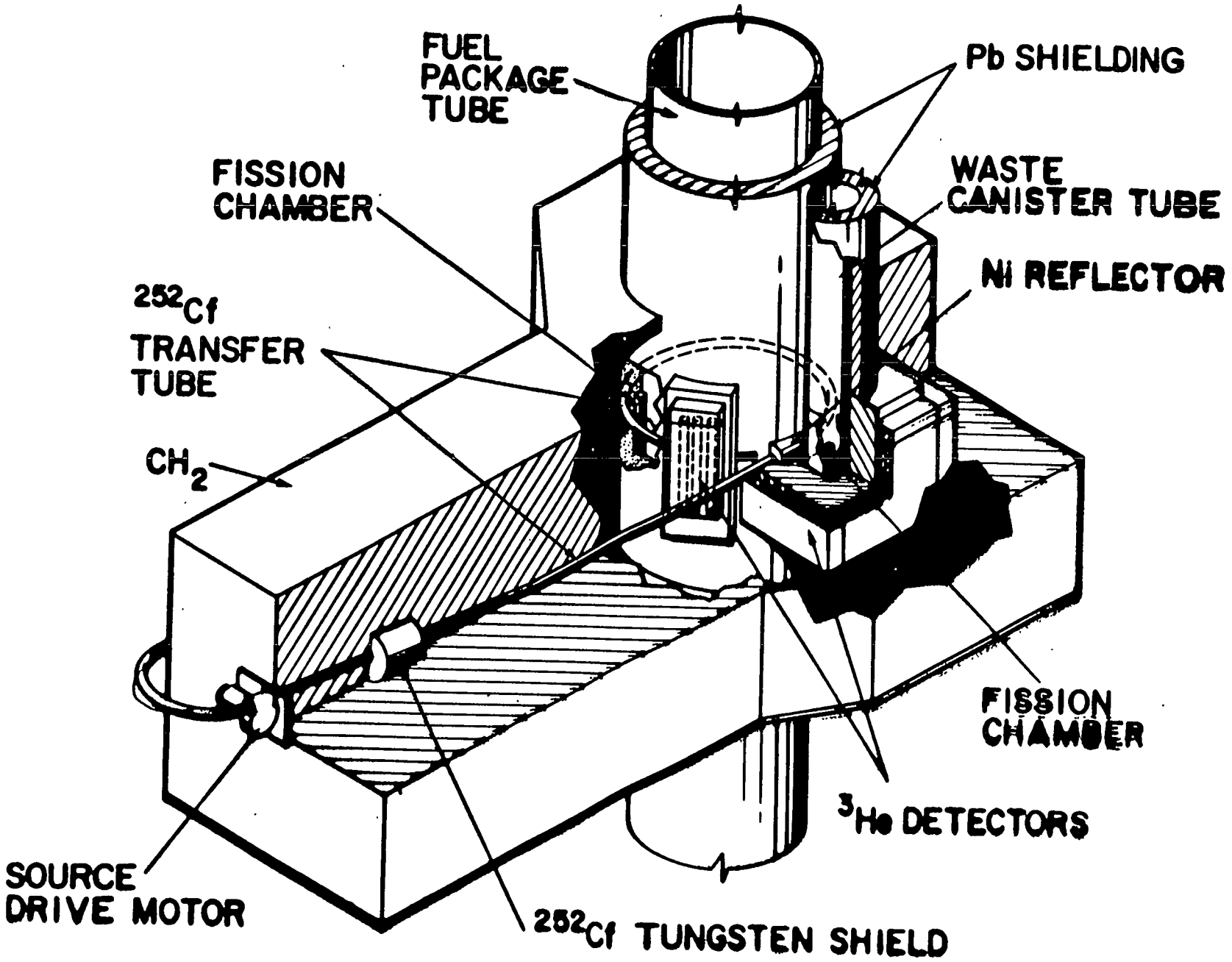
Spent fuel can be measured with the Fork Detector, which will simultaneously give the gross gamma and neutron rates emitted by the fuel element. The detector is placed around a partially raised assembly (see inset) to perform the measurement. A GRAND electronics unit (not shown) is used to collect and process the measurement data.

