NUREG-1103

Contaminated Mexican Steel Incident

Importation of Steel Into the United States That Had Been Inadvertently Contaminated With Cobalt-60 as a Result of Scrapping of a Teletherapy Unit

U.S. Nuclear Regulatory Commission

Office of Inspection and Enforcement

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Importation of Steel Into the United States That Had Been Inadvertently Contaminated With Cobalt-60 as a Result of Scrapping of a Teletherapy Unit

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ABSTRACT

This report documents the circumstances contributing to the inadvertent melting of cobalt 60 (Co-60) contaminated scrap metal in two Mexican steel foundries and the subsequent distribution of contaminated steel products into the United States. The report addresses mainly those actions taken by U.S. Federal and state agencies to protect the U.S. population from radiation risks associated with the incident. Mexico had much more serious radiation exposure and contamination problems to manage. The United States Government maintained a standing offer to provide technical and medical assistance to the Mexican Government. Assistance was provided as described briefly in Appendix A. The report covers the tracing of the source to its origin, response actions to recover radioactive steel in the United States, and return of the contaminated materials to Mexico. Some information outside of this scope is recounted, e.g., some information about the incident within Mexico. The incident resulted in significant radiation exposures within Mexico, but no known significant exposure within the United States. Response to the incident required the combined efforts of the Nuclear Regulatory Commission (NRC), Department of Energy, Department of Transportation, Department of State, and U.S. Customs Service (Department of Treasury) personnel at the Federal level and representatives of all 50 State Radiation Control Programs and, in some instances, local and county government personnel. The response also required a diplomatic interface with the Mexican Government and cooperation of numerous commercial establishments and members of the general public. The report describes the factual information associated with the event and may serve as information for subsequent recommendations and actions by the NRC.

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ACKNOWLEDGEMENTS

This report was prepared by the Nuclear Regulatory Commission (NRC) staff of the Safeguards and Materials Program Branch of the Division of Quality Assurance, Safeguards, and Inspection Programs, Office of Inspection and Enforcement. The report is a summary of key actions during the incident response and, as such, omits specific mention of many organizations and individuals who made important contributions to resolution of the incident. A listing of these participants, even if available, would be too long to include here, but without their collective input, cooperation, and hard work, resolution of the incident would have indeed been difficult.

The authors also wish to thank the NRC offices and regional representatives who provided constructive comments and recommendations on drafts of this document.

1.0 THE INCIDENT

On or about December 10, 1983, small pellets of cobalt 60 (Co-60) mixed with scrap steel were charged into the melt of two steel foundries in Mexico. A scrap yard (Yonke Fenix, in Ciudad de Juarez, Mexico) that supplied scrap to the foundries, purchased parts of a medical teletherapy unit as scrap without knowledge that the scrap contained radioactive material. The Co-60 was mixed with the scrap steel that was fed to the furnaces. The source capsule in the head of the unit had been intentionally broken open before the scrap yard had purchased the scrap on or about December 6, 1983. The very small, loose pellets of Co-60 were scattered throughout the yard during scrap-handling operations (see Figure 1.1). The dispersal was increased by the magnetic properties of the pellets as most of the handling was done with a magnet loader.

The original pellets were cylindrical in shape, measuring about 1 mm in diameter and length, and very highly radioactive (about 25 roentgens per hour at 5 cm from a single pellet).* The scrap steel, contaminated with these pellets, was transported from Yonke Fenix to its customers in open trucks, resulting in further dispersal of the pellets into the streets of Juarez and along the routes to Chihuahua, Torreon, and Guadalajara. During initial surveys by Mexican response teams, 62 pellets were found in these areas. At least 21 other pellet locations were later discovered during the March 19-25 aerial surveys of Juarez and along the Juarez-Chihuahua route.

The contaminated scrap was charged into steel melts that were formed into reinforcing bars (rebar) at the Aceros de Chihuahua foundry in Chihuahua, Mexico, and into table pedestal castings at the Falcon Products Company foundry in Juarez, Mexico. A third foundry in Torreon, Mexico, that did not ship products to the United States, was reported to have cast valve bodies and electric motor parts using contaminated steel. The Mexican Government reported that a minor amount of contaminated steel had found its way to a specialty steel producer in Guadalajara, Mexico. Distribution of these products was prohibited.**

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* ° Roentgens per hour is a radiation exposure rate and is used in this report when referring to measurements made with detection instruments. REM (roentgens equivalent man) is used in this report when referring to absorbed dose to individuals. In a general sense, a radiation worker is normally limited to 5 rem per year and a member of the general public 1/2 rem per year total dose from nuclear operations. Naturally occurring radiation exposure to the general public from background radiation in the United States varies from 1/10 to 1/4 rem per year.

° Milliroentgen is one one thousandth (1/1000) of a roentgen or 0.001 roentgen.

** The details in this and other sections of the report about what happened within Mexico are based on information provided by the Mexican National Safety and Safeguards Commission, Falcon Products (which owns a foundry in Juarez), and by a representative of the NRC who assisted the Mexican authorities for two days in Juarez.

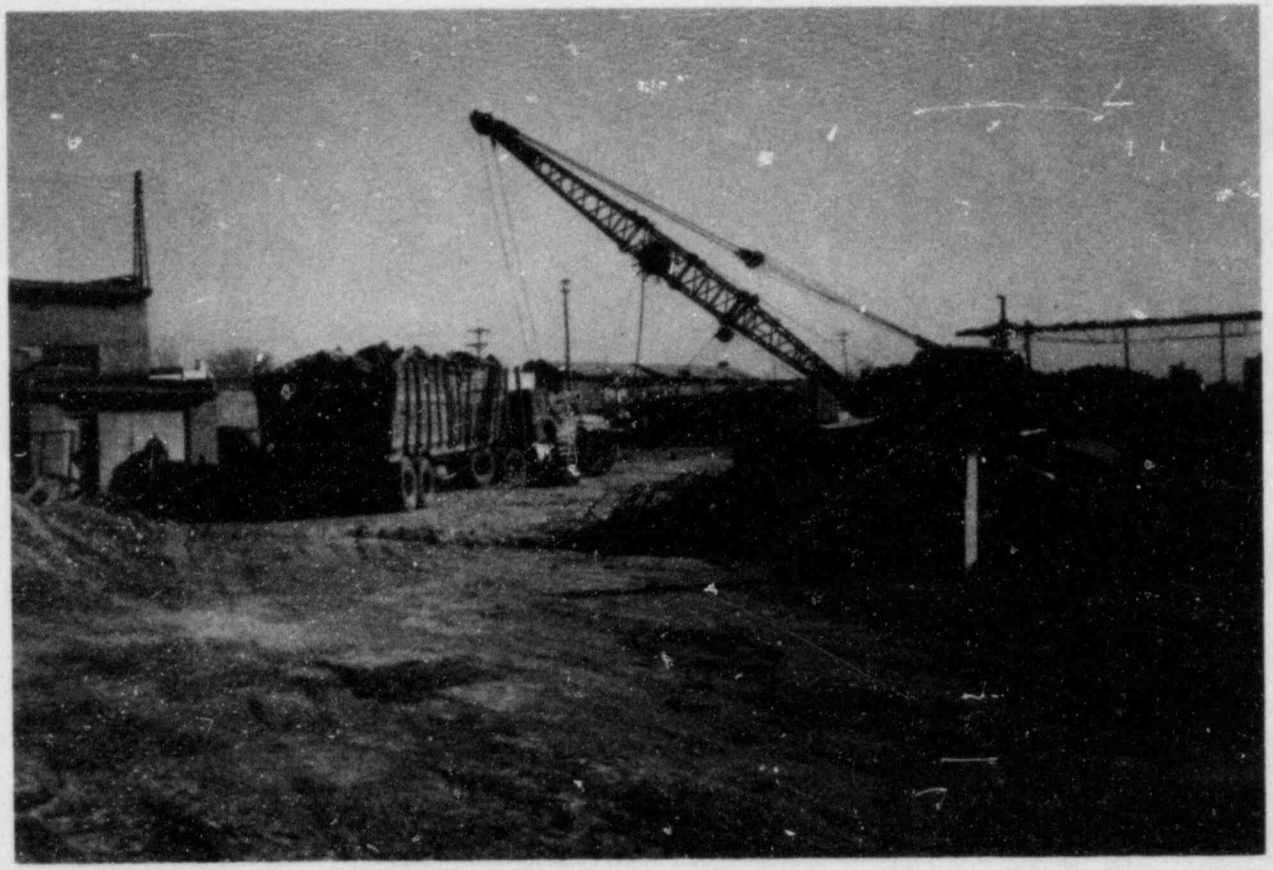

Figure 1.1 Yonke Fenix scrap yard showing loading of scrap on truck for transport to a foundry customer

During melting at the foundries that charged the contaminated scrap, the metallurgical process was such that the Co-60 pellets were unevenly melted throughout the steel, resulting in a product that contained minute "hot spots" of random location and radioactive intensity ranging to a maximum of about 600 milliroentgens per hour at contact. Most of the contact radioactivity measurements were in the range of 0.025 milliroentgens per hour to a few milliroentgens per hour.

All of this activity involving the scrap was carried out by participants who were unaware that the contamination existed. It was not until January 16, 1984, after the steel products were in both Mexican and American distribution networks that the problem was discovered.

Appendix A contains a chronology of the major events pertaining to the incident and the response to it by the states, NRC, and others.

2.0 PRODUCTS SHIPPED TO THE UNITED STATES

2.1 The Reinforcing Bars

The first indication that a problem existed in either Mexico or the United States was a result of a chance happening on January 16, 1984, when a truck delivering steel passed through a road radiation monitor at the Los Alamos Scientific Laboratory (LASL) in New Mexico. If the driver had followed the proper route and had not taken a wrong turn, the truck would not have passed the road monitor. The truck that carried contaminated reinforcing bars (rebar) triggered the road radiation monitoring/detection mechanism, was automatically photographed, and was subsequently identified as belonging to the Smith Pipe and Steel Company of Albuquerque, New Mexico. Followup by LASL and State of New Mexico personnel identified the source of the radiation that tripped the monitor as Co-60 fixed in reinforcing bars that could have originated in Mexico at the Aceros de Chihuahua foundry and been shipped to the Smith Pipe and Steel Company or transshipped from Free Market Steel Distribution Company of Phoenix, Arizona. Because this appeared to be a potential interstate and international problem, the New Mexico authorities notified the NRC Region IV office in Arlington, Texas, on January 17. The NRC Region IV office, in turn, notified the NRC office in Region V, Walnut Creek, California, and NRC State Programs in Washington, DC.

At this point the significance of the problem was not known. Officials of the State of New Mexico confirmed on January 18 that the radioactive rebar from Free Market Steel in Phoenix, Arizona, originated in a shipment of steel from the Aceros de Chihuahua steel foundry in Mexico. State officials also learned that an additional shipment from Aceros de Chihuahua was located at the border in El Paso, Texas. This information was provided to officials of the Texas and Arizona departments of radiation control and the NRC. The shipment at the border, consisting of five truckloads, was detained by U.S. Customs, surveyed by the Texas Bureau of Radiation Control, and found to be contaminated (see Figure 2.1). (It was subsequently returned to Mexico.) The states and the NRC then began actions to restrict further import, distribution, and use of the rebar in their respective jurisdictions. Distribution of the contaminated rebar in the United States had to be traced. It was determined that the Mexican foundry, Aceros de Chihuahua, had four American distributors. These were identified as Free Market Steel of Phoenix, Arizona, and Kaibab Industries, W. Silver Company, and IRCA Company, all of El Paso, Texas. Followup on the distribution of steel by these companies led to the discovery of contaminated rebar in four states: Texas, Colorado, New Mexico, and Arizona. Later, contaminated rebar also was found in California and Nevada.

