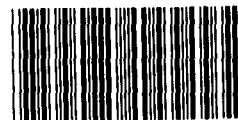
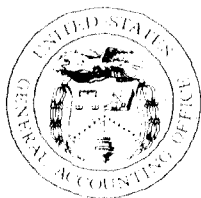


March 1991

NUCLEAR NONPROLIFERATION

Controls Over the Commercial Sale and Export of Tritium Can Be Improved



143689

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**Resources, Community, and
Economic Development Division**

B-242882

March 25, 1991

The Honorable John D. Dingell
Chairman, Subcommittee on
Oversight and Investigations
Committee on Energy and Commerce
House of Representatives

The Honorable Edward J. Markey
House of Representatives

This report responds to your February 8 and March 5, 1990, requests that we examine the adequacy of existing controls by the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) on the commercial sales and exports of tritium, a radioactive isotope of hydrogen that can be used to enhance the explosive power of nuclear weapons. You both expressed concern about reported losses of radioactive tritium gas from DOE's Oak Ridge National Laboratory (ORNL).¹

Subsequently, we met with your offices and agreed to examine the following issues:

- The promptness and adequacy of DOE's and NRC's investigations into the major tritium discrepancies which occurred in 1988 at ORNL, including any investigations into the possibility that the tritium might have been stolen or diverted.²
- The weaknesses in the management and operation of the DOE isotope sales program that led to reported tritium discrepancies and the weaknesses in existing material controls over and accounting for tritium.
- Whether DOE and NRC should reevaluate their positions on the level of controls required for possessing and shipping tritium or the reporting requirements imposed on tritium licensees, including the feasibility and desirability of having NRC include a determination of tritium end use in its inspections of licensees to alleviate concerns that tritium might not be used as intended.

¹ORNL is a government-owned facility operated under contract by Martin Marietta Energy Systems, Inc. The DOE Oak Ridge Operations Office is responsible for overseeing the contractor's operation of ORNL.

²It was not uncommon for ORNL to have "small" tritium shipping discrepancies of 10 percent or less with its customers, but the July-August 1988 discrepancies were about 40 percent and are thus referred to as "major" discrepancies.

Your offices also asked us to determine (1) whether DOE had admonished the ORNL contractor for its tritium operations performance and (2) what personnel actions, if any, had been taken as a result of the ORNL tritium discrepancies. This information is in appendix IV.

Results in Brief

ORNL and DOE's Oak Ridge Operations Office were slow to investigate the major shipper-receiver and internal tritium discrepancies which occurred at ORNL in July and August of 1988. Five investigations were conducted by DOE and ORNL from about 1 to nearly 2 years after the tritium incidents. Investigators were forced to deal mainly in possibilities and probabilities to determine the causes of the discrepancies because of their late start and the limited amount of ORNL documentation. However, the investigators concluded that the probability of tritium theft or diversion was low. With regard to NRC's investigation of the discrepancies, there is no formal requirement for DOE to notify NRC or for NRC to become involved with DOE's investigations of shipper-receiver discrepancies. NRC became involved when DOE asked for its help in investigating the possible causes of these discrepancies.

Investigators found that the tritium discrepancies at Oak Ridge revealed weaknesses in ORNL's management and DOE's oversight of the tritium operation, including the lack of rigorous inventory control practices. In analyzing the reported tritium discrepancies at Oak Ridge, DOE concluded that the lack of ORNL management attention to establishing and enforcing proper procedures required by DOE orders for the internal control of tritium and the lack of oversight by DOE's Oak Ridge Operations Office led to the tritium discrepancies. DOE has made changes it believes will improve its tritium operations, including moving the tritium operation to DOE's state-of-the-art tritium facility at Mound Plant in Ohio. The tritium operation was moved for a number of reasons, one of which was DOE headquarters' dissatisfaction with ORNL's tritium operations performance.

NRC concluded that its current level of control over tritium end use is adequate and that the ORNL tritium discrepancies were not due to poor tritium-licensing practices or a lack of inventory transaction reporting requirements. NRC relies on its review and approval of license application information to determine intended end use for tritium. NRC has authority to confirm end use by domestic users. However, except for initial screening, NRC has little direct control after-the-fact on actual end use by foreign companies. NRC and Executive Branch agencies emphasize

that only a few companies in a very small number of countries with long histories of nuclear nonproliferation are allowed to buy U.S. tritium gas.