LANL55226

Combined Application of Containment and Surveillance



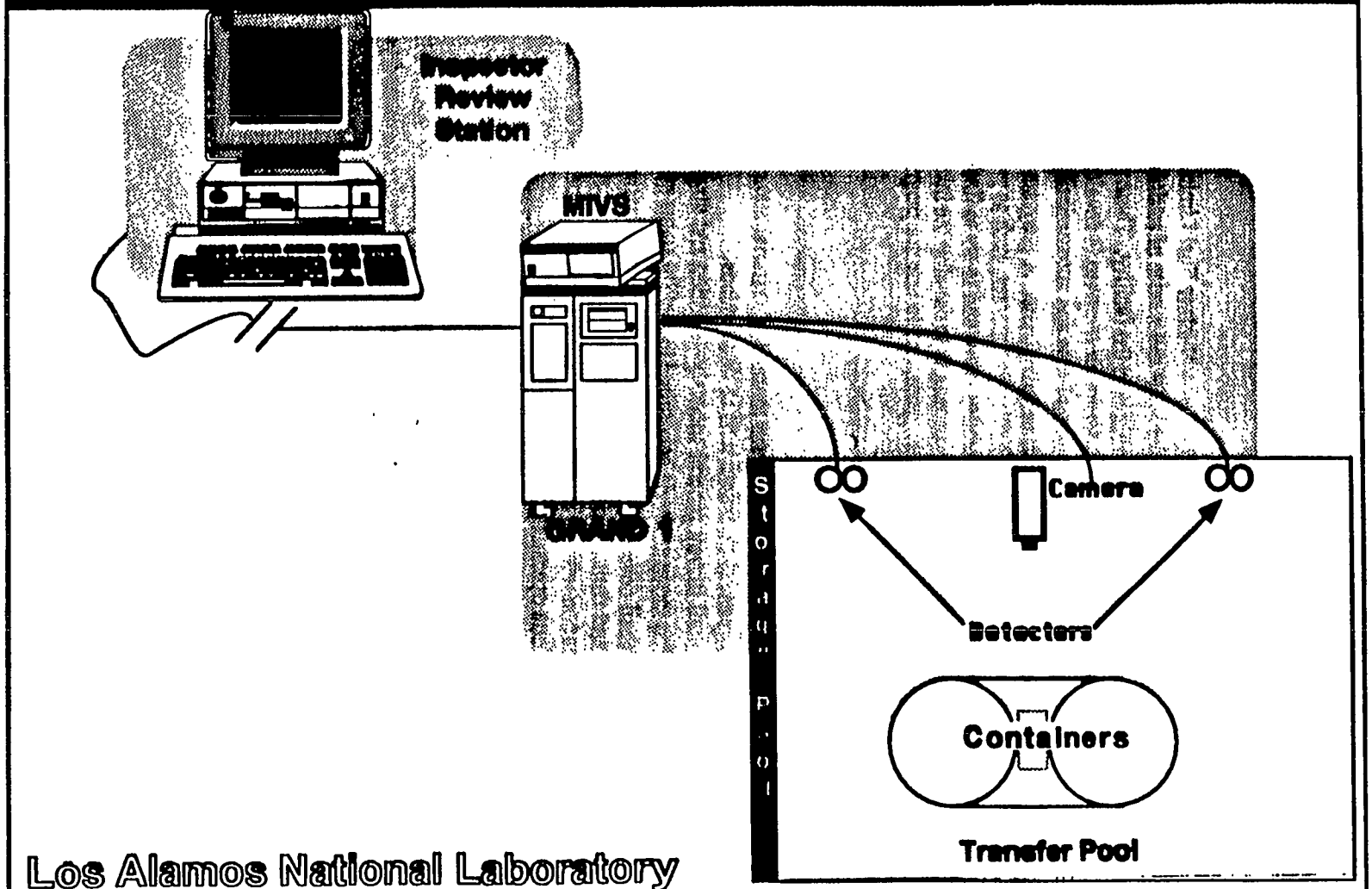
FLOURINEL AND STORAGE FACILITY DELAYED NEUTRON INTERROGATOR



Head-end Operations

- Unattended automated fuel transfer measurement
  - Sellafield tests
  - Monju system