To locate and restrict further distribution and use of this rebar, each state government obtained a list of each of the distributors' customers in their respective states. These customer lists were used to locate the rebar. When the contaminated rebar was found it was quarantined on the customers' premises pending a decision on its final disposition (see Figures 2.1 and 2.2). Except in the State of Arizona, very little contaminated rebar had left the distribution network to be used in construction. In Arizona, a number of concrete projects (about 27), including residential housing projects, had been completed before the rebar was found. One instance of contaminated rebar installed in concrete was later

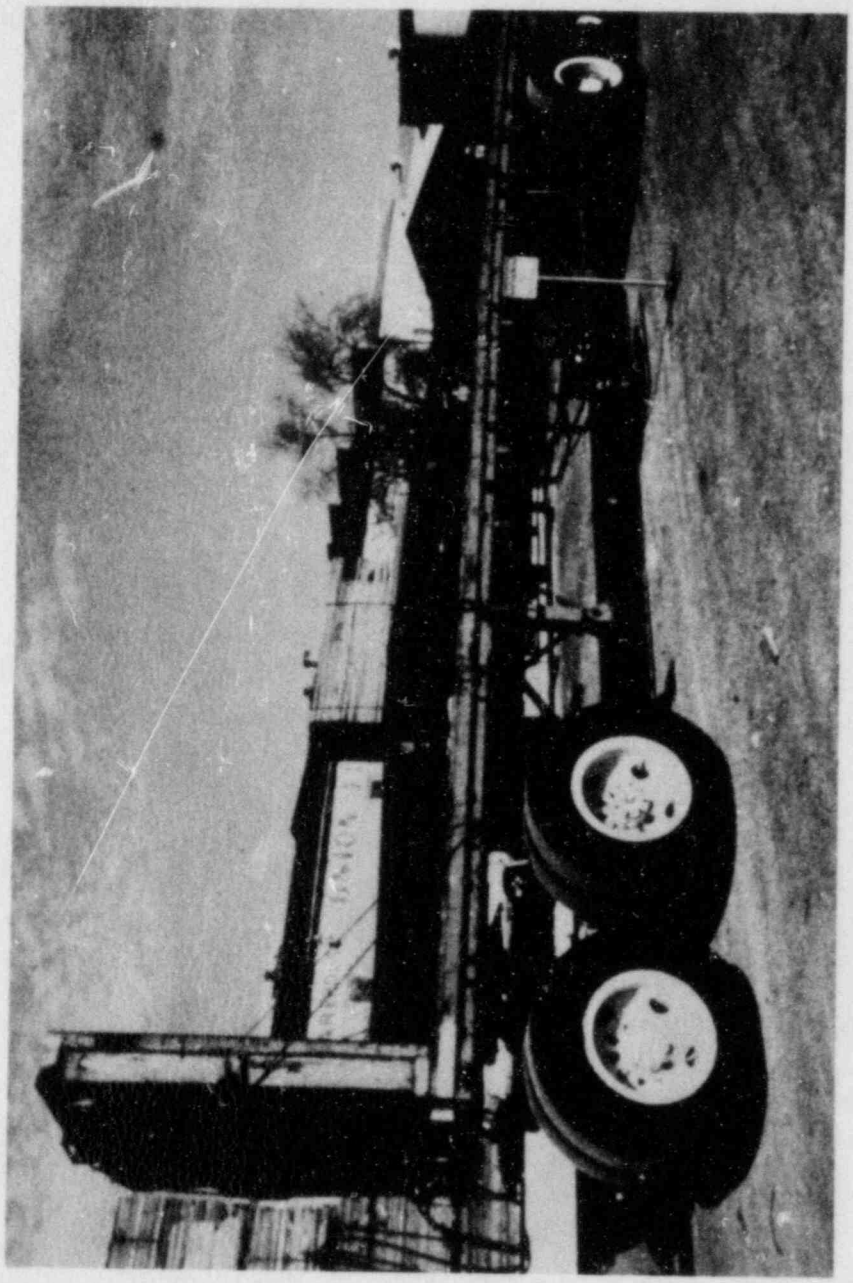

Figure 2.1 Truckload of steel rebar detained at El Paso border crossing

Figure 2.2 Rebar quarantined in Arizona

reported to have occurred in California. It also was reported that two truckloads of contaminated steel were turned back to Mexico at the Calexico, California, border crossing.

A total of about 1,500 tons of rebar from the Aceros de Chihuahua foundry was eventually returned to Mexico from the United States. The returned rebar included uncontaminated rebar mixed with contaminated rebar in some instances. NRC Region IV has attempted to account for the contaminated rebar. The best estimate is that between 500 and 931 tons of contaminated rebar entered the United States. In many cases, because no attempt was made to separate contaminated rebar from noncontaminated rebar in a lot, Region IV could not determine the exact amount of contaminated rebar shipped from Mexico, recovered, and returned (see Appendix B).

All the reinforcing bars discovered during the incident recovery efforts have been returned to Mexico, except for the amounts found that had been installed during construction of various structures. The contaminated rebar that was removed from structures has been disposed of in a manner consistent with NRC guidance. Future radiation exposures and resultant health effects to the public from unrecovered rebar or rebar imbeded at construction sites are considered unlikely or insignificant.

2.2 The Table-Base Castings

The Mexican Government investigation of the contamination incident and the distribution of rebar led to the discovery on January 24, 1984, of a steel foundry (Falcon Products Company, Juarez, Mexico) that had bought scrap from the Yonke Fenix scrap yard in Juarez to make table-base castings for sale in the United States. The exported castings were in the form of grey iron parts for table bases used mainly in commercial establishments (see Figure 2.3). The distributor of these products was reported to be based in St. Louis, Missouri. On January 24, 1984, Region IV notified NRC Region III, Glen Ellyn, Illinois, of these findings. NRC staff of Region III, in cooperation with the State of Missouri Health Department personnel, identified the distributor as Falcon Products Company. The Falcon Products Company steel foundry in Juarez, Mexico, casts iron parts for assembly and distribution in the United States. On January 25, 1984, a State of Missouri inspector confirmed that some of the castings at the Falcon plant were contaminated. Falcon representatives indicated that the most recent lot of materials received from Mexico consisted of 10 truckloads of table bases. Nine of the trucks had been unloaded and were being processed through the plant and one truck had not been unloaded. Falcon agreed to halt distribution of the table bases, hire a radiation consultant, and attempt to recover the bases that had been distributed in the public domain.

Falcon started the process of recovery of the table bases by segregating the bases at its St. Louis plant and at the location of its main distributor in Greenville, Tennessee. Falcon believed that the table-base castings had not yet been widely distributed, but on January 30, 1984, a truck that was carrying contaminated

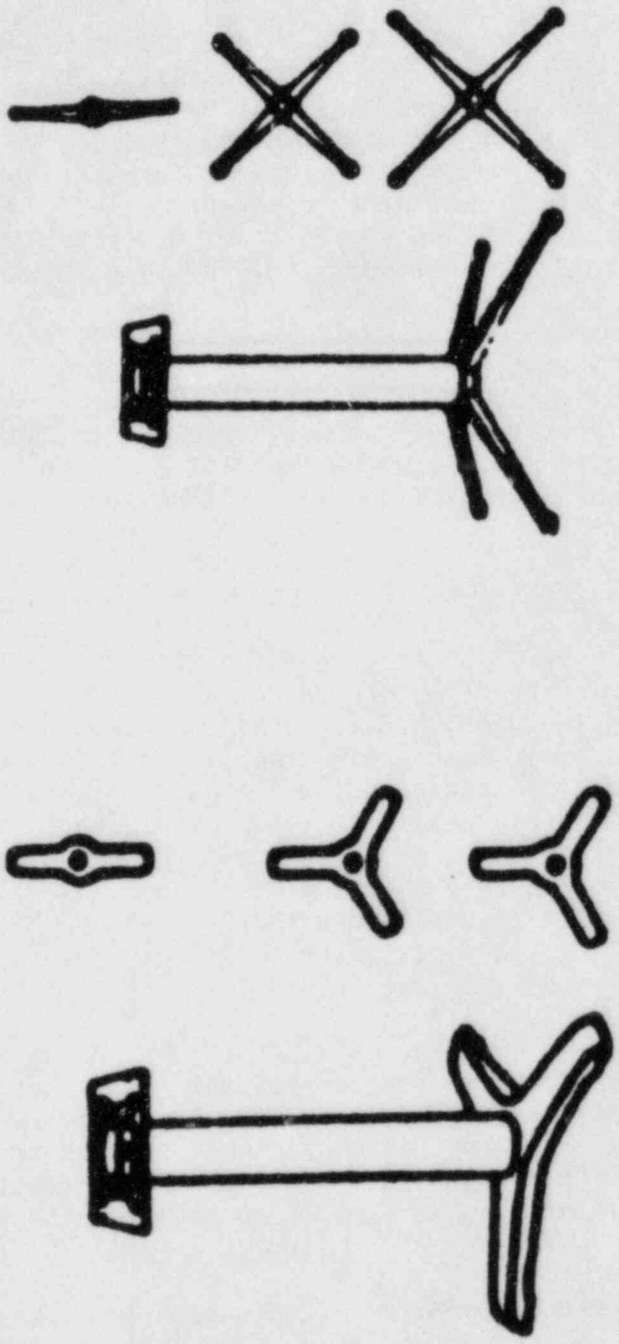

Figure 2.3 Cast iron table bases

Falcon table bases, was detected and stopped on an Illinois toll road by an Illinois State trooper who was operating a cruiser equipped with radiation detection equipment. The truck was routed back to St. Louis. By February 7, 1984, the Falcon recovery effort had found contaminated castings in Illinois, Nevada, California, Nebraska, and Tennessee. At this time it was recognized that the bases had a widespread distribution and that Federal and state actions would be needed to ensure prompt recovery of the contaminated castings.

Falcon Products Company developed a computer list alphabetically by customer that showed 33,000 castings had been shipped into 50 states to 1,400 customers between December 10, 1983, the date contaminated scrap was charged into the Jaurez foundry, and January 25, 1984, the date that Falcon stopped distribution at the St. Louis plant. This computerized list was distributed to radiation control program officials in 50 states. Using this master list, the NRC Region III office segregated the customers by state and sent to officials of each state a list of firms located in their state, with a request to perform radiation surveys of any castings found at the firms on the list (see Appendix C). The states were requested by the NRC to directly notify Falcon Products Company in St. Louis whenever they found radioactive castings. Out of about 33,000 parts, approximately 2,500 were found to be contaminated. Falcon replaced the approximately 2,500 contaminated parts for its customers during this effort. Contaminated castings were found at distributors' and at users' establishments in 40 states. The radiation levels on the recovered radioactive pieces ranged from a maximum of 375 milliroetgens per hour to 0.020 milliroentgens per hour at the surface. About 100 tons of contaminated pieces were shipped back to Mexico for final disposition.

A radiation survey of the Falcon Products plant in St. Louis on March 4, 1984, conducted by the NRC Region III office, indicated no radiation levels above background. An accountability of the contaminated parts was performed by Falcon and NRC personnel that showed the contaminated bases had been recovered from all but seven states. The remaining seven states completed recovery at later dates. Consultant reports for the Falcon Products Company show that contamination has been reduced to acceptable levels at the Falcon foundry in Juarez, Mexico, and that all incoming scrap and finished foundry products are now being surveyed for radioactivity to preclude recurrence of the incident. Falcon also has established a program of surveying for radiation and certifying that shipments from its St. Louis, Missouri, facility are free of contamination.

3.0 THE SOURCE

When the radioactivity in the rebar was analyzed, it was identified as pure Co-60 contamination. With the absence of other radionuclides in the steel it was assumed that the source of the contamination must have been a commercial sealed source of Co-60. Because there had been an incident previously at an American mill, it was initially thought that the contamination may have been from a gauge used in the Mexican foundry or discarded as scrap from some other location and charged to the furnace. However, the Mexican Government investigation into the incident showed that the origin of the steel contamination was from scrap received by the Aceros de Chihuahua and Falcon Foundries from the Yonke Fenix scrap dealer in Juarez, Mexico. The radioactive materials found at the scrap yard were small, discrete, highly radioactive particles. The particles (pellets) were eventually traced by Mexican authorities to a medical teletherapy unit owned by a medical clinic in Juarez (see Figure 3.1). The unit was traced back through an equipment supplier in Fort Worth, Texas, that bought it from the original owner, Methodist Hospital in Lubbock, Texas. The Methodist Hospital purchased the unit new from the Picker Corporation. Since the original purchase, Picker has been merged into the Advanced Medical Systems Corporation of Cleveland, Ohio. This Corporation has retained most of Picker's records and employees. The unit was identified by Advanced Medical Systems as a Picker C-3000 unit that was designed to accommodate a source up to 5,000 curies of Co-60.* Methodist Hospital records showed that in 1977 the unit was sold to X-Ray Products in Fort Worth, Texas, a firm that buys and sells both new and used equipment. The unit was sold and exported shortly thereafter to Dr. Lemus of Centro Medico de Especialidades, a clinic in Juarez, Mexico. The involved parties observed all required U.S. regulations necessary for the various transactions, including export to Mexico. At the time of sale, the unit was listed on the export declaration as having an activity of 1,003 curies of Co-60. At the time of the incident, the source activity had diminished to about 400 curies as a result of radioactive decay (see Appendix D).

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* During the course of the investigation to identify the source, Advance Medical Systems indicated that in 1982, the Picker C-3000 unit had been declared obsolete because of an apparent structural defect in the "C" arm mechanism. Because structural failure of the "C" arm, while the machine was in operation, could have resulted in the arm collapsing on a patient causing injury or death, the company notified owners of the C-3000 unit and recommended that they be scrapped. In addition, the company informed owners that no new sources would be installed in these units unless the owner legally released the company of responsibility for structural failure (see Appendix D).

No 10 CFR Part 21 report was submitted to the NRC regarding the defect. None was required because the defect in the unit was not directly related to the components necessary for the radiological safety of the machine.