Background

Tritium, which is most notably used to enhance the explosive power of nuclear warheads, is also used commercially for such items as self-powered airport runway lights and biological research. DOE is the only U.S. supplier of tritium. However, those seeking to buy tritium from DOE must first obtain a license from NRC to possess and/or export tritium since it is a controlled nuclear material.

ORNL was responsible for DOE's tritium sales and distribution until July 1990, when the program was transferred to DOE's Mound Plant in Ohio.³ ORNL obtained gaseous tritium from DOE's currently shut-down Savannah River Plant, where it was a product of nuclear production reactor operations. ORNL's isotope program personnel transferred the tritium gas into smaller containers, which were then packaged and shipped to customers. ORNL sold an average of approximately 180 grams of tritium annually—about \$5 million worth a year.⁴ However, customers complained that ORNL occasionally shipped less tritium to them than stated on the shipping documents. These reported shortages were generally less than 10 percent and much less than 1 gram each. However, in July and August of 1988, two British companies complained of "major" shortages, in excess of 40 percent of the amount stated on the shipping document and totaling about 5 grams from four ORNL shipments (see app. II). Shortly after these major shipper-receiver discrepancies, ORNL was unable to account for another 2.2 grams of tritium which was allegedly transferred between buildings at ORNL for testing.

In the chain of responsibility for controlling the sales and exports of commercial tritium, NRC is responsible for screening applications for licenses to possess and/or export tritium and is responsible for regulating its private domestic use. DOE sells tritium to those qualified by NRC to possess or export it. DOE is responsible for safeguarding the tritium in its possession, including investigating and reconciling any shipper-receiver discrepancies occurring with its tritium customers.

DOE's and NRC's system for safeguarding nuclear material places the strictest control on special nuclear materials (plutonium and enriched

³ORNL's isotope program also involves other radioisotopes, such as krypton and yttrium, and stable isotopes, such as isotopes of zinc and cadmium.

⁴Calculated at approximately \$28,000 per gram.

uranium) because they can be used directly to make a nuclear explosive device. Although tritium may be used to boost a special nuclear material explosion, it cannot be used alone to create a nuclear explosion. Consequently, tritium is controlled to a lesser degree than special nuclear materials.⁵ For example, unlike special nuclear materials, tritium has no domestic or international safeguards for the physical protection of tritium from theft and diversion.

ORNL and DOE Slow to Investigate Tritium Discrepancies

DOE requires that its facilities have a program and written procedures for assessing nuclear material shipper-receiver discrepancies and complete investigations of such discrepancies within 30 days of their discovery. However, ORNL and DOE's Oak Ridge Operations Office (DOE Oak Ridge) did not have such procedures and did not start formal investigations until nearly a year after the July and August 1988 discrepancies. Furthermore, they did not resolve the discrepancies with the customers until nearly 2 years after their occurrence. In the meantime, other shipper-receiver discrepancies, totaling about 3 grams, were reported. ORNL and DOE Oak Ridge officials told us that they were slow to formally investigate the tritium discrepancies, mainly because of low concern, higher priority work, and skepticism about their customers' complaints.⁶

ORNL and DOE Oak Ridge officials told us that tritium gas is difficult to contain and shipper-receiver discrepancies were considered a routine part and cost of the tritium sales business.⁷ Consequently, ORNL, with agreement from DOE Oak Ridge, had developed the practice of accepting customer claims of shipping shortages and reimbursing them accordingly, with little investigation. ORNL officials told us that higher priority DOE work, such as a leaky radioactive cesium capsule episode in Atlanta, Georgia, also diverted their attention from conducting a more timely investigation of the major tritium discrepancies of July and August 1988. ORNL and DOE Oak Ridge officials also said that they were slow to act because they were skeptical about these particular customer claims since the claims occurred at the same time that DOE had more than

⁵DOE and NRC control the distribution and use of tritium pursuant to the Atomic Energy Act of 1954, as amended, and the Nuclear Non-Proliferation Act of 1978.