Integrated Monitoring System at the THORP Facility



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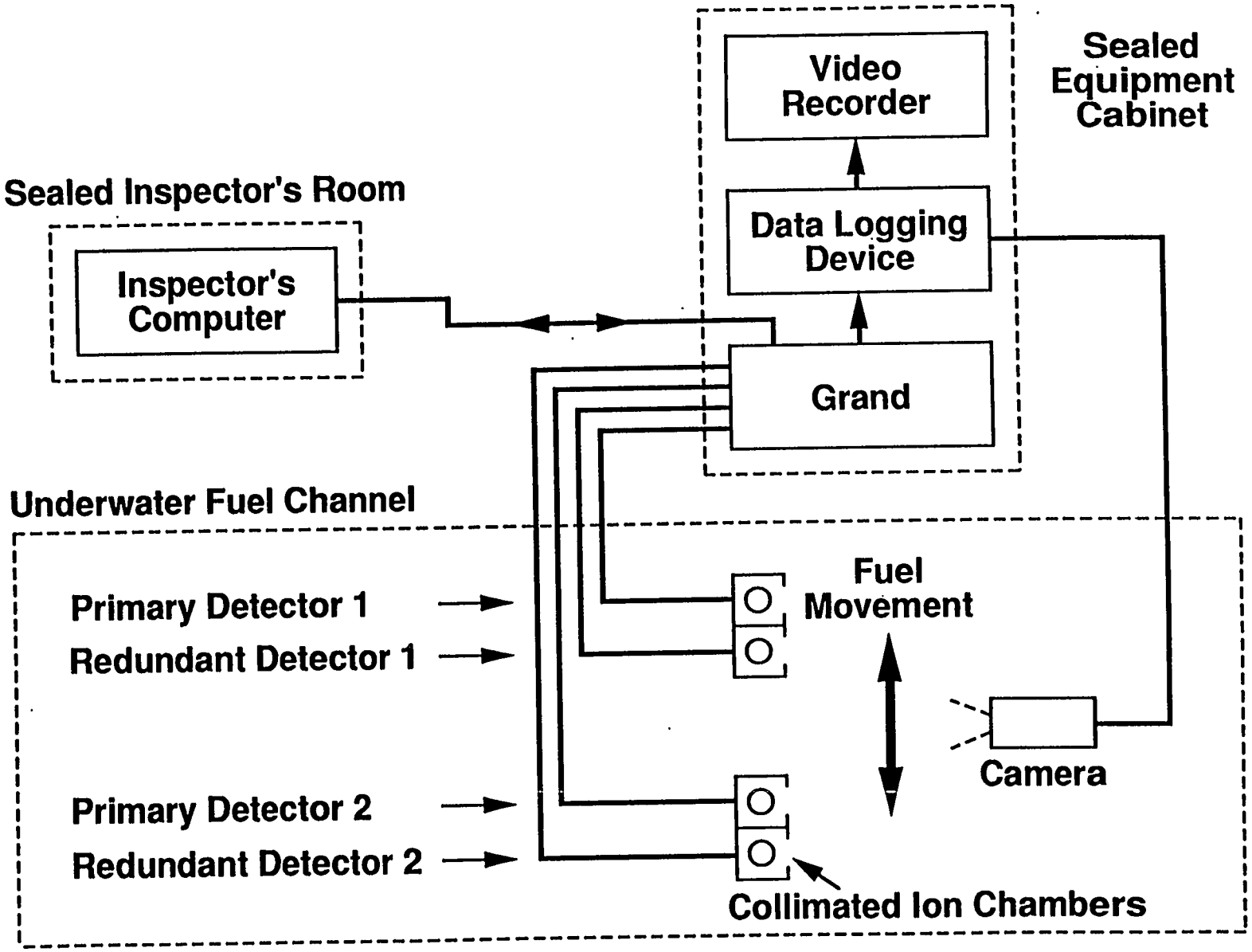
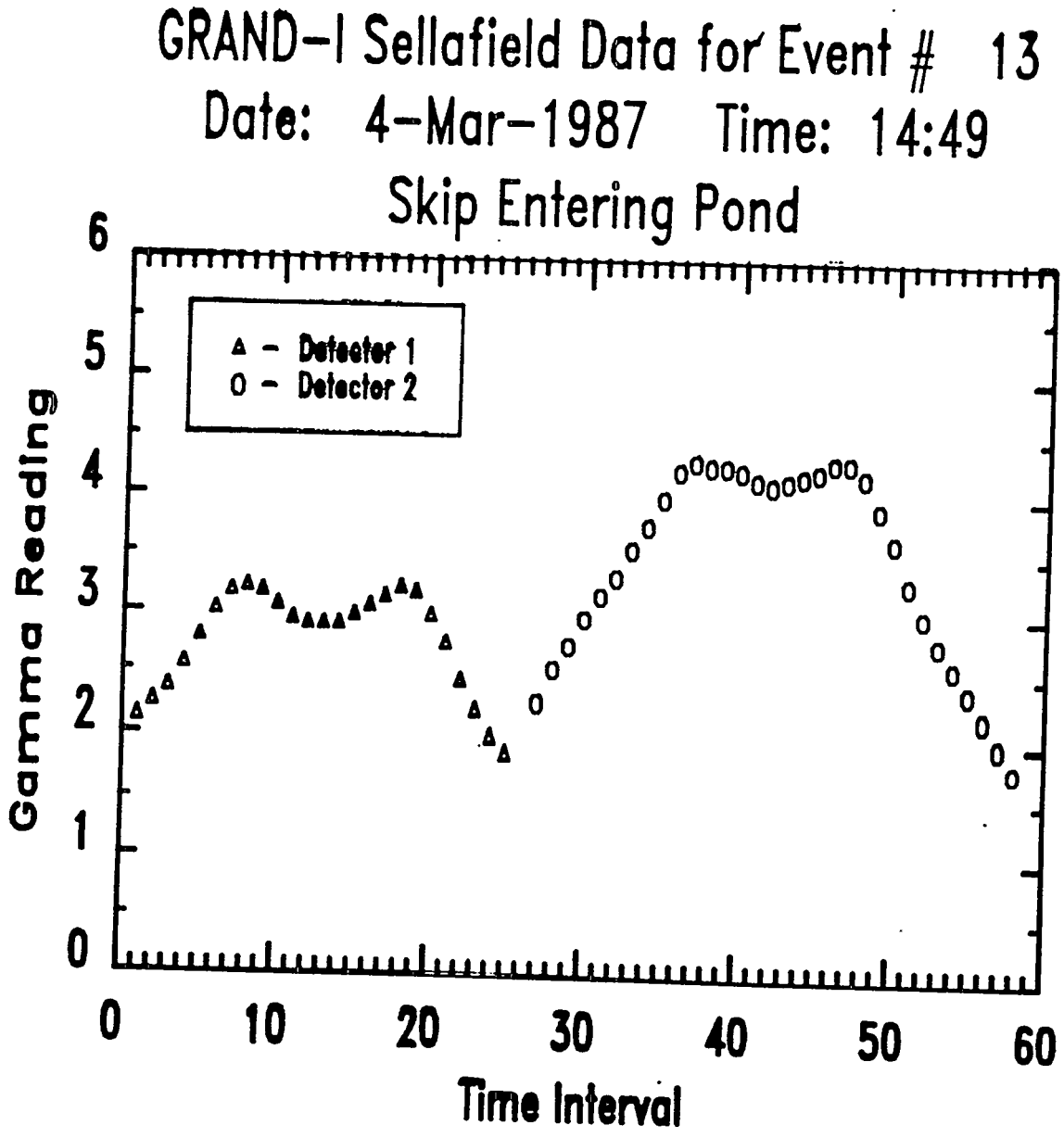
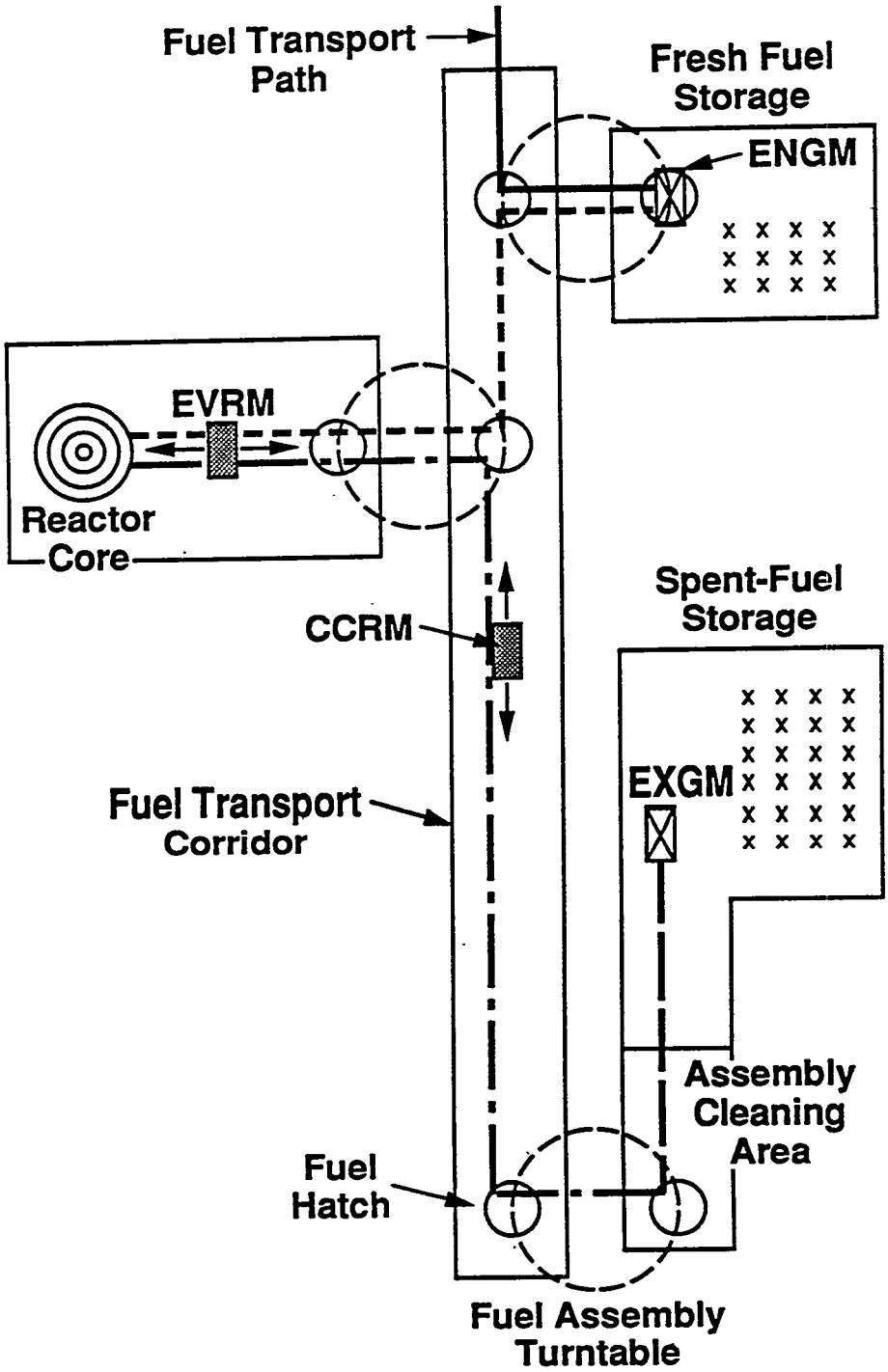