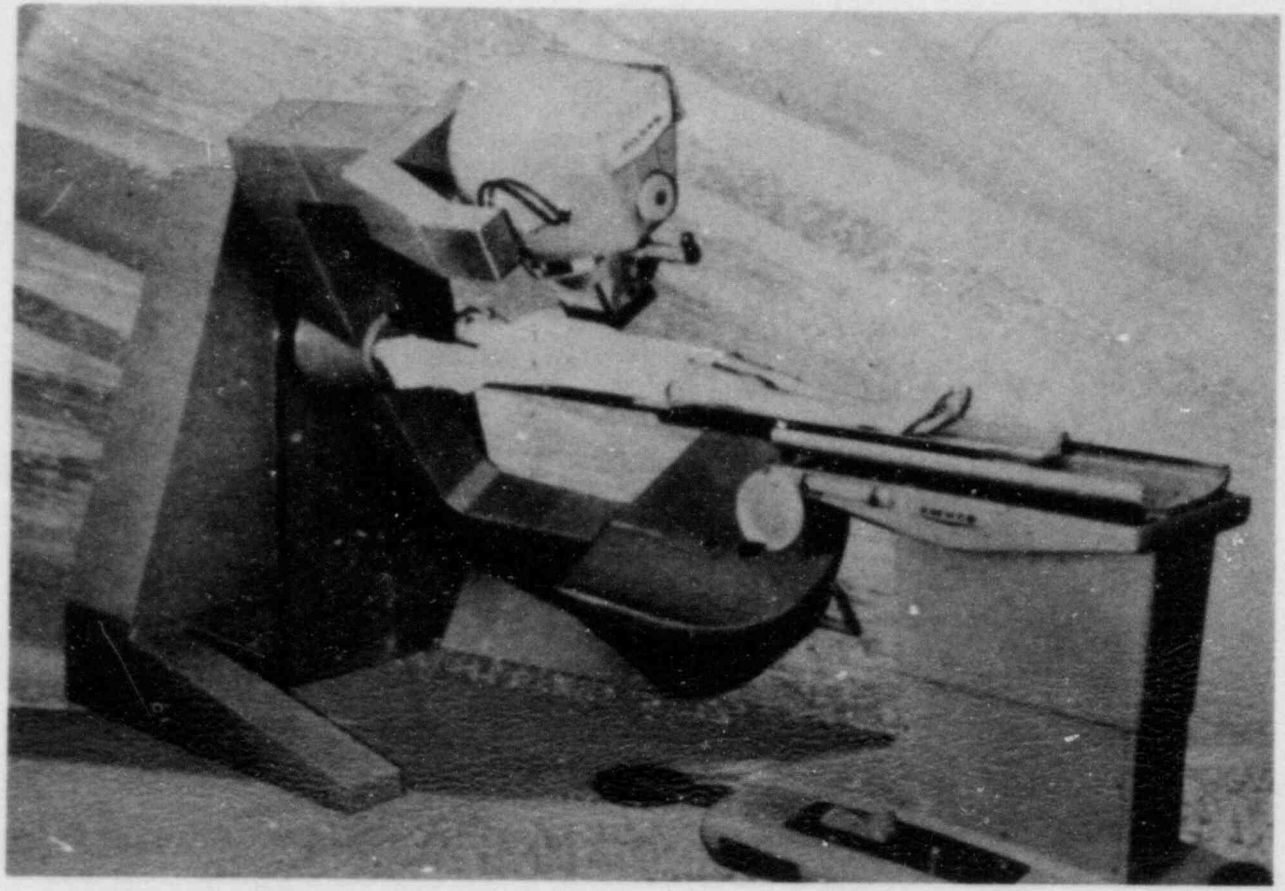

Figure 3.1 Picker C-3000 (75cm SAD) cobalt therapy unit

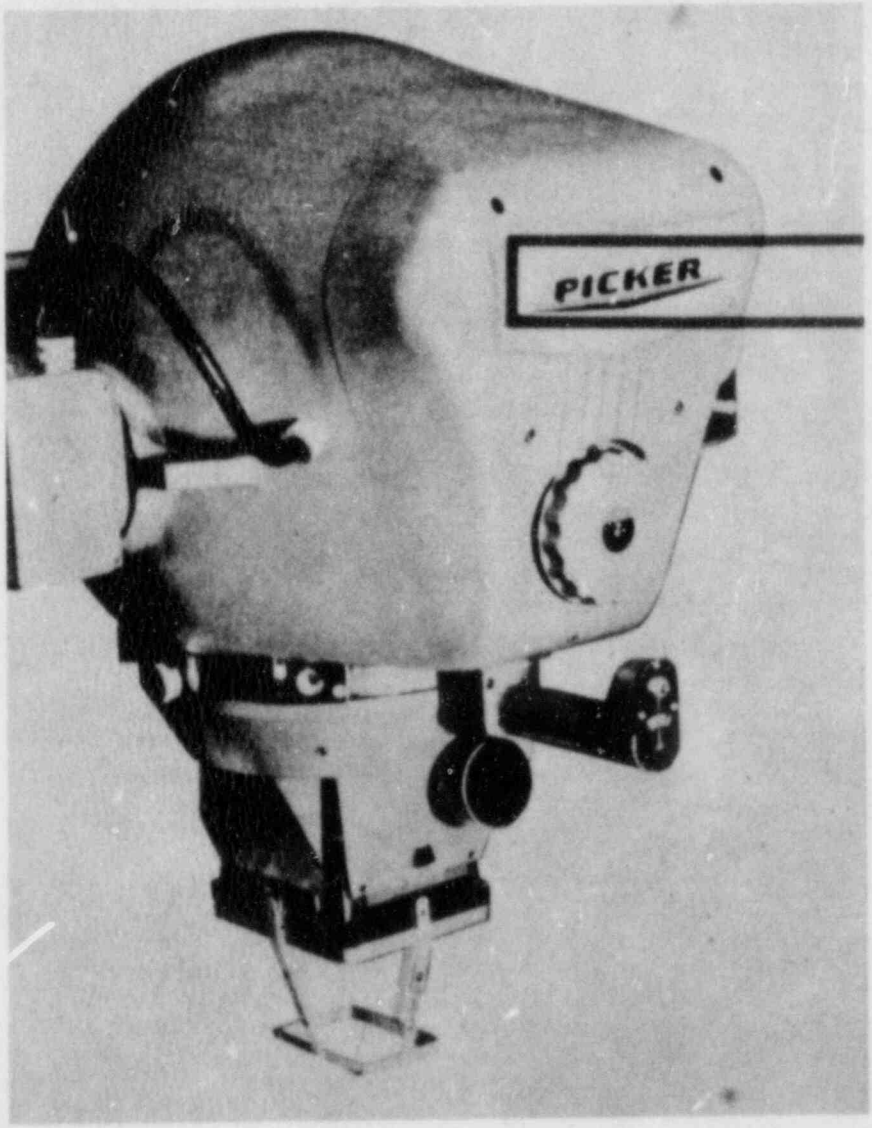

Figure 3.2 Picker C-3000 source head

The stainless steel, doubly encapsulated source capsule, located in the head of the teletherapy unit, measured about 2 cm in diameter and contained about 6,000 cylindrical cobalt metal pieces (pellets) about 1 mm by 1 mm. At the time of the incident each pellet contained about 0.07 curie of Co-60 and had an exposure rate of about 25 roentgens per hour at 5 cm (see Figures 3.2 and 3.3).

Mexican authorities verbally advised the NRC that Centro Medico de Especialidades had contacted them regarding licensing before receiving the teletheraphy unit in Mexico in 1977. The clinic was informed by the Mexican authorities of the requirements to be met to use the unit. It is assumed that the clinic did not pursue licensing further and elected to place the unit in storage rather than put it in operation. The unit remained in the clinic warehouse until about November 1983. It was then dismantled at the warehouse by a clinic electrician and others, loaded into a truck, and transported to the vicinity of the electrician's Juarez home where it was parked until the parts were sold to Yonke Fenix as scrap on December 6, 1983. During the transfer of the source to the truck, or during transit, the source capsule was deliberately ruptured and a significant number of Co-60 pellets remained in the truck after sale of the unit's parts to the scrap yard.

Some of the Co-60 pellets were dropped into the streets of Juarez while the truck was in transit. The truck was again parked in the street in the Juarez residential neighborhood until discovered on January 26, 1984. The contamination remaining in the truck contributed significant radiation exposures to a number of residents of the area who lived nearby or who stood or played around it. When discovered, radiation exposure rates measured at a distance of 1 m from the truc ranged from 8 roentgens per hour to 50 roentgens per hour.

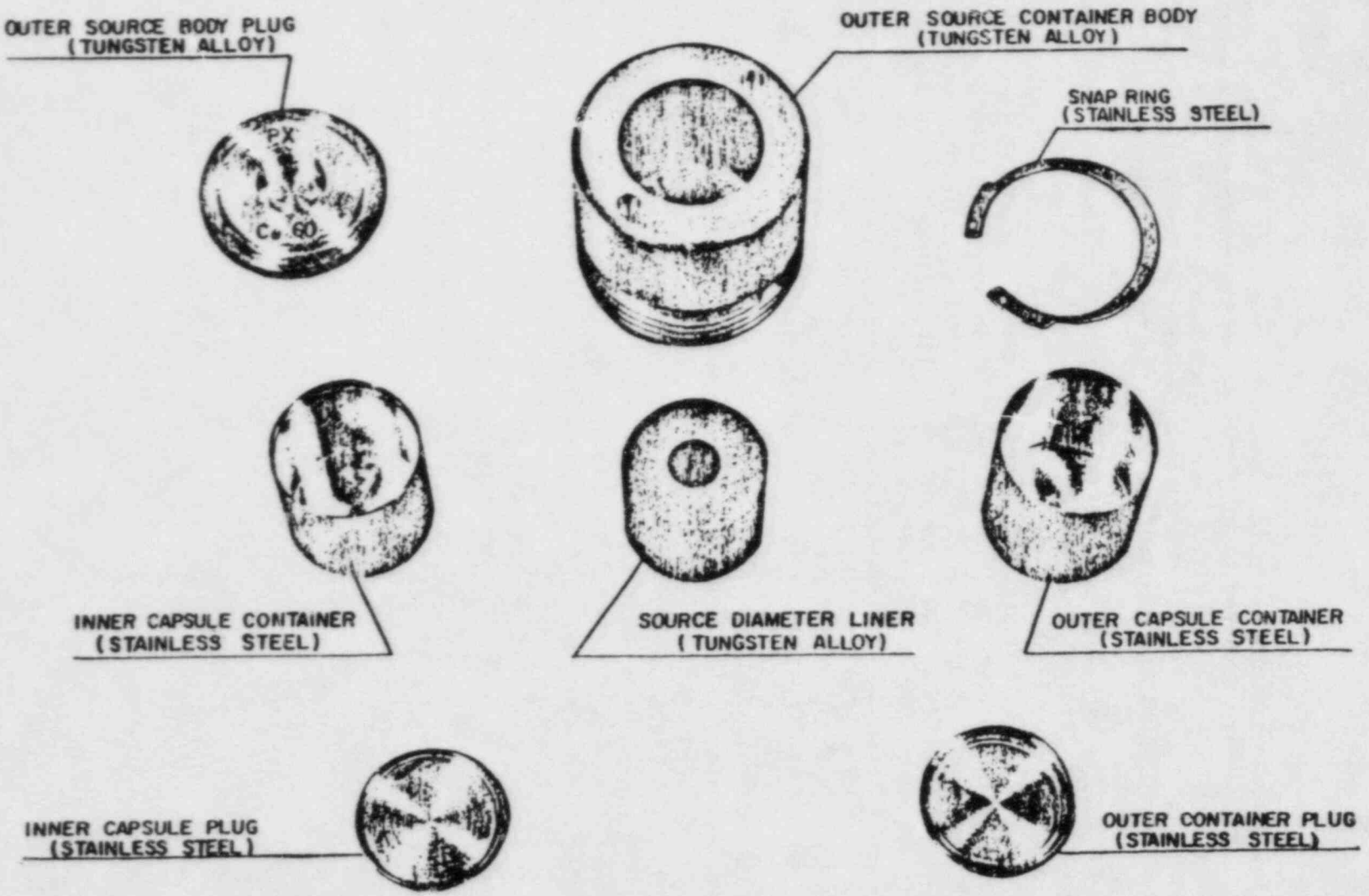

Figure 3.3 Source capsule components

4.0 INTERNATIONAL COOPERATION

The United States has a formal regulatory cooperation arrangement with Mexico. Generally, this arrangement states the commitment of the countries to exchange information and to cooperate bilaterally in nuclear safety matters. During the contaminated steel incident, the NRC had two main objectives under this arrangement: first, to obtain from Mexican officials all possible information to protect the public of the United States and, second, to assist Mexico in their efforts to protect their citizens.

Within the NRC, the Office of International Programs has the responsibility to interface with foreign government officials as NRC's official representative. This interface was established early in the incident between the Deputy Director of the NRC Office of International Programs and the Technical Secretary of the Commision Nacional de Seguridad Nuclear y Salvaguarda (CNSNS) (Mexican National Safety and Safeguards Commission). These officials are designated as the official administrators for the United States and Mexico under terms of the agreement.

Early on January 19, 1984, the State of Texas first informally notified the Mexican Government (CNSNS) of the contamination traced to Mexico. The NRC officially notified CNSNS by telegram later that day. Approval of procedures to return steel products to Mexico along with facilitating and gaining official permission for American technical personnel to aid the Mexican recovery effort were negotiated through the NRC-CNSNS contacts.

The daily exchange of information through this NRC-CNSNS interface of current activities on both sides of the border contributed to prompt dissemination of official information and helped provide bases for decision making regarding the incident investigation and recovery. The NRC International Programs office issued a daily information letter that was widely distributed. Involved individuals were kept up-to-date on all aspects of the incident through this daily update, which involved considerable interaction with other NRC offices, the Department of Energy, Pan American Health Organization, the Department of State and embassy personnel.