⁶In addition, some believed that the lack of a single DOE headquarters director for isotopes during this time also slowed initiation of formal investigations. DOE headquarters was reorganizing its multidivisional isotope program into a single division program and subsequently appointed a headquarters director for this program at the end of May 1989.

⁷Tritium experts at Mound Plant confirmed that tritium is difficult to handle.

doubled its price of tritium to customers from about \$13,000 per gram to \$28,000.

It was not until customer complaints reached DOE headquarters, were publicized by the media, and aroused the concern of Members of Congress that ORNL and DOE decided to formally investigate the large ORNL shipper-receiver discrepancies and the internal loss of tritium. Subsequently, five different investigations (see app. III) were performed by DOE, ORNL, and others between June 1989 and March 1990. However, the investigators said that the investigative "trail was cold" by the time these studies began. In addition, ORNL had made few inventory control records of the actual steps followed in filling customer orders. Thus, the investigators had to deal mainly with possibilities and probabilities rather than facts. However, the investigators identified human error, facilitated by weaknesses in management and oversight, as the most probable cause for the discrepancies.

One study concentrated on the question of theft and diversion. That study, performed by DOE's Inventory Difference Anomaly Resolution Team (IDART), was initiated in October 1989 after DOE's Inspector General reported that previous studies dealt more with speculation than fact and none had seriously investigated the possibility of theft or diversion. Although the IDART study was hampered by its lateness and the lack of ORNL documentation, the authors concluded that the probability of theft or diversion was low, compared with other possible causes of the discrepancies—the most likely cause being human error in measuring and loading the tritium.

Management and Oversight Weaknesses Identified as Underlying Causes of Tritium Discrepancies

Although DOE, ORNL, and other investigators identified possible causes for the ORNL tritium shipper-receiver discrepancies and internal loss, they were unable to reach a definitive resolution regarding specific causes for the specific discrepancies and loss. They did agree, however, that the underlying cause was the lack of appropriate ORNL management and DOE Oak Ridge oversight of the tritium operations. For example, adequate tritium inventory control procedures either did not exist or were not followed, including the keeping of adequate records of the step-by-step process ORNL followed to arrive at statements of amounts of tritium that were shipped to customers.

ORNL managers admitted that the procedures followed by the tritium operation did not ensure the adequate control of tritium. For example, ORNL used only one tritium operator, working alone with no one checking

his work, to routinely transfer tritium gas into small containers for subsequent packaging and shipment to customers. The loading procedures that the operator followed had evolved mainly from experience rather than a prescribed quality assurance regime. In addition, he kept few records of the steps (and their results) that he followed in loading the tritium. According to investigators, these practices led to undetected errors in measuring and loading the tritium.⁸ The lack of adequate procedures also extended to ORNL's tritium packaging and shipping operation, where poor practices and errors led to a number of safety violations, including sending a leaking tritium container through the commercial transportation system.

The DOE Oak Ridge Operations Manager admonished the ORNL contractor, Martin Marietta, for its tritium operations performance. He said that if the contractor had transferred the lessons learned from other programs that had recently experienced similar problems, the tritium discrepancy incidents might not have occurred. The Manager had strongly suggested such transfers of lessons learned in his earlier appraisals of the contractor's performance.

Investigators and other DOE and ORNL officials pointed out that inadequate oversight by DOE Oak Ridge's isotope program managers at the time also allowed ORNL's problems in its tritium operations to exist and go uncorrected. In addition, investigators stated that DOE Oak Ridge did not enforce existing DOE orders for control of nuclear material, which, if followed, might have precluded the major tritium discrepancies.

As a result of its tritium investigations, DOE concluded that customer claims were valid and compensated these customers for the major shipper-receiver discrepancies which occurred in 1988. In addition, as part of the reorganization of its national isotope program and because of dissatisfaction with the contractor's performance, DOE headquarters moved its tritium sales operation to its Mound Plant in Ohio in July 1990.⁹

According to DOE, Mound Plant has the most state-of-the-art tritium facility in the DOE complex. Mound has tritium control procedures in

⁸DOE and ORNL officials said that the operator's work load was particularly difficult during the time that the large tritium discrepancies occurred because customers increased their orders prior to an impending large increase in the price of tritium.