Video Recorder
Sealed Equipment Cabinet
Sealed Inspector's Room
Data Logging Device
Inspector's Computer
Grand
Underwater Fuel Channel
Primary Detector 1
Redundant Detector 1
Fuel Movement
Camera
Primary Detector 2
Redundant Detector 2
Collimated Ion Chambers


GRAND-I Sellafield Data for Event # 13
Date: 4-Mar-1987 Time: 14:49
Skip Entering Pond
Δ - Detector 1
O - Detector 2
Gamma Reading
Time Interval
0
1
2
3
4
5
6
0
10
20
30
40
50
60


Fuel Transport Path
Fresh Fuel Storage
ENGM
EVRM
Reactor Core
CCRM
Spent-Fuel Storage
EXGM
Fuel Transport Corridor
Assembly Cleaning Area
Fuel Hatch
Fuel Assembly Turntable

N-1/JB-397

Main Process Area

- Covers input accountability tank to PuO_2 or $(U, Pu)O_2$
- IDMS is primary input measure
  - IDGS is alternative
  - x-ray densitometry / XRF
- Process sample analysis
  - intrinsic gamma ray densitometry
- Pu Nitrate product
  - x-ray densitometry
  - high resolution gamma ray spectrometry

Comparison of Total Plutonium Concentrations of Dissolver Solutions as Determined by IDGS and IDMS

Sample	IDGS (g Pu/l)	IDMS (g Pu/l)	IDGS/IDMS
A. First Experiment			
1	0.9702	0.9769	0.9931
2	0.9750	0.9778	0.9971
3	0.9838	0.9822	1.0016
4	0.9811	0.9806	1.0005
Average			**0.9981**
B. Second Experiment			
1	1.2968	1.298	0.9991
2	1.2933	1.298	0.9964
3	1.3852	1.375	1.0074
4	1.3776	1.375	1.0019
5	1.2713	1.266	1.0042
6	1.2708	1.266	1.0038
Average			**1.0021**
C. Third Experiment			
1	1.6025	1.586	1.0104
2	1.4909	1.496	0.9966
3	1.4901	1.481	1.0061
4	1.3113	1.306	1.0041
5	1.5055	1.502	1.0020
Average			**1.0038**

Comparison of Plutonium Isotopic Abundances as Determined by IDGS and IDMS

IDGS/IDMS

Batch No.	^{238}Pu	^{239}Pu	^{240}Pu	^{241}Pu	$^{240}Pu/^{239}Pu$
1	1.149	0.997	0.993	1.003	0.995
2	1.152	0.996	0.997	0.996	1.000
3	1.123	1.005	0.989	1.013	0.984
4	1.125	0.997	0.991	1.007	0.994
5	1.011	0.998	0.998	1.006	1.000
6	1.011	1.000	0.996	1.002	0.996
7	1.018	1.002	0.992	1.009	0.990
8	1.021	1.000	0.997	1.007	0.997
9	1.006	0.994	0.993	1.046	1.000
Average	1.068	0.999	0.994	1.010	0.995

Integrated Systems

- Integrated systems should be defined for the entire reprocessing facility
  - C/S
  - NDA
  - Other facility information
  - Centralized computer handling of all safeguards relevant information

Experience

- Good system design requires contributions from
  - physics
  - hardware
  - software
- To begin, the problem must be well defined

  Sometimes we help in the specification

Experience

- Once the problem is defined, good basic physics
  - must determine which information is required to accurately draw conclusions
  - must assure that signals being measured represent required information
- Once physics has defined the measurement problem, experienced engineering resources are used to
  - analyze the problem
  - design the hardware and software systems

Design Considerations

- Core equipment that is absolutely required for acquisition of safeguards information must be identified
- The core equipment should be
  - outwardly simple
  - as close to the source as possible
  - stand alone

Design Considerations

- The system is made of building blocks
  - Hardware and software modules
  - Small pieces allow modification or reuse
  - Interface
    - Serial interface
    - Usable protocol
    - Well-defined format
    - Format and interface principles common among instruments

Costs—System Design

- Limit system requirements to basic requirements
- Functional specifications are developed in an iterative and dynamic fashion (cooperative interaction between the user, system designer, and facility)
- Qualified system designer must point out practical alternatives that
  - fulfill needs of safeguards authority
  - do not unduly burden the facility
  - result in cost and development time savings