5.0 REGULATIONS AND GUIDANCE

Numerous questions were raised when it was discovered that Co-60 contamination that might exceed Federal or state guidelines or limits was being distributed in consumer products. In most cases these questions could be answered using NRC regulations as a basis. However, in some cases no regulatory basis existed to make decisions, and the NRC Office of Nuclear Material Safety and Safeguards (NMSS) provided guidance. Examples of some of these instances follow.

(1) How much radiation, if any, should be permitted to remain in the public sector as a result of the incident? What release levels should be used? On January 27, 1984, guidance was established as 20 microroentgen per hour above background radiation not to exceed 130 millirad per year to an individual (see Appendix E).

(2) Should there be an exemption to item 1 for special cases; for example, where the contaminated rebar was imbedded in concrete? If so, what limit should be set? Guidance was established on January 27, 1984, that permitted use of occupancy factors to be used to calculate doses to individuals. These factors were: 0.75 for residences, 0.4 for commercial buildings, and 0.1 for structures such as bridges. On February 21, 1984, NMSS issued guidance on disposal of concrete contaminated with rebar permitting disposal in landfills (see Appendix E).

(3) What type of instrument should be used to make consistent radiation measurements? Because of the very low action level, official participants generally agreed that a "micro R meter" should be used to make surveys. No formal requirement or procedure was issued.

(4) How can the curie content of a truckload of rebar be estimated? NMSS issued guidance for this calculation on February 17, 1984 (see Appendix E).

Guidance to resolve other questions also was developed by NMSS and verbally transmitted to the NRC regional offices for general distribution and to the Office of State Programs for distribution to the agreement states (see Section 8.0 of this report).

6.0 PUBLIC INFORMATION

From the time of the discovery of the contaminated rebar in Los Alamos, New Mexico, interest in the incident has remained high. Many newspaper and magazine articles have been published recounting the incident, its effect and implications. During recovery of the contaminated steel items, the NRC issued press releases and notifications to keep the public informed of its progress (see Appendix F). State governments and the Mexican Government also issued press releases to inform the public of activities in their jurisdictions.

Through the combined effort of press releases and individual interviews, the commercial news media kept the public well informed of the situation. A sampling of news coverage is presented in Appendix F.

7.0 TRANSPORTATION

The U.S. Department of Transportation (DOT) has very specific regulations for the transportation of radioactive materials within the United States. Those regulations include rules on the amounts and types of radioactive materials that may be transported in certain packages. They also include specific requirements for the paperwork (licenses, bills of lading, shippers' certificates, etc.) needed to transport radioactive materials.

The steel products shipped from Mexico met all the DOT requirements for shipment of standard steel cargo. Because it was not known that the products were radioactive, the shipment did not meet the necessary requirements of radioactive cargo such as placarding, packaging, and special shipping documents.

The DOT issued an exemption to portions of their regulations that permitted Falcon Products Company to return its recovered contaminated table castings to St. Louis, Missouri. This was reported to be the first exemption of its kind to be issued (see Appendix G). This exemption was terminated when Falcon released the radiation consultant who was required as a condition of the exemption.

DOT also issued a verbal exemption to permit rebar to be shipped back to Mexico in trucks without a covering that normally would have been required by the regulations.

Except for these minor exceptions, all transportation of radioactive material was performed within the DOT regulations. All steel was returned to Mexico without a transportation incident.

8.0 EFFORTS IN THE UNITED STATES

The Atomic Energy Act of 1954 permits the Nuclear Regulatory Commission to transfer certain of its responsibilities under the Act to state governments. Generally, the licensing and regulation of all nuclear activities--except nuclear reactors, fissile materials used in reactors, defense activities, and import and export of radioactive materials--may be transferred to state jurisdiction. Before a state may assume this responsibility, it must request such an arrangement with the NRC and show that the state has the resources to implement a program in its state that is comparable and compatible with the program that the NRC would otherwise perform in the state. After the state accepts the status of "agreement state" a periodic compatibility review of the state's program is performed by the NRC to ensure that an adequate program continues to be implemented. Of the 50 states, 27 have agreement state status. In the remaining states the NRC continues to license and regulate all radioactive materials under the Atomic Energy Act. These states are usually referred to as "non-agreement states." The NRC Office of State Programs develops policy and procedural guidance for regional offices, which serve as the primary contact with the states. The responsibilities of the regions include the periodic review of agreement state programs and technical assistance. Training is provided by NRC for the agreement states. The NRC has agreement state representatives in four of the five NRC Regional Offices that interface with the agreement states within their region. These representatives were the NRC contact for the agreement states during the incident. Each region also has a Regional State Liaison Officer. In Region III, where there are no agreement states, the State Liaison Officer was the primary contact with the states in that region.

All of the states in which rebar was found were agreement states with excellent capabilities to react to the incident and to coordinate with each other. The States of Texas, Colorado, New Mexico, Arizona, and California have common borders with at least one of the other states, and regional cooperation existed.

This situation aided the rapid isolation of the contaminated rebar from the public. The affected states kept the NRC informed of their recovery operations and requested NRC assistance to help resolve technical problems. The major technical areas for which NRC provided assistance were

(1) an acceptable release level for unused rebar
(2) an acceptable release level for rebar installed in concrete
(3) a method for determining the curie content of a truckload of rebar
(4) interpretations of DOT regulations and possible exemptions
(5) relief from border monitoring*
(6) instructions for returning contaminated products to Mexico

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* The border port at El Paso was being monitored by the State of Texas personnel. Because the regulation of import and export of radioactive materials was retained by the NRC and not included in the agreement state program, the State of Texas requested that the NRC relieve them of this activity.

The activities to recover the contaminated table-base castings were organized in a different manner. Because the majority of the contaminated parts were initially found in non-agreement states, the NRC assumed responsibility for coordinating the recovery effort. The NRC Region III office worked directly with Falcon Products Company, distributed information obtained from this source to the affected states, and provided procedures to the states for recovery operations (see Appendix C).

All the non-agreement states involved have radiation detection capabilities adequate to respond to this type of situation in their states. These capabilities were provided at the request of the NRC and in only a few instances were NRC personnel involved in the recovery efforts within these states.

Throughout the entire incident, there was a high degree of cooperation among the NRC, the states, commercial establishments, and the general public.

A study performed by the NRC Office of State Programs assisted by the Conference of Radiation Control Program Directors, Inc., showed the total out-of-pocket expenditures by the 50 states, District of Columbia, and Puerto Rico incurred in responding to the incident was about $233,000. This included the cost of 7.9 staff-years of professional effort, plus costs of clerical work, travel, telephone, and miscellaneous.

9.0 RADIATION MEASUREMENTS - MONITORING AND SURVEYING

Radiation measurement capabilities were essential to the response effort in this incident. The initial discovery of the contaminated rebar was made by a sophisticated road radiation monitor at the Los Alamos National Laboratory. Equally sophisticated helicopter overflight radiation measurements by DOE showed El Paso free of contamination and pinpointed the remaining contamination in the Juarez-Chihuahua area of Mexico.

Technical difficulties in detecting the contamination were not as great as they might have been if the contamination had been alpha or low-energy beta radiation instead of the relatively high-energy Co-60 gamma radiation. Gamma radiation could be detected from a distance, providing a more rapid isolation of radiation hazards. An additional advantage was that gamma detection instrumentation is the most common type of radiation detection equipment in use.

Some of the major radiation measurement efforts were as follow:

(1) On January 24, 1984, the NRC office in Region IV loaned a detection instrument to U.S. Customs officials at the El Paso, Texas, commercial border vehicle crossing and trained customs agents in its use. U.S. Customs agreed to survey every truckload of commercial steel that was crossing the border. No contaminated steel was detected at the border crossing while using this detection instrument.

(2) During the third and fourth weeks in January 1984, the State of Texas performed radiation surveys using hand-held and mobile detectors in selected areas of El Paso. No contamination was found during these surveys.

(3) A U.S. Army helicopter using hand-held detectors made two flights over Juarez, Mexico, on February 3, 1984. The survey flights, requested by the Mayor of Juarez and U.S. Consulate in Juarez, included at least one Mexican radiation technician in the crew. The surveys detected three previously unknown areas of Co-60 contamination in the Juarez area.

(4) On March 1, portable radiation detectors (portal monitors) were installed on two bridge crossings at the border of El Paso, Texas. The detectors were loaned by officials of the DOE to Customs personnel. No Co-60 contamination was found by these installations on traffic crossing the border.

(5) From March 2 through March 13, 1984, Aerial Measurements System (AMS) flights over El Paso and selected roads leading into New Mexico were conducted by DOE at the request of the States of New Mexico and Texas (see Appendix H). No previously unknown areas of Co-60 contamination were detected during this survey.

(6) From March 19 through March 25, 1984, AMS flights were conducted over Juarez, Chihuahua, and the Juarez-Chihuahua corridor of Mexico. Contamination was found in several previously unknown locations. This survey detected 21

locations where Co-60 was present in the Juarez-Chihuahua area (see Figure 9.1). Cleanup of these spots was performed by Mexican decontamination teams.

(7) On August 11, 1984, the NRC replaced the civil defense detection instruments at 23 border crossings with new "micro R" meters purchased by the NRC. The NRC plans to place portal monitors at major ports when the instruments are received from the manufacturer. As of the date of this report, no Co-60 contaminated products have been detected crossing the borders.

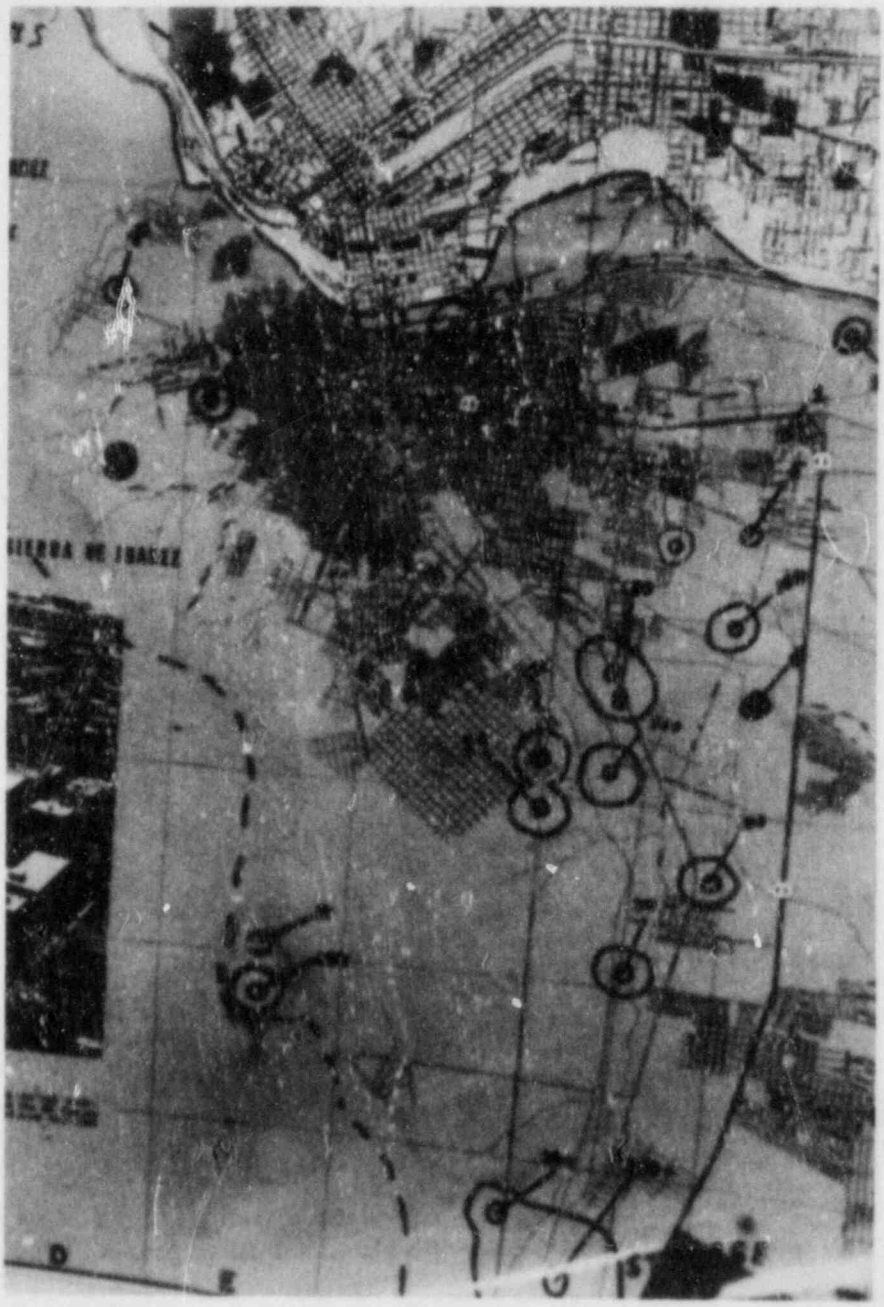


Figure 9.1 AMS map showing contaminated areas in Juarez

10.0 EVALUATION OF THE RADIATION DOSE TO THE GENERAL PUBLIC AND TRANSPORTATION WORKERS IN THE UNITED STATES

It would be impossible to make an accurate estimate of the radiation dose that each member of the public received who came in contact with or spent time in the vicinity of the contaminated rebar or table pedestals. However, it is possible to describe factors and develop scenarios that produce estimates of the maximum probable dose that any person could have received. On the basis of this type of analysis, the NRC staff concludes that it is unlikely that any person received a radiation dose above the accepted limits for radiation exposure to the general public or above DOT limits to transportation workers.