⁹Mound Plant is operated by the contractor EG&G Mound Applied Technologies, Inc., and DOE's Dayton Area Office provides oversight of the Mound operation. Mound has experience in the handling of radioactive isotopes, as well as the commercial sale of nonradioactive isotopes.

place from its many years of handling tritium for DOE's defense programs. In addition, in preparation for its new responsibilities, Mound developed and tested, and DOE approved, quality assurance procedures specifically for loading tritium gas for commercial sales. In contrast to ORNL's much older facility, Mound's tritium loading facility is completely computer-guided. The operator who loads the tritium gas into containers for shipment must successfully follow computer instructions in sequence and touch the computer screen at the end of each step to move to the next step in the process. This helps eliminate human error. The computer also records the process followed and the results of each transaction. Mound also has state-of-the-art equipment that accurately weighs the tritium gas during various stages of the operation.

Although Mound is well experienced and equipped for loading tritium, the actual administration, management, and oversight processes involved with the commercial sale of radioactive tritium gas are somewhat new to Mound personnel and DOE's Dayton Area Office personnel charged with oversight of Mound. Thus, there will be a learning period, at least for this part of the operation. In addition, some Mound officials told us they were not aware of all of the findings, recommendations, and lessons learned from the five investigations of the ORNL tritium discrepancies.

NRC Performs Limited Monitoring of Tritium End Use

Because tritium is considered less strategic than special nuclear materials, NRC plays a less active role in monitoring tritium use than it does with special nuclear materials. However, NRC believes that this role, consisting mainly of reviewing and approving applications to possess and/or export tritium and inspecting domestic tritium users, provides adequate control over the tritium that is sold commercially.

For domestic purposes, NRC monitors the possession of tritium primarily for health and safety reasons, not to ensure intended end use. To do this, NRC (or state authorities) will periodically (about every 2 years, according to NRC officials) inspect companies that manufacture tritium products.¹⁰ Tritium users are not required to report inventory transactions to NRC. Domestic tritium users, however, must maintain inventory transaction records for 3 years for NRC's possible inspection for the purpose of gathering health and safety data, or, if the question arises, to check for theft or diversion. Domestic users are required to notify NRC if

¹⁰NRC also has agreements to allow some state authorities (called Agreement States) to issue tritium licenses and inspect facilities.

a suspected theft or diversion of tritium has occurred. According to NRC, during the last 10 years, no companies that handled tritium domestically informed NRC that a theft or diversion had taken place.

NRC's procedure for controlling the export of tritium consists of reviewing and approving applications for tritium export licenses. Export license regulations require that certain Executive Branch agencies (called the Subgroup) help NRC screen these applications to ensure that the exported tritium will not be harmful to the common defense and security of the United States.¹¹

First, NRC and the Executive Branch Subgroup examine the reputations of those involved with the export license application—the U.S. company seeking to export the tritium, the foreign company wishing to purchase the tritium, and the recipient country. This may involve detailed NRC discussions with and visits to the U.S. company; a review of any available intelligence community reports and other information on the activities of the foreign company; and a review of the recipient country's nonproliferation record and verification that the country is properly regulating private companies that purchase U.S. tritium. NRC emphasized that U.S. tritium gas is sold only to countries with solid nonproliferation records and as strict or stricter controls than the United States.

After this initial examination, the Subgroup reviews the details of the specific application, including the applicant's proposed commercial end use for the tritium, with respect to the total quantity of tritium requested over the period of the license. This review is to help prevent the possibility that the exported tritium might be used for nonpeaceful purposes. As a result of the Subgroup's review, NRC may place conditions on a tritium export license—limits on the quantity of tritium shipped per year and the quantity per shipment, and a requirement for notice/approval before retransferring the tritium to another country.