Costs—Optimal Design

- Optimal design must balance the trade-offs among
  - Extra high quality equipment
  - Backup components or systems
  - Redundant components or systems, and
  - Cost and development time

Costs—Implementation

- Implementation is best when there is a cooperative relationship among
  - the inspection authority
  - the facility personnel, and
  - a technical consultant when one is used

Costs

- Development and installation costs can be very high
  Systems can be cost effective when
  - amortized over operation period
  - compared with savings in operational expenses

Authentication

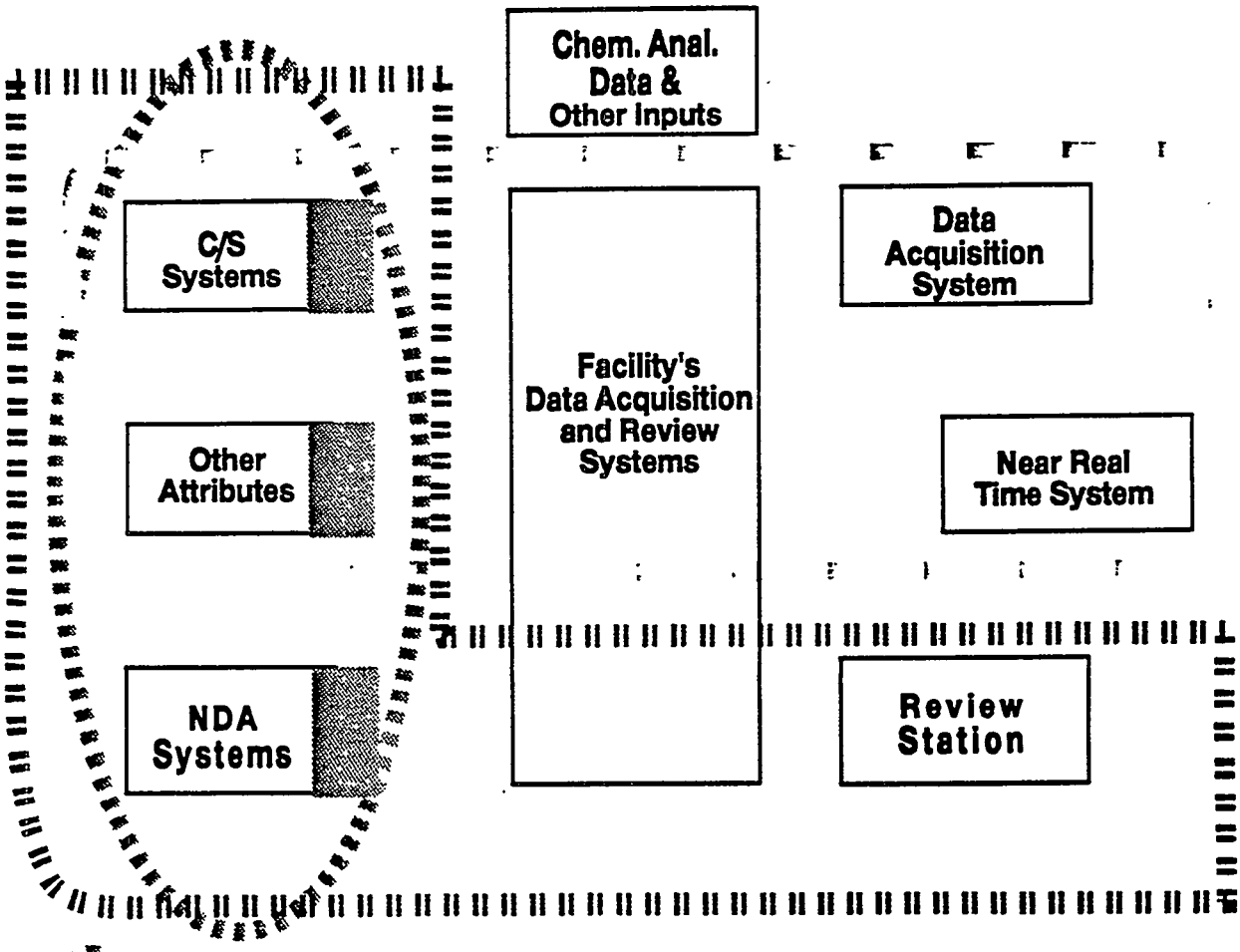
- IAEA definition of *Authentication*:

  the process to assure that genuine information is obtained for safeguards purposes using equipment (including systems and methods) for which the IAEA lacks sufficient control or knowledge

Authentication

- Classes of authentication
  - Authentication of system components and interactions during operation.
  - Authentication of software or software-based hardware produced by the facility or national support program of country under inspection

Conceptual Design of Integrated Safeguards



Integration of signals from C/S, NDA, and other attributes measurements

Integration to check for relations between C/S alarms and near-real-time alarms

Integration to investigate anomalies during inspection using NDA audit trail or C/S signals

Los Alamos National Laboratory

Conclusions

Appropriate combinations of measurement techniques, early design information, and authentication of plant operator instruments could enable successful determination of non-operation of reprocessing plants

Appendix H

Issue Sheets

Appendix H

Issue Sheets

PUREX Exercise

Date: 3/29/94

Issue/Problem/Question Description:

The implementation of international safeguards under a cutoff convention will almost certainly require changes in facility procedures to verify flows and inventories. It may also require the installation of additional equipment such as surveillance cameras. Such changes will require the facility to perform safety analyses and, possibly, criticality and/or personnel radiation dose analyses.

Comments:

The performance of required safety, criticality, or personnel radiation dose evaluations is costly and time-consuming. The costs and time required for these activities must be considered in evaluating the various proposed options for implementing international safeguards under a cutoff convention. An analysis of possible conflicts with DOE, OSHA, or EPA requirements should also be done when evaluating various safeguards options.

Name Alan Bieber Team Facility

PUREX Exercise

Date: 3/29/94

Issue/Problem/Question Description:

INFCIRC/153 safeguards require facilities to submit extensive and detailed nuclear materials accounting reports to the IAEA. Safeguards activities also typically involve examining facility accounting records in detail and comparing records with reports by IAEA inspectors. Experience with implementing IAEA safeguards at U.S. facilities has shown that some changes are usually necessary to make facility accounting systems comply with IAEA records-keeping and reporting requirements.