As described previously in this report, the contamination in the steel was in the form of radioactive specks (point sources). Distance effectively reduces the exposure rate to such sources as the exposure rate falls off sharply with distance (inversely proportional to the square of the distance). This factor, in itself, significantly reduced the potential radiation exposure from the steel (in most cases by 2 to 3 orders of magnitude).

For the table bases, the maximum exposure rate measurement at contact was about 375 milliroentgens per hour. The majority of the measurements at contact were in the range of about 1 to 100 milliroentgens per hour. NRC Region III performed radiation measurements of a table installed briefly in a restaurant to determine the exposure rate to a customer seated at the table and to the waiter or waitress serving the table (see Appendix I). However, most of the tables with contaminated bases were stored in warehouses and presented no radiation exposure to anyone except for brief periods of time when the boxes were unloaded from a truck or loaded on a truck for delivery to a restaurant. Within about 4 weeks of delivery, most contaminated tables had been identified by the affected states and removed from use in the restaurants. Thus, for a waiter or waitress, we can assume a maximum exposure of about 3 millirem per day for 32 days in the vicinity of a contaminated table. This would give a total estimated dose of 96 millirem.

However, since most of the tables had contact radiation readings in a much lower range of about 1 millirem per hour, the more likely dose would have been less than 1 millirem for the 32 day exposure.

With respect to the rebar, it is more difficult to develop a generic scenario. Generally, rebar is handled in bundles by a crane because of the weight. In most cases the rebar remained on the truck. Based on radiation measurements of loaded trucks, the exposure rates were within the DOT limits for transport of radioactive material. Those individual construction workers who handled the rebar as it was being installed in place before concrete was poured, spent the greatest amount of time in the vicinity of the contaminated rebar. If it is assumed that the average whole-body exposure rate to an iron worker installing rebar was 3 millirem per hour (the same as for the restaurant worker working around a table base), working with and around the contaminated rebar, in the one

day's time needed to install rebar in a typical basement slab for a home, the maximum dose would total about 24 millirem. If an iron worker worked on four basement slabs, the total dose would be about 100 millirem, about the same as would be received from background radiation in a year.

APPENDIX A

CHRONOLOGY OF MAJOR EVENTS IN CONTAMINATED STEEL INCIDENT

Autumn 1977: A cobalt 60 (Co-60) teletherapy unit was exported to Mexico by a firm in the United States. All United States requirements for export were met. No license from Mexican authorities to possess or operate the unit in Mexico was obtained by the owner. The unit was stored, not used.

Autumn-1983: The source and some incidental hardware were taken from storage; the source encapsulation was intentionally ruptured; tiny pellets of Co-60 metal started to be lost from the capsule about the time the components were loaded into a truck outside the storage place. The loaded truck was parked in a residential area of Juarez, Mexico, until December 6, 1983.

December 6, 1983: Several items, including the ruptured radioactive source, were sold to the Yonke Fenix scrap yard as scrap metal. The contaminated truck was again parked in the residential area until about January 26, 1984.

December 6, 1983 through January 20, 1984: Yonke Fenix transported contaminated steel scrap by truck to customers in Mexico. Radioactive pellets were spread during transit from the Yonke Fenix scrap yard to its customers.

December 10, 1983: The first radioactively contaminated reinforcing bar (rebar) was produced at Aceros de Chihuahua, Chihuahua, Mexico, and the Falcon Products Company foundry in Juarez, Mexico. Shipments of contaminated steel were made to the United States until January 25, 1984.

January 16, 1984: The Los Alamos Scientific Laboratory (LASL) at Los Alamos, New Mexico, detected radioactive rebar on a truck driving within the LASL reservation. The State of New Mexico was notified.

January 16, 1984: LASL confirmed that the contamination was Co-60. The State of New Mexico confirmed that the contaminated rebar originated in a shipment of steel from Aceros de Chihuahua foundry in Mexico and that five truckloads of steel from the same source was located at the El Paso, Texas, border crossing. The States of Texas and Arizona, U.S. Customs Service, and the U.S. Nuclear Regulatory Commission (NRC) were notified. The trucks were detained after contamination was found by the State of Texas.

January 19, 1984: The State of Texas, informally by telephone in the midmorning, notified the Mexican Government of the contamination. The NRC formally notified Mexican Commision Nacional de Seguridad Nuclear y Salvaguarda (CNSNS) by telegram in the afternoon. Texas, New Mexico, and Arizona began investigations to recover rebar. NRC issued preliminary notification (PNO IV-84-01). Texas performed radiation surveys in El Paso.

January 20, 1984: The Mexican CNSNS team started its investigation in Juarez. Texas authorities participated. First Co-60 pellet recovered (3R/nr at 5 cm), and there appeared to be a possibility of some pellets being tracked around by workers. CNSNS reported it would prohibit further shipments of contaminated steel. Texas provided monitoring at the border crossing in El Paso.

January 24, 1984: NRC Region IV office provided U.S. Customs with a radiation survey instrument and trained Customs personnel in its use. Five truckloads, previously detained by U.S. Customs in El Paso, returned to Chihuahua. Discovery that the Falcon Products Company foundry received contaminated steel.

January 25, 1984: CNSNS reported the source arrived at Yonke Fenix scrap yard December 6, 1983; the first contaminated rebar was produced at Chihuahua, Mexico December 10, 1983. Falcon Products Company of St. Louis, Missouri, was notified that it had received potentially contaminated table castings.

January 26, 1984: Hundreds of tons of contaminated rebar had been found in five American states. A State of Missouri inspector surveyed table castings in a warehouse of the Falcon Products Company and confirmed that the castings were contaminated. The contaminated pickup truck that carried scrap to the Yonke Fenix scrap yard was discovered in Juarez, Mexico.

January 27, 1984: CNSNS sent a telegram approving return of steel to Mexico; other Mexican agencies were also to be consulted. NRC issued guidance for residual radioactivity in structures built using contaminated steel rebar.

January 30 through 31, 1984: CNSNS reported findings about origin and description of the medical teletherapy unit--the origin of Co-60 contamination. A shipment of contaminated table castings was detected in Illinois by a state police cruiser. NRC Region III inspectors visited Falcon Products Company, which distributed the table castings, and obtained lists of customers (about 1,400) who had received table castings after December 10, 1983. Recovery or checkout of 33,000 table-base parts began.

February 1, 1984: The U.S. Department of State transmitted a cable to the U.S. Embassy in Mexico confirming NRC's offer of assistance and asked Mexico to approve the instructions for return of steel products. Additional information on source and personnel exposures in Mexico were received by the NRC from CNSNS. Headquarters IE assigned lead to coordinate NRC effort.

February 2, 1984: A number of newspaper articles published on the incident. Congressman Udall briefed by NRC staff regarding incident.

February 3, 1984: U.S. Army helicopter survey using hand-held meters was made, by CNSNS experts of Juarez, Mexico. Mexico City press reported 150 persons hospitalized as a result of radiation injury. Mexican health officials reported to the NRC that about 100 persons had received blood tests and three or four persons showed evidence of 100-450 rem whole-body doses. The United States offers technical assistance to Mexico. The U.S. Department of Transportation (DOT) issues transportation exemptions to Falcon Industries Inc. to aid return of contaminated table base parts.

February 7, 1984: NRC requested states to perform table-base-parts surveys and distributed the list of Falcon Products' customters.

February 8, 1984: NRC meeting held in Region III with Falcon Products Company to coordinate search for table-base parts.

February 9 through 10, 1984: An NRC staff member from Region V accompanied a CNSNS representative in a visit to Juarez, Mexico. The NRC staff member developed a list of recommendations for the Mexican authorities regarding recovery and for actions that should be taken by NRC. These actions included a recommendation for aerial overflights as a precautionary measure.

February 14, 1984: Mexico agreed to the NRC instructions for return of steel. Falcon Products Company returned about 100 tons of table-base castings to Juarez.

February 15, 1984: CNSNS advised that the high dose rate from the truck parked near the border was reduced and pellets immobilized by concrete poured into truck. The Mexican Government's approval of the NRC instructions for return of steel was distributed to NRC regional offices.

February 18, 1984: Dr. K. Hubner, a consultant for DOE-Oak Ridge, visited health officials and patients in Juarez, Mexico.

February 21, 1984: NRC Commission paper (SECY 84-85), updating information on incident, submitted to the Commission. The NRC Region V report recommending actions was published.

February 23, 1984: The States of New Mexico and Texas formally requested DOE to do aerial surveys and provide border monitoring (see Appendix H).

March 1, 1984: Portable radiation detectors to monitor vehicles and pedestrians were placed by DOE at two of the bridge crossings in El Paso.

March 2, 1984: DOE aerial survey flights began over El Paso, Texas, and parts of New Mexico.

March 4, 1984: NRC Region III surveyed and agreed to unrestricted use of Falcon Products Company facilities in St. Louis, Missouri.

March 12, 1984: U.S. agencies were notified that the Mexican Government had approved aerial survey of the cities of Juarez, Chihuahua, and the highway between.

March 20 through 26, 1984: DOE aerial survey of the Mexican areas.

May 15, 1984: Mexican investigation and cleanup still in progress. U.S./Mexico ports of entry being surveyed for installation of more monitoring equipment.

August 11, 1984: NRC replaced the civil defense detection instruments at 22 border crossings with new "micro R" meters. Portal monitors are on order by NRC to be placed at busier border ports of entry.

APPENDIX B

CONTAMINATED REINFORCING BAR ACCOUNTABILITY

ACCOUNTABILITY OF POTENTIALLY CONTAMINATED REBAR BY STATE

	Arizona	California	Colorado	Nevada	New Mexico	Texas	TOTALS
Total amount of potentially contaminated rebar imported and distributed	~249	<0.1	~3	~22	~10	~647	~931
Amount of steel retrieved to Mexico	~400	<0.1	0	~4	~35	~1048	~1487
Amount of steel surveyed, found contaminated and released	~300	0	N/A	N/A	~25	N/A	~325
Amount of steel from that surveyed that has been incorporated into structures	~33	<0.1	0	~18	~0.1	0	~51
Amount of steel left in structures	~13	0	0	~18	0	0	~31
Amount of steel removed from structures and returned to Mexico	~20	<0.1	0	~0.1	~0.1	0	~20
Amount of steel disposed of by burial in the United States	0	0	0	0	0	0	0
Amount of steel awaiting return to Mexico	0	0	0	0	0	0	0
Total amount of potentially contaminated steel unaccounted for	~5	0	0	0	0	0	~5

Notes: All amounts are in tons (2,000 lbs./ton)
N/A means state did not observe

SUBJECT: ACCOUNTABILITY OF CONTAMINATED STEEL REBAR

BACKGROUND

Since the majority of contaminated rebar has been returned to Mexico and the NRC has entered into a long term monitoring and control program, it is important to try to reconstruct the amount of contaminated rebar that was initially imported to the U.S., amounts received by the various states, amount returned to Mexico, and amount left in place. The estimation of these amounts has been based upon review of NRC records and memoranda and contacts with the steel brokers and state representatives who surveyed and documented the flow of steel during the critical time frame.

Soon after the rebar was discovered, brokerage firms, distributors, representatives from specific states, the Comision Nacional de Seguridad Nuclear Y Salvaguardias (CNSNS) of Mexico, and management personnel of the Mexican steel plant, Aceros de Chihuahua, estimated that 4,000 to 5,000 tons of potentially contaminated steel rebar had been manufactured by the Mexican plant, and about one third of a month's production from the plant (about 500 tons) had been imported to the United States. Approximately 500 tons was imported by two Texas brokerage firms: the Martin Company, who retailed to the IRCA Company and W. Silver Company located in El Paso, Texas, and Free Market Steel located in Phoenix, Arizona; and BAB brokerage company who retailed to a distributor, Kaibab Industries located in El Paso, Texas. These distributors had a varied listing of customers throughout the United States; however, the rebar appeared to have been delivered to the states listed below during the critical period of December 6, 1983, to January 25, 1984.

In the section to follow, the amounts of contaminated steel rebar imported, returned to Mexico, left in place in the various states, or unaccounted for are presented. The amounts tabulated summarize the best knowledge at the present time. A discussion section describes each tabulated line item as to proper interpretation.

ACCOUNTABILITY BY STATE

Determine	Arizona	California	Colorado	Nevada	New Mexico	Texas
1.(a)	~249	<0.1	~3	~22	~10	~647
1.(b)	~400	<0.1	0	~4	~35	~1048
1.(c)	~300	0	N/A	N/A	~25	N/A
1.(d)	~33	<0.1	0	~18	~0.1	0
1.(d)(1)	~13	0	0	~18	0	0
1.(d)(2)	~20	<0.1	0	~0.1	~0.1	0
1.(d)(3)	0	0	0	0	0	0
1.(e)	0	0	0	0	0	0
2.	~5	0	0	0	0	0

Notes: All amounts are in tons (2,000 lbs./ton)
N/A means state did not observe

DISCUSSION

1.(a) The Total Amount of Potentially Contaminated Steel Rebar Imported and Distributed - From the above tabulation, it appears that approximately 931 tons of potentially contaminated steel rebar was imported and distributed to recipients in the United States. The amounts in this tabulated line contain a great deal of duplication since no distinction was made between what had been imported, distributed, redistributed, or received by each recipient. For example: an amount of steel rebar, which was imported to a broker and distributed to a recipient, was reported as imported by the broker and again by the recipient. This double reporting cannot be undone, therefore, these estimates of the amounts importe. will be high.