We reviewed some of the export licenses that NRC has granted and questioned whether the amount of tritium allowed in an individual shipment may or may not be enough to boost a nuclear weapon. NRC and DOE officials said that the individual shipment size that is requested by the exporter is analyzed to determine its potential risk, but no maximum limit has been established for the quantity of commercial tritium gas

¹¹The Executive Branch members of this subgroup include the Departments of State, Commerce, Defense, and Energy, and the Arms Control and Disarmament Agency.

that can be exported in a single shipment. A risk assessment expert that DOE consults with on tritium license applications told us that the individual shipment size allowable under an export license may be a matter of weighing the risks involved with sending one large shipment versus two or three smaller ones. More shipments may provide more opportunities for theft. DOE tritium sales office officials told us that even though NRC licenses may allow larger amounts, the sales office limits the size of individual shipments to much less in order to avoid having to meet additional transportation requirements, such as special highway routing and additional shipping container warning markings.

We also questioned how NRC is able to enforce license conditions that U.S. tritium not be transferred from the original foreign buyer to a third country. NRC and State Department officials told us that agreements not to transfer U.S. tritium to another country without notification/approval of the United States are oral agreements. NRC believes that long-standing relationships with recipient countries make written agreements unnecessary.

In response to recent congressional concerns regarding the adequacy of safeguards for possessing and exporting tritium, NRC reviewed its current controls over tritium and concluded that they are adequate. NRC pointed out that investigators concluded that recent tritium shipper-receiver discrepancies were caused by internal problems at ORNL and had nothing to do with NRC's current controls over the possession and export of tritium. NRC officials said they believed that imposing additional requirements to have customers report tritium inventory transactions to NRC would not have prevented the ORNL tritium discrepancies.¹² Although NRC does require that domestic tritium users maintain tritium inventory transaction records, in case NRC needs to review these records, NRC has no such authority over foreign companies. However, in the case of the 1988 major tritium discrepancies, DOE was able, with the cooperation of the recipient countries, to check inventory records to validate claims of discrepancies at foreign companies.

According to NRC and State Department officials, more stringent U.S. controls and safeguards over tritium would be costly to domestic tritium users and add little national security benefit since other countries also possess tritium, for example, Canada, England, France, and the Soviet

¹²DOE uses a "Nuclear Material Transaction Report" (Form 741) to document all DOE transactions, including shipments to customers. However, some customers return this form to DOE confirming receipt of a tritium shipment, but not confirming the actual weight of the tritium received. They weigh the tritium later when they begin to use it.

Union. In addition, these officials and others pointed out that the commercial tritium business is an expanding international business. For example, DOE and NRC said that Canada has the potential for dominating the commercial tritium market, and the Soviet Union, through aggressive marketing, has been able to take away some of the United States' tritium business. Thus, the control of commercial tritium is becoming an international issue. Consequently, the United States is pursuing the possibility of international guidelines for the control of tritium. According to NRC and State Department officials, U.S. controls over tritium are similar to those held by most other nonproliferation countries.

Conclusions

We believe that with proper ORNL management and DOE Oak Ridge oversight, the tritium discrepancy incidents at ORNL might not have occurred, or at least with enforcement of good inventory control practices, their occurrence and cause would have been immediately recognized. Because investigations were done late and records were poor, investigators were able to identify only what they believed to be possible causes for the tritium losses. We agree with the DOE Oak Ridge Operations Manager about the importance of transferring lessons learned, and we believe that the lessons learned from ORNL's tritium problems and their investigation can help other DOE programs avoid similar problems. Mound Plant, now responsible for DOE's tritium sales program, may benefit from being made aware of the details of the investigations and all lessons learned, particularly those that apply to the actual administration, management, and oversight of a commercial tritium sales operation.

With regard to the NRC controls over tritium, the tritium incidents at ORNL were not caused by weaknesses in NRC's licensing procedures. However, we believe that setting a maximum limit on shipment size and obtaining written agreements for retransfer of tritium may provide added insurance against the possible consequences of theft and the possibility of diversion. For example, concerning individual shipment size, while more frequent smaller shipments provide more targets for possible theft, these smaller shipments may not contain enough tritium to boost a nuclear device, and if one is stolen, it would immediately alert DOE to protect other shipments. On the other hand, without a maximum limit on the size of an individual shipment, a thief may in one encounter be able to obtain enough tritium gas to boost a nuclear device. In addition, we believe that with the tritium business expanding and other countries and companies entering the market, it may be prudent for the United States to seek written agreements from recipient countries for notifying/approving of the retransfer of U.S. tritium to a third country.