Comments:

Changes to facility nuclear materials accounting systems typically require modifications to existing computer software. Planning, testing, and implementing these changes (and training personnel to use the new system correctly and accurately) is costly and time-consuming. Any analysis of possible safeguards options for a cut-off treaty must include an analysis of potential costs due to new reporting and records-keeping requirements imposed on facilities. (Changes in the NMMSS and DOE orders must also be considered.)

Name Alan Bieber Team Facility

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

Conversations on defining MBds, Cs, etc., seem to suggest a diversion scenario assessment, similar to what the Agency uses, would be required. One can estimate costs for the pieces of a Cs/ inspection regime, but the estimate for a system depends on diversion scenarios being covered.

Comments:

Name Sharon Deland Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

Given the nature and current definition of the MBAs at PUREX, it may be difficult to detect a diversion (e.g., it might be possible to pipe around KMPs).

Comments:

Two approaches might solve this problem. The first would be to redefine the MBAs, but this action would not eliminate the ID and would significantly increase the cost (e.g., number of samples, number of inspectors, other efforts).

Another approach would be to expand the containment/surveillance activities beyond their current scope (which could be ineffective at PUREX in deb?? diversions) to include other activities (e.g., detectors and cameras at many locations, remote monitoring) to identify inconsistencies. Additionally, this approach would be expensive and be a non-trivial effort to monitor and review.

Name R. K. Wilson Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

Sample C?? or custody is currently not strict enough to ensure Agency on non-substitution.

This would require observation from sampling to analysis.

Comments:

Name C. R. Goergen Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

How can plant adaptability (piping/flowsheet changes) be implemented?

Comments:

Name C R Goergen Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

SRS remote tank calibrations currently are not performed.

Comments:

?? calibration.

Name C. R. Goergen Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

Regarding the loss of item pieces before charge to dissolver: How are these accounted for? Are they written off as reactor calculation errors?

Comments:

Name C. R. Goergen Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

What happens to undissolved **fines?** Where do they come out?

Comments:

Name C. R. Goergen Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

Un?? losses

SRS has centrifuge fines ?? ??

Comments:

Name C. R. Goergen Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

What type of change control must be used for any information that is discussed in the DIQ?

Comments:

Name C. R. Goergen Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

What is the piece count into dissolver
The dissolver has ??
The dissolver receipts will not match output except for a total camp?? or dissolver ?? c??

Comments:

Name C. R. Goergen Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

To prepare and send IAEA samples off-site, what are the

- HP requirements for moving materials off-site
- DOT requirements (e.g., certified containers and packers)
- paperwork and signature requirements for NNMSS
- necessary approvals
- referee sample requirements (in case of discrepancies).

Comments:

Name Michael Whitaker Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

We need to summarize IAEA total space requirements for the following:

- locked/sealed area for spike vials
- locked/sealed area for calibration weights
- lab area for sample preparation
- area for HLNCC/Ge
- supply room for liquid nitrogen
- storage area for calibrating NDA equipment and for working with the standards (HP knowledge of location & content)
- place to review tapes
- place for maintaining/repairing equipment
- office area for paperwork

Comments:

Name Michael Whitaker Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

At several points, independent IAEA lab capability was discussed:

- will an additional IAEA lab analysis be required to perform tests
- need assurance that equipment and procedures meet U.S. OSHA, DOE, etc., requirements

Comments:

Name Michael Whitaker Team Control

PUREX Exercise

Date: 3/30/94

Issue/Problem/Question Description:

How easy is it to bypass the D-5 input accountability tank?

Comments:

Any possible means of bypassing the input or output accountability tank must be declared in the DIQ; the facility attachment must include advising the IAEA of any piping changes prior to making the changes.

Name A. Hakkila Team Inspector

PUREX Exercise

Date: 3/29/94

Issue/Problem/Question Description:

A green fuel monitor (gamma) is present as fuel elements are pulled from the railroad cars to the dissolver. How sensitive is the detector? Is the limit on detecting fuel tied to the sensitivity of the detector or to the normal background?

Comments:

Perhaps redesigning or relocating the detector could permit it to be used to count fuel cans transferred to the dissolver.

Name A. Hakkila Team Inspector

PUREX Exercise

Date: 3/29/94

Issue/Problem/Question Description:

(Question 33)
Physical inventory: when the process is being emptied for a physical inventory, is it possible to predict through models how much uranium-plutonium is left in the process?

Comments:

It is possible that computer codes, such as FACSIM, could be tested to check a code against actual PUREX activities. The code would follow the buildup of plutonium in a PUREX process on startup and should work equally well going from normal feed to acid ?? feed.

Name A. Hakkila Team Inspector

PUREX Exercise

Date: 3/29/94

Issue/Problem/Question Description:

(Question 25)
How well do we have to dynamically measure/know inventory of the solvent extraction contactors?
The MUF has three components:
throughput
measured (measurable) inventory
unmeasured (estimated) inventory (contactors).

Comments:

The contactor inventory and, therefore, contribution to MUF is small relative to thruput and measurable inventory, and estimates to ± 10% to 20% probably is acceptable. This needs to be evaluated on a case by case basis for each facility.

Name A. Hakkila Team Inspector

PUREX Exercise

Date: 3/29/94

Issue/Problem/Question Description:

Question 35 vii
Check analytical method and error for nitrate to loadout (M tank or L9 tank)

Question 35 viii
Check sampling error for D5 input accountability tank--0.05% seems low when tanks that are easier to sample are 0.1%.

Comments:

These values are used in error propagation and could significantly affect the detection limits.

Name A. Hakkila Team Inspector

PUREX Exercise

Date: 3/29/94

Issue/Problem/Question Description:

Most United States facilities have limited missions, whereas foreign facilities have futures.

Comments:

Our safeguards could be stomached for a short period of time until D&D. Foreign ____ would have to subscribe to long-term costs.