Another source of error is the use of a variety of units for reporting the amounts of contaminated steel imported and distributed. For example, bundles, bars, long tons were reported which required conversion to U.S. tons or 2000 pounds per ton. The error should be small; i.e., a few percent. The most significant error in the values imported is the double reporting which could, if known and applied, reduce the totals reported to an amount near the earlier estimate of 500 tons.

1.(b) The Amount of Steel Returned to Mexico - This amount includes both contaminated and uncontaminated steel rebar. A distinction was not made between the two in that when contamination was observed in a bundle or pile of rebar, the entire bundle or pile was sent back to Mexico. This introduces a significant error that makes comparison with import quantities indeterminate.

1.(c) The Amount of Steel Surveyed, Found Uncontaminated, and Released - The steel rebar found uncontaminated was released for use in the normal business channels in that state and no further controls were exercised by either the broker, distributor, or the state regulatory agencies.

1.(d) The Amount of Steel From That Surveyed That Has Been Incorporated Into Structures - Arizona personnel observed 66 structures with contaminated rebar. It was estimated that each structure contained approximately 0.5 tons of potentially contaminated rebar. The contaminated rebar was removed from 40 structures. Nevada personnel observed structures containing approximately 18 tons of potentially contaminated rebar.

(1) Left In Place - Arizona has 26 structures containing approximately 13 tons of potentially contaminated steel rebar. Nevada has structures containing approximately 18 tons of potentially contaminated steel rebar.

(2) Returned to Mexico - Arizona was the only state that returned a significant amount of contaminated steel back to Mexico after it had been used in structures.

(3) Disposed of by Burial - Each state regulatory agency reported that no contaminated steel rebar has been disposed of by burial.

1.(e) The Amount of Contaminated Steel Awaiting Return to Mexico - Personnel from Colorado indicated that approximately three tons of contaminated steel had been sent to Texas for return to Mexico; however, personnel from Texas indicated that all contaminated rebar had been returned to Mexico including approximately 3 tons from Colorado. The brokers and other states reported no contaminated steel awaiting return to Mexico.

2. The Total Amount of Potentially Contaminated Steel Remaining Unaccounted For - Arizona estimated that about five tons are unaccounted for due to the apparent result of companies dealing independently with Mexico through the six border crossings at San Luis, Douglas, Nogales, Naco, Lukeville, and Sasabe. This estimate is rough and little confidence can be placed in it.

CONCLUSION:

Based upon records and interviews with state regulatory personnel, it appears that only rough estimates of amounts of contaminated steel imported and returned to Mexico can be made. The amounts imported appear to range between 500 and 931 tons, with the 500 tons value more likely due to double reporting. The amounts returned cannot be used in a material balance since the shipments contained both contaminated and uncontaminated steel. It is concluded that all potentially contaminated rebar exported to the U.S. during the time period in question has been returned to Mexico, except for about 31 tons incorporated into structures in Arizona and Nevada and the possibility of a few tons unaccounted for in Arizona.

APPENDIX C

ORGANIZATION OF TABLE BASE SURVEYS

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

February 7, 1984

SUBJECT: NOTIFICATION OF AND REQUEST TO SURVEY FOR POTENTIAL RADIOACTIVE CONTAMINATION IN TABLE BASES

Between November 9, 1983 and January 29, 1984, approximately 4,000 customers throughout the United States received cast iron table bases and parts which may be contaminated with cobalt-60. The contaminated parts were cast at a Mexican facility (Falcone de Juarez) and subsequently distributed by Falcon Products, Inc. of St. Louis, Missouri to recipients in the United States.

The table bases were cast using scrap metal apparently contaminated with cobalt-60 from a medical therapy device. The cobalt-60 is non-uniformly distributed throughout the castings, with reported radiation levels of 25 micro-R per hour to a maximum of 300 milli-R per hour on contact.

By way of this letter, appropriate State agencies are requested to assist in the performance of radiation area surveys and in arrangement for isolation of contaminated table parts distributed to customers in their respective States. (An updated listing of customers receiving potentially contaminated parts is enclosed.)

You will note that the list contains names of the companies which the material was sold to and sent to. In many cases, distributors are involved in the sales process. In such cases you will need to check and followup any redistribution or subsequent sales.

Upon identifying contaminated parts, the states are requested to contact Falcon Products (314/991-9200) for instructions on the return of the material to their facility in St. Louis, Missouri. It is also requested that the appropriate NRC Regional Office be informed of survey results.

Enclosed is survey criteria and techniques to assist your staff. Further information may be obtained by contacting your respective NRC Regional Office.

The NRC does not presently plan to generally release the identity of the customers on the Falcon list and is disseminating the list only to those with a need-to-know. Since we expect that most of these customers will turn out not to have contaminated table legs, we request that you also restrict dissemination of the customer list to those with a need-to-know.

We appreciate your support in the performance of these surveys. If you are unable to perform these surveys please notify the appropriate NRC Regional Office.

Sincerely,

A Bert Davis

for James G. Keppler
Regional Administrator

Enclosures:
Preliminary Notification No. RIII-84-11B
Proposed Press Release
Survey Criteria and Techniques

SURVEY CRITERIA AND TECHNIQUES FOR FALCON PRODUCTS TABLE BASES

The following procedure is recommended when conducting surveys of potentially contaminated table bases:

1. Contact the customer by telephone and schedule a survey. Customers may or may not be aware of the potential problem and survey schedule times should be flexible and agreed upon with the customer.

2. Some customers may be dealers and as such may have sold the product to others. If possible, try to contact these customers and schedule a survey.

3. Perform contact surveys with a properly calibrated micro-R meter. Open boxes if necessary and ensure entire surface of table bases are surveyed. Consider the material contaminated if readings are above background. Measurements should be made by persons sufficiently familiar with the use of micro-R meters so that proper interpretations can be made between materials that are likely to be contaminated and normal variations in background and variations due to instrument instability.

4. Falcon Products believes the most critical time interval of December 22, 1983, to January 25, 1984, should be surveyed first. It is unlikely that contaminated table bases will be found from shipments made in November (1983) and late January (1984). However, it is recommended to survey these customers after completion of the critical time interval.

5. Contamination is assumed for radiation levels which are greater than background. Recent contact surveys have shown that the cobalt-60 is non-uniformly distributed, with radiation levels ranging from 25 μR/hr (greater than background) to 300 mR/hr.

6. Possessors of contaminated table bases should be instructed to isolate and secure such bases pending pickup and to notify Falcon Products of St. Louis, Missouri at 314/991-0200. Falcon Products has agreed to pick up the contaminated material and replace it. A special waiver of Department of Transportation regulations has been granted to Falcon Products to allow them to pick up and transport this material back to the St. Louis, Missouri warehouse.

7. According to Falcon Products, the table bases consist of three parts--a cross-shaped or circular base, a tubular post, and a fingered connector which attaches the base to a table top. The bases come in various sizes--the weight of the bottom piece ranges from 15 to 40 pounds. All the segments are gray cast iron. Most have been painted black, but other colors have been used as well.

   Each base has a series of numbers and letters on its underside. All of the number-letter sequences used by Falcon Products include the letter "F" There is no other marking identifying the table bases, although the shipping containers are marked "Falcon Products, Inc."

8. Records of survey results should be maintained and include as a minimum:

   a. Name, address and telephone number of the customer (facility, restaurant, warehouse, etc.).

   b. Name of person or agency performing the survey.

   c. Type(s) of survey instrument used.

   d. Results of survey.

   e. Survey comments (e.g., specific area of high contamination, location of table base within facility, length of time customer possessed table base, etc.).

9. Inspection results should be provided to the appropriate NRC representatives indicated below:

Region I	John Kinneman	215/337-1252
Region II	John Potter	404/221-5571
Region III	Darrel Wiedeman	312/790-5616
Region IV	Robert J. Everett	817/860-8187
Region V	Robert Thomas	415/943-3763

BREAKDOWN OF FALCON PRODUCTS RECIPIENTS
BY STATE
THIS INFORMATION IS BEING MADE PUBLICLY AVAILABLE

ALASKA	2	MONTANA	7
ALABAMA	9	NORTH CAROLINA	21
ARKANSAS	9	NORTH DAKOTA	1
ARIZONA	9	NEBRASKA	15
CALIFORNIA	46	NEW HAMPSHIRE	5
COLORADO	22	NEW JERSEY	18
CONNECTICUT	7	NEW MEXICO	1
D.C.	6	NEVADA	4
DELAWARE	1	NEW YORK	17
FLORIDA	91	OHIO	85
GEORGIA	34	OKLAHOMA	23
HAWAII	1	OREGON	5
IOWA	16	PENNSYLVANIA	63
IDAHO	3	RHODE ISLAND	5
ILLINOIS	53	SOUTH CAROLINA	16
INDIANA	37	TENNESSEE	42
KANSAS	6	TEXAS	91
KENTUCKY	13	UTAH	7
LOUISIANA	23	VIRGINIA	27
MASSACHUSETTS	18	VERMONT	5
MARYLAND	23	WASHINGTON	24
MAINE	5	WISCONSIN	24
MICHIGAN	19	WEST VIRGINIA	5
MINNESOTA	40	SOUTH DAKOTA	3
MISSOURI	50		
MISSISSIPPI	12		

APPENDIX D

SOURCE DESCRIPTION

Texas Department of Health

Robert Bernstein, M.D., F.A.C.P.
Commissioner

1100 West 49th Street
Austin, Texas 78756
(512) 458-7111

Radiation Control
(512) 835-7000

Robert A. MacLean, M.D.
Deputy Commissioner
Professional Services

Hermas L. Miller
Deputy Commissioner
Management and Administration

February 13, 1984

Mr. Robert J. Doda
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011

Dear Bob,

Attached are copies of records obtained from X-Ray Equipment Company and Bailey Mora Brokers concerning the transfer of the Cobalt-60 teletherapy unit to Doctor Lemus in Juarez, Mexico. In addition, I am including a copy of correspondence from Mr. Norm Kelbley of Advanced Medical Systems, Inc. Based on his data of 46.23 grams of 1mm X 1mm Cobalt-60 metal pieces and his earlier statement that there were 130 metal pellets per gram, there should have been 6,010 pellets.

If you have any questions, please contact me.

Sincerely,

Richard A. Ratliff, P.E., Director
Division of Compliance and Inspection
Bureau of Radiation Control

Enclosures

U.S. DEPARTMENT OF COMMERCE · BUREAU OF THE CENSUS

SHIPPER'S EXPORT DECLARATION

OF SHIPMENTS FROM THE UNITED STATES

Export Shipments Are Subject To Inspection By U.S. Customs Service and/or The Office of Export Control

READ CAREFULLY THE INSTRUCTIONS ON BACK TO AVOID DELAY AT SHIPPING POINT

Declarations Should be Typewritten or Prepared in Ink

CONFIDENTIAL - For use solely for official purposes authorized by the Secretary of Commerce. Use for unauthorized purposes is not permitted. (Title 15, Sec. 30 C.F.R., Sec. 7(c) Export Administration Act of 1969, as amended, P.L. 91-184)

Authentication (When required)

FILE NO. (For Customs use only.)

Do Not Use This Area	District	Port	Country	(For customs use only)
	24	02	201	

1. FROM (U.S. Port of Export): EL PASO, TEXAS

2. METHOD OF TRANSPORTATION (check one): ☐ Vessel ☐ Air ☒ Other (Specify) (INCL. FERRY) TRUCK

2a EXPORTING CARRIER (If vessel, give name of ship, flag and pier number. If air, give name of airline.)
TRUCK

3. EXPORTER (Principal or seller — licensee): [illegible] CO.,R — ADDRESS (Number, street, place, state): 904 906 [illegible] AVE. FORT WORTH TEXAS

4. AGENT OF EXPORTER (Forwarding agent): RUDOLPH MILES & SONS, INC. — ADDRESS (Number, street, place, state): 800 S. SANTA FE STREET, EL PASO, TEXAS 79901

5. ULTIMATE CONSIGNEE: [illegible] — ADDRESS (Place, country): [illegible] AVE. DE LAS [illegible] CD. JUAREZ CHIH MEXICO

6. INTERMEDIATE CONSIGNEE — ADDRESS (Place, country)

7. FOREIGN PORT OF UNLOADING (For vessel and air shipments only)

8. PLACE AND COUNTRY OF ULTIMATE DESTINATION (Not place of transshipment): CD. JUAREZ CHIH MEXICO

(9) MARKS AND NOS.	(10) NUMBER AND KIND OF PACKAGES, DESCRIPTION OF COMMODITIES, EXPORT LICENSE NUMBER, EXPIRATION DATE (OR GENERAL LICENSE SYMBOL)	(11) SHIPPING (Gross) WEIGHT IN POUNDS	(12) "D" or "F"	(13) SCHEDULE B COMMODITY NO.	(14) NET QUANTITY IN SCHEDULE B UNITS	(15) VALUE AT U.S. PORT OF EXPORT
61350						
[illegible]	13 PCS. & 1 BDLE. CONT:					
	USED PICKER C3000 COBALT PUMP W/10083					
	CURIES OF COBALT 60, AND SOURCE DIAMETER					
	OF 2 CMS. [illegible] COBALT SOURCE IS					
	DOUBLE ENCAPSULATED C [illegible] (4)		D	726.2015	-	16,[illegible]

These commodities licensed by U.S. for ultimate destination .... MEXICO .... Diversion contrary to U.S. law pro[hibited]
VALIDATED LICENSE NO. OR GENERAL LICENSE SYMBOL

16. BILL OF LADING OR AIR WAYBILL NUMBER

17. DATE OF EXPORTATION (Not required for shipments by [illegible]): 11/14/77

18. THE UNDERSIGNED HEREBY AUTHORIZES ______ (Name and address—Number, street, place, State) TO ACT AS FORWARDING AGENT FOR EXPORT CONTROL AND CUSTOMS PURPOSES.