Recommendations

To help ensure that problems similar to those that occurred in ORNL's tritium program do not occur in future DOE commercial tritium operations, other isotope programs, and other similar DOE programs, we recommend that the Secretary of Energy:

- Emphasize to DOE program managers the need to adhere to existing DOE orders for the control of tritium, including DOE's policy for immediately identifying, investigating, and reconciling shipper-receiver tritium discrepancies.
- Direct DOE's Isotope Production and Distribution Program Director and DOE operations office managers to ensure that management and oversight lessons learned from the Oak Ridge tritium program are transferred to other Oak Ridge programs and other DOE isotope programs at other locations, including the new commercial tritium operation at Mound Plant, Ohio.

In addition, we recommend that the Chairman, Nuclear Regulatory Commission:

- Analyze the advantages and disadvantages of establishing a limit on the size of individual shipments that are allowed under tritium licenses, particularly as they relate to ensuring that the amount sent in a single shipment cannot be used as a booster in a nuclear weapons device if stolen or otherwise diverted.
- Pursue, with the aid of the Department of State, obtaining written agreements from recipient countries for notification/approval of retransfer of exported U.S. tritium.

We conducted our review from April 1990 through November 1990 in accordance with generally accepted government auditing standards. To complete our work, we interviewed officials at DOE headquarters, DOE's Oak Ridge National Laboratory and Operations Office, DOE's Mound Plant and Dayton Operations Office, DOE's Savannah River Plant and Operations Office, NRC headquarters, the Departments of State, Defense, and Commerce, and the Arms Control and Disarmament Agency. We did a general overview of the other isotopes that ORNL sells, but we concentrated our effort on tritium. We did not review the programs of the states to which NRC has granted tritium licensing and inspection authority. We reviewed pertinent documents, including written DOE and NRC orders and regulations concerning the control of nuclear materials,

the five previous investigations (see app. III) of the tritium discrepancies at Oak Ridge, and NRC and DOE responses to congressional inquiries concerning the tritium discrepancies at Oak Ridge.

We discussed the results of our work with DOE and NRC officials and incorporated their comments where appropriate. In general, they agreed with the information presented. As requested, we did not obtain official agency comments on this report.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time we will provide copies to the appropriate congressional committees; the Secretary of Energy; the Chairman, Nuclear Regulatory Commission; other agencies involved in our review; and the Director, Office of Management and Budget. We will also make copies available to others upon request.

This work was performed under the direction of Victor S. Rezendes, Director, Energy Issues, (202) 275-1441. Other contributors to this report are listed in appendix V.



J. Dexter Peach
Assistant Comptroller General

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Appendix V
Major Contributors to
This Report

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Abbreviations

DOE	Department of Energy
GAO	General Accounting Office
IDART	Inventory Difference Anomaly Resolution Team
IG	Inspector General
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory

Chronology of Tritium Discrepancies Occurring at Oak Ridge National Laboratory

1985-mid 1989	Numerous tritium shipment shortages (and a few overages) were reported by Oak Ridge National Laboratory (ORNL) customers, ranging from less than 1 percent up to 43 percent, with most less than 10 percent. According to ORNL records, these discrepancies totaled about 15 grams, 1 gram of which was from sending too much to customers.
July-Aug. 1988	Foreign customers claim major shortages in shipments made during this period. Four shipments made to two British companies had discrepancies of 37 to 43 percent (about 5 grams). Several smaller shortages were also reported which totaled much less than 1 gram.
Aug. 1, 1988	ORNL announces tritium price increase from about \$13,000 per gram to about \$28,000 per gram effective October 1, 1988.
Aug. 11, 1988	ORNL transfers 3 grams of tritium from its loading facility to another building for tests. When it is returned to the tritium loading facility in November, three-quarters of the tritium (2.2 grams) is missing.
Oct. 1988	Department of Energy's (DOE) Oak Ridge Operations Office is informed of ORNL's latest tritium discrepancies.
Sept. 1988-June 1989	Shipments continue with at least 11 additional reported losses totaling over 3 grams. Foreign customers continue to complain of losses and threaten legal suit.
May 30, 1989	Newly appointed Director of DOE headquarters Isotope Production and Distribution Program first learns of tritium discrepancies.
June 16, 1989	ORNL initiates study of tritium discrepancies; main concentration is on internal loss of tritium. The results are published on July 20, 1989—about a year after the occurrence.
June 21, 1989	DOE headquarters Isotope Director initiates a joint DOE-Nuclear Regulatory Commission (NRC) study of the major discrepancies occurring in July-August 1988. This is the first formal DOE study of this matter. The results are published on July 28, 1989—about a year after the occurrence.
July 21, 1989	The studies initiated in June (DOE-NRC and ORNL) reach no definitive conclusion on causes for specific losses which occurred nearly 1 year before; therefore, Acting Assistant Secretary for Nuclear Energy shuts down tritium operation at Oak Ridge and orders another study by a team from the Office of Nuclear Energy, Oak Ridge, Savannah River, and Mound Plant.
Aug. 16, 1989	Tritium shipments are resumed, except to those companies with unresolved shipper-receiver discrepancies. However, ORNL must send shipments of tritium greater than about 0.1 grams through Mound Plant for accurate weighing on Mound's calorimeter. Mound will also weigh "empty" containers returned from the customers to determine amount of tritium absorbed by container.
Sept. 7, 1989	A DOE Inspector General (IG) memo is critical of DOE's investigations of the tritium discrepancies. The IG points out that none of the studies to date seriously evaluated the possibility of diversion.

(continued)

**Appendix I
Chronology of Tritium Discrepancies
Occurring at Oak Ridge National Laboratory**

Sept. 28, 1989	The Nuclear Energy Division's Technical Review Team, established on July 21, 1989, to study the tritium discrepancies, publishes its report. No definitive conclusions reached for specific losses but review team identifies what it believes are most probable causes for the discrepancies.
Oct. 2-5, 1989	ORNL violates shipping safety regulations for tritium containers and a new discrepancy occurs, involving a domestic shipment of about 0.04 grams. ORNL concluded that it was caused by a leak in the tritium loading system, which resulted in air rather than tritium being sent to the customer.
Oct. 30, 1989	DOE activates the Inventory Difference Anomaly Resolution Team (IDART) to investigate the major discrepancies which occurred in July-August 1988. IDART is the first study team mandated to investigate possible theft and/or diversion. The results of IDART's study are published on December 12, 1989. Study team was forced to deal mainly with possibilities and probabilities because of lateness of study (1-1/2 years after the fact), but team concludes probability of theft or diversion is low.
Dec. 1, 1989	Secretary of DOE sends letter to Chairman of the Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, stating that corrective actions taken and validated by DOE are now satisfactory for proper control of commercial tritium, and the Secretary orders that all tritium shipments be resumed.
Dec. 8, 1989-Jan. 8, 1990	ORNL violates safety procedures by sending leaking tritium container to Mound.
Mid-Dec. 1989	DOE headquarters orders ORNL to honor the claims of customers concerning the major tritium shortages that occurred during July-August 1988.
Mid-Jan. 1990	ORNL reorganizes parts of its isotope program. Two key tritium operations supervisors are removed and replaced.
Feb. 1990	ORNL ad hoc committee formed to investigate the possibility of personal culpability within the tritium operations at ORNL to determine if disciplinary action is warranted and to recommend appropriate discipline. Results of investigation are published on March 23, 1990. The ORNL committee finds that ORNL personnel did not act with negligence or malicious intent. However, the committee found that the ORNL personnel did not follow a disciplined approach to the conduct of tritium operations. The committee recommended that a letter of "counseling and coaching" be presented to each employee involved. The committee also recommended that operating areas that "stem from the same past management chain, particularly the krypton operation, should be reviewed thoroughly for similar problems."
Mid-1990	ORNL experiences shipper-receiver discrepancies in another isotope, krypton. DOE officials said that they investigated and believe they have sufficient documentation to deny the claim.
July 1990	DOE transfers its tritium loading, sales, and distribution operation from ORNL to Mound Plant. Mound is now responsible for DOE's commercial tritium operation.