Name Chuck Goergen Team Control

Appendix I

Options: Pros/Cons

Appendix I

Options: Pros/Cons

1. Random Inspections (Tied to 153 Safeguards)

Pros:

- might be made consistent with challenge inspections in other treaties (e.g., CWC)
- reduces Agency impact
- may deter diversion by "threat" of inspection
- might be designed to be less intrusive
- could be designed to be more intrusive (like special inspections)
- could capture 153 measurements better than other alternatives
- could enhance other alternatives

Cons:

- inspection rights etc., would have to be negotiated
- not as effective as 153 safeguards
- the Agency would lose continuity of knowledge
- could be too intrusive to get buy-in
- could have facility impacts (e.g., unplanned shutdowns)
- could enhance other alternatives

2. Portal Perimeter Monitoring (PPM)

Pros:

- provides implementation experience from INF
- does give some information on input/output
- might be designed to be less intrusive than other measures
- could be used to protect facility information (i.e., less risk of revealing sensitive information)

Cons:

- expensive/personnel intensive
- intrusive
- non-conclusive (i.e., incompatible with 153 goals)
- treaty item/object of verification unknown
- easy to defeat (i.e., diversion)
- low diversion detection sensitivity

3. Running Book Inventory (RBI/ARBI Concept)

Pros:

- is a material accounting approach and gives information on MUF
- piggy-backs on existing facility procedures
- requires reduced facility access
- could be combined with other alternatives to improve information flow

Cons:

- rejected in other international discussions
- can not meet sensitivity goals
- reliance on facility provided information limits validity of results if used by itself
- by itself does not have redundancy
- sensitive to large, daily swings
- easily spoofed by operator
- PUREX record has sometimes been outside warning limits and alarm limits (especially during startup/shutdown)
- Savannah River experience also contains evidence which would have to be explained and this could reduce effectiveness of approach
- may require other alternative measures to provide confidence

4. Processing Monitoring (with instruments)

Pros:

- beneficial to facility operator by providing operator with additional information ("carrot for the operator")
- reduces required inspection personnel onsite (and could be desirable to countries who do not like continuous onsite presence)
- difficult to falsify continuity of information throughout plant
- gathers information on a timely basis
- easy to transmit data offsite

Cons:

- facility operation concern about data transmission offsite
- lack of experience base (i.e., untested at nuclear facilities)
- must be careful in addressing information sensitivity
- still does not answer the input question
- authentication of instruments
- intrusive
- collects too much data? (hundreds of instruments - data reduction could be difficult
- difficult and expensive to backfit new equipment into existing facility
- may be difficult to use existing instruments
- requires calibration of instruments
- impact to facility operations because of instrument breakdown
- installation of system at PUREX could equal 50% of operating budget ($30 to $35 million to install in 1987 when operating budget was $75 million)

5. Zone Safeguards

Pros:

- provides wider "chain-of-custody" (i.e., incorporates a larger zone)
- offers more deterrent capability
- addresses substitution (shell game)
- could include "dead" facilities that might otherwise be locations for non-permitted/covert activity

Cons:

- requires many more personnel
- results in a loss of sensitivity as zone increases
- is data intensive
- could capture activities (e.g., defense, naval fuels) that need to be protected
- leaves the system weak if entire system is not captured
- raises the question of will this threaten cutoff negotiations by exceeding mandate?
- requires declarations of past-production (raises grandfathering to higher visibility level) [RAL]

6. Environmental Monitoring

Pros:

- offers the most effective option as adjunct to other options
- less intrusive
- could require relatively low resources
- eliminates need for facility access
- provides go/no go measurements on reprocessing activities
- permits acquisition of historic information
- allows easy monitoring of utility consumption
- may allow semiquantitative measurements if stack is monitored

Cons:

- does not work well for operating facilities (works best for shutdown facilities)
- provides no closure of material balance
- needs to monitor stack to be semi-quantitative
- could be spoofed
- not sensitive to diversion
- says nothing about design or design capacity
- does not distinguish recycle (I don't agree with this one--I think it could. RAL)

7. Enhanced Information Monitoring (Declarations + Open Source Information)

Pros:

- provides overall picture of nuclear activities at facility
- entirely non-intrusive
- minimizes risk of sensitive information loss
- may be only alternative that permits universal acceptance
- could not be accused of being substitute to NPT
- may be hard for government to orchestrate spoofing

Cons:

- remains dependent on national intent
- does not allow for material balance
- not quantitative (is subjective)
- effectiveness might be less in closed societies
- reliability of information

Appendix J

PUREX Exercise Follow-On Activity at Los Alamos National Laboratory (LANL)

PUREX INSPECTION EXERCISE

Hanford, WA - March 29-31, 1994
Los Alamos, NM - May 10, 1994

A REPORT

OBJECTIVES OF THE PUREX EXERCISE

- To develop a number of options for inspections at operating, existing U.S. reprocessing plants

- To help the USG to understand the problems that might be involved in allowing international inspections of operating, existing U.S. reprocessing plants to verify cutoff of SNM production for weapons

- To understand the effects of operating status on inspection problems
  - a facility separating direct use material from fission products (spent fuel or targets)
  - a facility processing nuclear material (waste stabilization, Pu rework, etc.), but not separating direct use material from fission products
  - a facility that is still capable of operation, but not currently operating

METHODOLOGY

- Participants divided into three teams
  - Facility Team
  - Inspector Team
  - Control Team

- Facility Team prepared a Design Information Questionnaire (DIQ)

- Inspector Team prepared Inspection Plans based on the DIQ

- Control Team responsible for support and documentation

- During exercise
  - Facility Team presented DIQ and reacted to Inspection Plans
  - Inspector Team presented Inspection plans
  - Control Team acted as facilitators and recorded data

- During follow-ups all participants evaluated options and combinations of options as well as discussing lessons learned

- Representatives from INEL and Savannah River Site discussed application of results to their facilities

TEAM ASSIGNMENTS

Facility Team:

Mike Ehinger, Team Leader
Ken Plummer
Bill Bailey
Alan Bieber
Paul Ethington

Inspector Team:

Larry McRae, Team Leader
Cal Delegard
Ken Apt
Cindy Heinberg
Jack Hartwell
Arnie Hakkila

Control Team:

Josh Segal, Team Leader
Bill Stanbro
Bob Sorenson
Dick Libby
Rod Wilson
Chuck Goergen
Connie Johnson
John Brown
Jon Sanborn
Chuck Bieber

VERIFICATION OPTIONS EXAMINED DURING THE PUREX EXERCISE

- Materials Balance Accounting with Interim Inspections of In-Process Inventories

- Randomized Inspections
  - Materials Balance
  - "Smoking Gun"
  - Visual Inspection Only

- Portal/Perimeter Monitoring
  - Perimeter Encloses Entire Facility
  - Perimeter Enclosing Only Key Points

- Running Book Inventory/Adjusted Running Book Inventory

- Process Monitoring
  - On-Site Data Readout and Storage
  - Off-Site Data Readout and Storage

- Zone Approach

- Environmental Monitoring
  - Inside of Facility
  - Outside of Facility

- Enhanced Information Management

- Enhanced Containment/Surveillance

POTENTIAL DATA PROVIDED BY EACH OPTION

Options	Type of Data						
	Abrupt Diversion	Trickle Diversion	"Smoking Gun"	Quantity	Rework	Operating	National Intent
Material Balance Accounting with Interim Inspections	X	X	X	X	X	X	
Randomized Inspections to Determine Material Balance	X	X	X		X	X	
Randomized Inspections to Look for a "Smoking Gun"			X		X	X	
Randomized Inspections using only Visual Observation			X			X	
Portal Perimeter Monitoring around the Entire Facility				X		X	
Portal Perimeter Monitoring around the Key Points				X		X	
Running Book Inventory		X		X	X	X	
Process Monitoring with On-Site Readout	X	X	X	X	X	X	
Process Monitoring with Off-Site Readout	X	X	X	X	X	X	
Zone Approach	X	X	X	X	X	X	
Environmental Monitoring Inside of Facility			X	X	X	X	
Environmental Monitoring Outside of Facility			X		X	X	
Enhanced Information Management							X
Enhanced Containment/Surveillance			X		X	X	

EVALUATION CRITERIA

1. Effectiveness (Degree of Confidence)

2. Intrusiveness (Loss of information, Disruption of Facility Operations, etc.)

3. Cost (Real Dollars Spent)

EVALUATION OF OPTIONS

Options	Effectiveness	Intrusiveness	Cost
Materials Balance Accounting with Interim Inspections	High	High	High
Randomized Inspections to Determine Material Balance	Moderate	Moderate to High	Moderate to High
Randomized Inspections to Look for a "Smoking Gun"	Moderate	Low to Moderate	Low
Randomized Inspections using Only Visual Observations	Low	Low	Low
Portal/Perimeter Monitoring around the Entire Facility	Moderate	Low	High
Portal/Perimeter Monitoring around Key Points	Low	Moderate	Low to Moderate
Running Book Inventory	Moderate	Moderate	Moderate
Process Monitoring with On-Site Readout	High	High	High
Process Monitoring with Off-Site Readout	High	High	High
Zone Approach	High	High	High
Environmental Monitoring Inside of Facility	Moderate	Low to Moderate	Low
Environmental Monitoring Outside of Facility	Low	Low	Low
Enhanced Information Management	Low	Low	Low to Moderate
Enhanced Containment/Surveillance	Moderate	Moderate	Moderate to High

COMBINATION OF VERIFICATION ALTERNATIVES

- Visual Only Random Inspections plus Inside Facility Environmental Monitoring
- "Smoking Gun" Random Inspections plus Portal/Perimeter Monitoring around Entire Site
- "Smoking Gun" Random Inspections plus Process Monitoring with On-Site or Off-Site Readout
- "Smoking Gun" Random Inspections plus Outside Environmental Monitoring
- Visual Only Random Inspections plus Running Book Inventory
- Portal/Perimeter Monitoring around the Entire Facility plus Outside Environmental Monitoring

EVALUATION OF COMBINATIONS OF OPTIONS

Options	Effectiveness	Intrusiveness	Cost
Visual Only Random Inspections plus Inside Facility Environmental Monitoring	Moderate	Low to Moderate	Low
"Smoking Gun" Random Inspections plus Portal/Perimeter Monitoring around Entire Site	High	Moderate to High	High
"Smoking Gun" Random Inspections plus Running Book Inventory	High	Moderate	Moderate to High
"Smoking Gun" Random Inspections plus Process Monitoring with On-Site or Off-Site Readout	High	High	High
"Smoking Gun" Random Inspections plus Outside Environmental Monitoring	Moderate	Low to Moderate	Low
Visual Only Random Inspections plus Running Book Inventory	Moderate	Moderate	Moderate
Portal/Perimeter Monitoring around the Entire Facility plus Outside Environmental Monitoring	Moderate	Low to Moderate	High

LESSONS LEARNED

- A wide range of verification strategies exist that could be applied at PUREX. The effectiveness, intrusiveness, and cost are highly dependent on the goals of the cutoff agreement and the operating status of the facility. It is easy to tell if a facility is not operating; it is harder to tell if an operating facility is not violating the agreement.

- If information on materials balance is not required for verification, several attractive verification schemes are available. If information on materials balance to detect diversion is a requirement of the agreement, then no approach is available that improves on classical materials balance accounting with interim inspections of in-process inventories. This option can be further improved with the use of adjunctive measures.

- Verification costs are dependent on verification goals ("Confidence Costs!")
  - In the absence of significant automation, a continuous inspector presence would be required to achieve the highest levels of confidence (~1000 inspector days/year).
  - Process monitoring can be effective, but is costly. ($20-$30 million in '87 dollars)

LESSONS LEARNED (Cont.)

- Design verification at a large, complex, highly radioactive facility such as PUREX is extremely difficult. C/S measures can provide some confidence regarding changes in facility configuration

- Under certain circumstances PUREX may be able to meet the IAEA timeliness goal (detection of diversion of 1 SQ in 30 days). However, it could not meet the goal of detection a 1 SQ diversion over a year.

- While this exercise centered on PUREX, most of the conclusions would apply at Savannah River and other old, large scale reprocessing plants in weapons states.

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