EXPORTER ______ BY (DULY AUTHORIZED OFFICER OR EMPLOYEE) ______

19. I CERTIFY THAT ALL STATEMENTS MADE AND ALL INFORMATION CONTAINED IN THIS EXPORT DECLARATION ARE TRUE AND CORRECT. I AM AWARE OF THE PENALTIES PROVIDED FOR FALSE REPRESENTATION. (See Paragraphs I (c), (e), on reverse side)

Signature [signature] For RUDOLPH MILES & SONS, INC.
(Duly authorized officer or employee of exporter or named forwarding agent) (Name of corporation or firm, and capacity of signer, e.g., export manager, etc.)

Address 800 S. SANTA FE STREET, EL PASO, TEXAS 79901

Declaration should be made by duly authorized officer or employee of exporter or forwarding agent named by exporter.
a. If shipping weight is not available for each Schedule B item listed in column (13) included in one or more packages, insert the approximate gross weight for each Schedule B item. The total of these estimated weights should equal the actual weight of the entire package or packages.
b. Designate foreign merchandise (reexports) with an "F" and exports of domestic merchandise produced in the United States or changed in condition in the United States with a "D" (See instructions on reverse side.)

Do Not Use This Area

INVOICE

X «RAY EQUIPMENT COMPANY

Invoice No. 13369

804-806 PENNSYLVANIA AVE., P. O. BOX 2431 • (817) 336-3461 • FORT WORTH, TEXAS 76101

INVOICE DATE

October 26, 1977

SOLD TO

Dr. Abelardo Lemus
Centro Medico
Avenida De Las Americus
Cuidad Juarez, Mexico

SHIPPED

OUR ORDER NO.	YOUR ORDER NO.	SALESMAN	TERMS	SHIPPED VIA	PREPAID

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	Used Picker C-3000 BOMBA de COBALTO with 1003 Curies of Cobalto 60, and Source diameter of 2 Centimeters. Cobalto Source is double Encapsulated. Stand Ser.# 1365E Style and Ser.#111 Cobalto de Bomba Style and Collimator 3347B Ser.# 153 Una Bomba de Cobelto completa con sus accesorios Marca "PICKER" Estilo 1365, Serie 111, Estilo 3347B, Serie 153. Approximate weight of above equipment is 6800 pounds, less skid weights. UN ATADO Y 13 Bultos 6,800 Lbs. Price of the above Cobalto de Bomba delivered to El Paso, Texas is ----------U.S. Dollars----------		$16,0
	*Traduccion Formulada por el Agte. Aduanal JAIME R. MORA		

Clyde D. Peabody

TELETHERPY SOURCE TRANSFER

This is to certify that a Cobalt 60 Teletherapy source:
Model P3802A
Containing 2855 curies as of Sept. 15, 1977
(from Methodist Hospital Lubbock, Texas)
Ser.# not known because Methodist Hospital
did not supply X-ray Equipment Co. with a
source certificate from orginal supplier
(Picker X-ray Corp.)

The above source is hereby transferred from X-ray Equipment Co.
Texas license TXS-1485 to a Dr. Abelardo Lerus Centro Medico
Avenida De Las Americus Ciudad Juarez, Mexico, Mexico license
number Y Assistencia #31532

Cedula Registrada Professional #142478

X-ray Equipment Co.
Clyde D. Peabody

RADIOACTIVE SHIPPING RECORD

SHIPPED FROM

Methodist Hospital
Lubbock, Texas

SHIP TO

Dr. Arlinda Lewis
[illegible], New Mexico D.F

CARRIER(S) X-Ray Express, Inc. R.A.M. LICENSE NO. TX-5-1415

DESCRIPTION RADIOACTIVE MATERIAL, SPECIAL FORM, N.O.S., RADIOACTIVE MATERIAL, NA 9182

ISOTOPE Co^{60} CONTAINING 2255 CURIES AS OF Sept. 27 (DATE)

TRANSPORT GROUP III TRANSPORT INDEX 5 NO. OF PACKAGES 1

QUANITY: TYPE __A ✓B __LARGE PACKAGE __A —B

PACKAGE IDENTIFICATION

INNER CONTAINER - D.O.T. SPECIFICATION NUMBER Spec. 6M

OVERPACK - D.O.T. SPEC. NO. 20WC-6 IAEA CERTIFICATE USA/5100/B

GROSS WEIGHT 6000 LBS.

LEAK TEST

_____ DPM/100 cm^2 PER _____ DATE _____

✓ NOT REQUIRED - CLEAN FACILITY, LEAK TIGHT SOURCE

SURVEY

METER Ludlum 14C CALIBRATION DATE _____

DOSE RATES - MR/HR - AT CONTACT 7 3 FEET FROM CONTAINER 5

6 FEET FROM CONTAINER 1 CAB OF TRUCK 4 0.5 Max C

TAMPER SEALS

IN PLACE ✓ YES _____ NO _____ NOT REQUIRED _____ SEAL NO

CERTIFICATION THIS IS TO CERTIFY THAT THE ABOVE NAMED MATERIALS ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED, AND LABELED, AND ARE IN PROPER CONDITION FOR TRANSPORTATION ACCORDING TO THE APPLICABLE REGULATIONS OF THE DEPARTMENT OF TRANSPORTATION.

SIGNED [signature] DATE Oct 24 77

COMPANY _____ (SHIPPER)

DATE OF SHIPMENT _____

Advanced Medical Systems, Inc.
1020 London Road
Cleveland, OH 44110
(216) 692-3268

February 7, 1984

Richard Ratliff
Texas Department of Health
Bureau of Radiation Control
1100 W 49 Street
Austin, Texas 78756

Dear Mr. Ratliff,

In response to your telephone call concerning the Picker C-1000 unit involved in the Mexico incident, we are forwarding the information you requested.

The source, as informed by you was a picker source serial number PX-745 (originally shipped to Methodist Hospital, Lubbock, Texas).

The source was a 2.0 cm diameter containing 46.23 grams of 1 mm x 1 mm Cobalt 60 metal pieces. The curies were 2855 on September 15, 1969.

If further assistance is needed please contact us.

Sincerely,

Norman D. Kelbley
Manager, London Road Operations

3 encl

SECTION 1

I N T R O D U C T I O N

1.A - GENERAL DESCRIPTION

The source of radiation in this equipment is the Radioactive Isotope Cobalt-60. The use of Cobalt-60 brings to the radiologist all the advantages of super-voltage radiation without the inconvenience and cost of a high voltage generating system.

This new teletherapy apparatus incorporates exact methods for beam direction and field localization providing closely controlled accuracy coupled with a high degree of flexibility for application.

The Picker Cobalt-60 C-3000 Unit is designed to precisely control and direct the gamma radiation from Cobalt-60. The Cobalt-60 is contained in a sealed capsule, which in turn is mounted on a cylinder embedded in an 18-1/4 inch protective lead and tungsten sphere. The radiation beam is turned off or on by rotating the cylinder, moving the source to either a safe position at the center of the sphere or adjacent to an aperture in the sphere. With the source in the "ON" position, radiation passes through the aperture and through a precision beam collimator which provides continuous adjustment of the field size. The entire head and collimator assembly is suspended on a stand capable of moving and tilting the head as required to set up a therapeutic treatment.

The following principles of operation will provide a fuller understanding of the features of this equipment.

1.B - PRINCIPLES OF OPERATION

1.B.1 SOURCE OF RADIATION

Cobalt-60 is a radioactive metal, manufactured by bombarding ordinary cobalt metal with neutrons in an atomic reactor. The usual source is a cylinder from 1.0 to 2.0 cm in diameter made up of a number of thin wafers, or of closely packed pellets. As a result of the high temperature and intense neutron flux to which the metal is exposed in the reactor, there can be a certain amount of flaking and oxidation of the surface of the cobalt. To prevent escape of this radioactive dust, the cobalt metal is placed in a capsule which has double welded seals. The capsule (see Figure A) is of heavy wall tungsten alloy except for a thin stainless steel window in each capsule container. The capsule serves four purposes:

a. It prevents escape of radioactive matter.

b. The tungsten walls add to the radiation protection.

c. The thin window stops beta radiation from the source but transmits readily the gamma radiation.

d. The external threads provide a means of holding the source in the head.

The radiation from Cobalt-60 consists of two (2) gamma ray lines of 1.17 Mev and 1.33 Mev emitted in equal quantities as Cobalt-60 decays to Nickel-60. The half-life of the material is 5.3 years. The head of the teletherapy unit will safely accommodate sources delivering up to 165 r/minute at 55 cm.

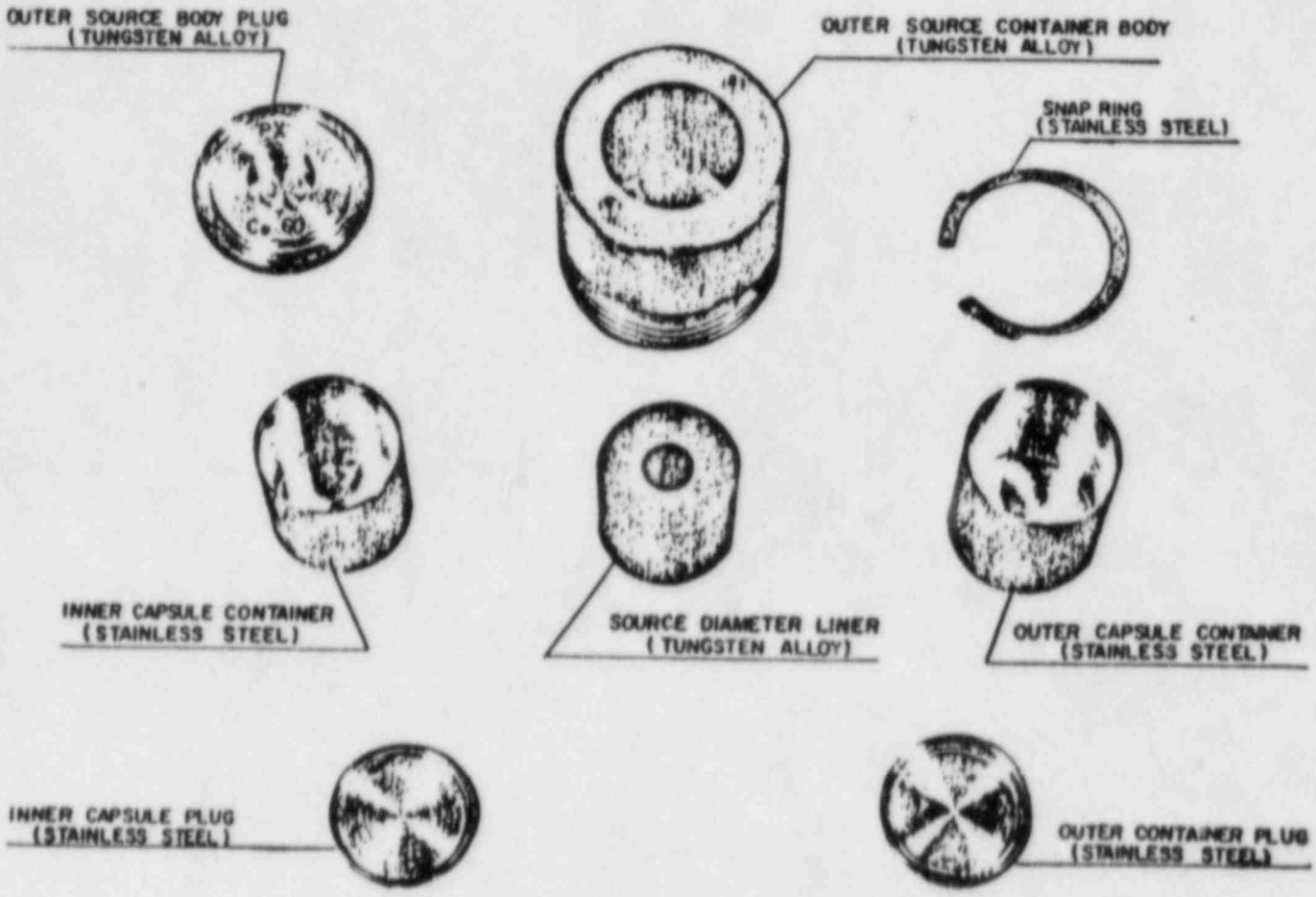
1.B.2 HEAD AND SHUTTER

The head and control switches are illustrated in Figure 10. The source capsule is housed inside the head in a cylinder made of lead, tungsten, and stainless steel. The cylinder is mounted in the head with its shaft extending out into the shutter drive, see Figure 12. The shaft of the cylinder is below center in the head; i.e., it is nearer the collimator side of the head than it is to the rounded top of the head. When the radiation beam is turned "OFF" the cylinder is rotated until the source is brought to the exact center of the head where it is completely surrounded by lead and tungsten, except in the direction of the aperture in the head. In this direction the radiation is blocked by a solid tungsten rod which is a part of the shutter cylinder. To turn the radiation "ON", the cylinder is rotated 180 degrees from its "OFF" position bringing the source adjacent to the aperture in the bottom of the head. The radiation is then free to pass through this opening out into the collimator.