Major Tritium Shipper-Receiver Discrepancies That Occurred in July and August of 1988 at Oak Ridge National Laboratory

Date shipped	Customer	Claimed discrepancy^a (in grams)
July 14, 1988	Surelite, Ltd.	1.1
Aug. 4, 1988	Saunders Roe	1.3
Aug. 11, 1988 ^b	ORNL Intra-Bldg Transfer	2.2
Aug. 15, 1988	Surelite, Ltd.	1.3
Aug. 30, 1988	Surelite, Ltd.	1.3

^aThese shipper-receiver discrepancies to customers ranged from a shortage of 37 to 43 percent. The intra-building transfer discrepancy/loss was almost 75 percent. At least 12 other discrepancies (totaling 3 grams) were reported after these discrepancies occurred in July and August of 1988. According to ORNL records, there were numerous reported discrepancies between 1985 and the end of 1989 totaling about 15 grams, 1 gram of which was due to sending more tritium (i.e., overages) to customers than ordered.

^bThis is the date that a tritium container was allegedly loaded with 3 grams for transfer to another building at ORNL. When the container was returned to the tritium loading facility in November 1988, 2.2 grams (75 percent) were discovered to be missing.

Source: DOE.

Studies Concerning the Tritium Discrepancies at the Oak Ridge National Laboratory

DOE and ORNL organized a total of five formal studies to investigate the major tritium shipper-receiver discrepancies that occurred from shipments made by ORNL during July and August of 1988. The investigators made many recommendations to improve the quality, security, and safety of the ORNL tritium operations. ORNL implemented some of these, but others were not implemented because of DOE's decision to move the commercial tritium operations to DOE's Mound Plant.

The following is a list of the five individual studies:

1. Investigation Committee Report on Tritium Inventory Discrepancy in ORNL Tritium Sales Program, July 20, 1989.

Authors: A committee of 12 ORNL employees, many of whom were from the isotope/tritium program.

2. Study of Discrepancies in Tritium Shipments from Oak Ridge to their Large, Commercial Customers, July 28, 1989.

Authors: A joint DOE-NRC study—one investigator from DOE, one from NRC.

3. Review of Discrepancies in Shipper-Receiver Measurements for Tritium Shipments Under the Isotope Production and Distribution Program, Sept. 28, 1989.

Authors: DOE Nuclear Energy Review Team composed of personnel from DOE's headquarters Office of Nuclear Energy, the Savannah River Site, the Mound Plant, and a systems engineer and quality control engineer from the Oak Ridge Operations Office.

4. Discrepancies and Related Issues at the Oak Ridge National Laboratory Tritium Isotope Sale Program, Dec. 12, 1989.

Authors: An Inventory Difference Anomaly Resolution Team composed of seven DOE and DOE Laboratories' personnel with expertise in safeguards' specialties.

5. Tritium Investigation Committee Report, Mar. 23, 1990.

Authors: An ad hoc committee of three ORNL people appointed by the Deputy Laboratory Director.

Contractor Appraisal and Personnel Actions Taken as a Result of the Tritium Discrepancies

Although the quality of Martin Marietta's tritium operation was questionable, DOE Oak Ridge continued to rate the contractor's isotope program performance as "excellent." It was not until formal investigations publicized the tritium problems that DOE Oak Ridge penalized the contractor in the award fee process for its performance. At this time, the DOE Oak Ridge Operations Manager criticized Martin Marietta for its tritium operations performance and for not having transferred earlier lessons learned from similar problems in other programs.

DOE and ORNL replaced key personnel who were involved with the tritium discrepancies. These personnel moved to equally responsible positions; at least one was promoted; and one took a position previously occupied by his supervisor. Although key ORNL tritium personnel were given letters of "counseling and coaching" signed by the Laboratory Director, DOE personnel did not receive similar admonitions. The former DOE Oak Ridge Director of Energy Programs, including the isotope program, stated that his people did their best with limited resources and heavy work loads. Thus, he believes that formal admonishment for this incident was not warranted. He and the individual responsible for tritium program oversight (at the time that the major discrepancies occurred) believed that the significance of the tritium discrepancies may have been exaggerated, since the discrepancies represent less than 5 percent of total annual tritium sales.

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