The cylinder is turned by a geared motor shutter drive through a vee belt from the "OFF" to the "ON" position, winding up a heavy clock spring as it goes. In the "ON" position, the motor stops while pulling against the force of the coiled-up clock spring. If electrical power is interrupted or turned off from the control, the motor ceases to exert force and the spring returns the cylinder to the "OFF" position. The return to "OFF" position requires the cylinder to turn 180 degrees, but only during 20 degrees is any significant amount of radiation coming out. Thus the sum of the effective shutter opening and closing times is only a little over one (1) second. In case of failure of the shutter to close, the hand wheel just forward of the head cover can be turned in the closing direction.

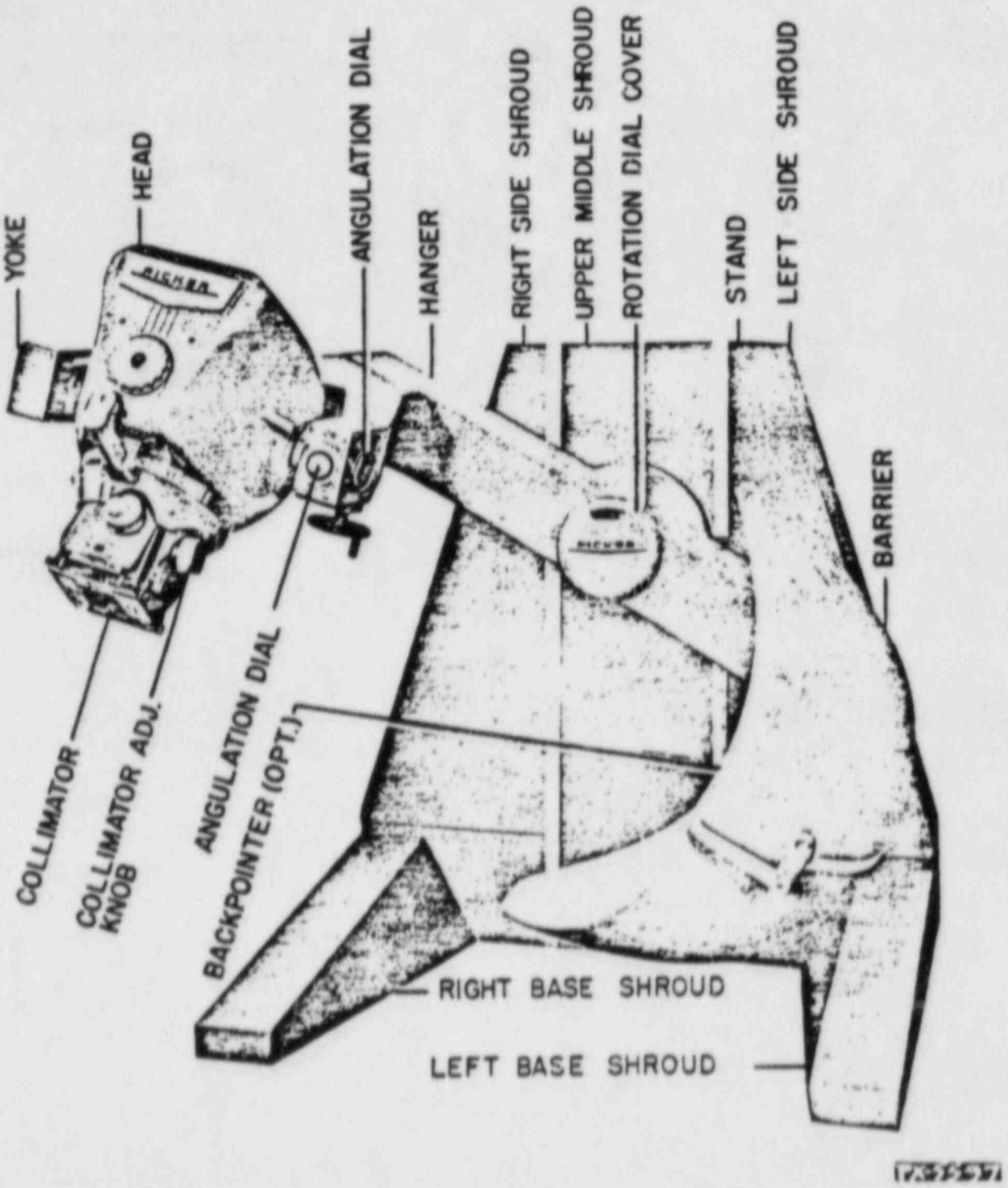
1.B.3 BEAM COLLIMATOR

The collimator is shown in Figure 19. The collimation of cobalt radiation presents a difficult problem because of its high energy, and because of the relatively large area of the face of the source. Experiment shows that a distance of 15 to 20 cm between the last diaphragm and the skin is necessary to minimize scattered electrons in the beam, but this distance coupled with a large diameter source and a relatively short SSD (source-to-skin-distance) usually means that a


OUTER SOURCE BODY PLUG
(TUNGSTEN ALLOY)
OUTER SOURCE CONTAINER BODY
(TUNGSTEN ALLOY)
SNAP RING
(STAINLESS STEEL)
INNER CAPSULE CONTAINER
(STAINLESS STEEL)
SOURCE DIAMETER LINER
(TUNGSTEN ALLOY)
OUTER CAPSULE CONTAINER
(STAINLESS STEEL)
INNER CAPSULE PLUG
(STAINLESS STEEL)
OUTER CONTAINER PLUG
(STAINLESS STEEL)

TSS-286

FIG. A



T55-286

FIG. 19

PICKER INTERNATIONAL

595 MINER ROAD
HIGHLAND HEIGHTS OHIO 44143
(216) 449-3000

October 22, 1982

Dr. S. S. Stein, Ph.D.
Advanced Medical Systems
621 Factory Row
Geneva, Ohio 44041

Dear Dr. Stein:

We evaluated the integrity of the Picker C-3000 Teletherapy units, Catalog Nos. 6183 and 6204 earlier this year. This evaluation was undertaken because we had received a report of unusual noises emanating from the C-arm and reports of cracking around the hub of the "C".

The evaluation included an examination and report by Massachusetts Materials Research, an accelerated cycle test and a careful review and examination of past history of the product. Based on the information gathered, we have concluded that this series of machines must be scrapped when removed from service. This decision was made based on the facts that the newest machine is 18 years old, the cracking is due to metal fatigue, the audible noises appear to be caused by internal metal stresses and new areas of cracking not previously observed.

Since the cracking is due to metal fatigue and it has been observed in areas not previously observed, we believe internal stresses are causing fatigue on internal structural components in the hub area. Because fatigue failures are very difficult to predict accurately and because a fatigue failure in the C-arm structure would be catastrophic in nature, repair of the C-arm is impossible.

The C-arm and barrier weigh nearly 3000 pounds and, therefore, if a catastrophic failure occurred in the C-arm, either one of these components could cause a lethal injury to anyone in the near vicinity of the machine.

Please be advised that any C-3000 Teletherapy units removed from service by AMS should be scrapped. We are also sending this notice to X-Ray Equipment Company, Fort Worth, Texas. and Neutron Products, Inc., Dickerson, Maryland.

Thank you.

Very truly yours,

K. J. Dragmen
Senior Product Review Engineer

KJD/r

APPENDIX E

U.S. NUCLEAR REGULATORY COMMISSION GUIDANCE

GUIDANCE ON RADIATION LEVELS ASSOCIATED WITH COBALT-60 CONTAMINATED REINFORCING BAR

This guidance has been prepared to assist federal and state authorities in assessing radiological health acceptability of structures utilizing reinforcing bar (rebar) steel contaminated with cobalt-60 in the concrete. The cobalt-60 contaminated rebar was recently imported from Mexico.

Primary Guidance

1. 10 CFR 20 Standards for Protection Against Radiation is not directly applicable to this situation, although it is intended to maintain exposure to individual members of the public within 500 mrem per year from licensed operations.

2. ICRP Report 26 recommends a limit of 500 mrem per year to individual members of the public exclusive of background radiation and medical irradiation. This limit is established with the expectation that the average annual lifetime dose to such individuals will not exceed 100 mrem per year.

3. 40 CFR 192 -- Health and Environmental Protection Standards for Uranium Mill Tailings, a portion of which pertains to remedial actions for gamma radiation in buildings [§192.12(b)(2)], states that gamma radiation shall not exceed the background level by more than 20 μR/hr. This is intended to maintain doses within 130 mrad per year assuming an occupancy factor of 0.75. Considering the similarity of the radiation exposure due to cobalt-60 contaminated rebar in residences and other structures to requirements for control of exposure from Radium-226 in 40 CFR 192, 130 mrad per year is established as the primary guidance level for this purpose. This level should, in most circumstances, maintain doses within 500 mrem per year from all sources of radiation as recommended by ICRP and, considering the 5.2 year half-life of cobalt-60, not likely cause the average annual lifetime dose to exceed 100 mrad per year.

Secondary Guidance

1. Levels of radiation in areas which can be occupied.

   A radiation level not exceeding 20 μR/hr above background with an assumed occupancy factor of 0.75 may be used to demonstrate that exposure will be within 130 mrad/yr. Radiation levels would normally be measured at one meter above the surface. If radiation levels exceed 20 μR/hr in some locations, refined assessments will be necessary to ensure the primary guidance is met. If measurements are made on structures with recently poured cement, sufficient time should be allowed for the cement to dry before final measurements are made. Occupancy factors and radiation levels can be adjusted to more closely fit the real situation. The following occupancy factors are suggested: 0.75 for residences, 0.4 for commercial buildings, and 0.1 for structures such as bridges (The last intended mainly for protection of maintenance workers.).

2. Rebar in place but concrete not yet poured.

   In certain situations rebar will be in place but concrete not yet poured and the rebar cannot be removed without undue expense. The following guidance might be used to estimate levels of radiation in occupied areas following pouring of concrete. In such situations, however, persons should be advised that only crude estimates can be made about the actual levels of radiation once the concrete is poured, and that it might be advisable to replace the rebar before pouring the concrete. This is particularly true for situations where dose estimates might be close to the boundaries provided in guidance.

   To determine whether or not the 20 μR/hr level would be met prior to pouring concrete into a rebar grid, adjustments to the basic guidance can be made. For example, if a minimum of 4 inches of concrete is to be poured above a horizontal rebar grid, the level should not exceed 40 μR/hr prior to pouring concrete. If 8 inches of concrete is to be poured above the rebar grid, the level should not exceed 200 μR/hr prior to pouring concrete.[1/] Radiation levels would normally be measured at one meter above the rebar grid.

1/ In buildings with reinforced concrete ceilings or roofs, the thickness of concrete under the rebar may be important.

   For attenuation of cobalt-60 gamma radiation, it is assumed that 4 inches of ordinary concrete (ρ=2.3) will reduce the dose rate by a factor of two, and that 8 inches of concrete will reduce the dose rate by a factor of ten. The effect of other thicknesses can be estimated from references such as the Radiological Health Handbook.

FEB 23 1984

GUIDANCE ON DISPOSAL OF CONCRETE CONTAINING COBALT-60
CONTAMINATED REINFORCEMENT BARS (REBAR) REMOVED FROM STRUCTURES

This guidance has been prepared to assist federal and state authorities in providing a suitable method for disposing of concrete containing cobalt-60 contaminated rebar. It applies only to cobalt-60 contaminated rebar imported from Mexico in late 1983 and early 1984 and only to concrete containing such rebar that has been removed from structures for radiation control.

Relevant Precedent for Control of Radiation Dose to the Public

1. 10 CFR 20 Standards for Protection Against Radiation is not directly applicable to this situation, although it is intended to maintain exposure to individual members of the public within 500 mrem per year from licensed operations.

2. ICRP Report 26 recommends a limit of 500 mrem per year to individual members of the public exclusive of background radiation and medical irradiation. This limit is established with the expectation that the average annual lifetime dose to such individuals will not exceed 100 mrem per year.

3. Nuclear Regulatory Commission's, "Guidelines for Decontamination of Facilities and Equipment Prior to Release and Unrestricted Use or Termination of Licenses For Byproduct, Source or Special Nuclear Material," provides guidelines for surface contamination resulting from beta-gamma emitters. The guideline radiation levels that should not be exceeded are an average of 0.2 mrad/hr at 1 centimeter and a maximum of 1.0 mrad/hr at 1 centimeter.

4. Nuclear Regulatory Commission's Uranium Fuel Licensing Branch's, "Technical Position on Disposal or Onsite Storage of Residual Thorium or Uranium from Past Operations," (SECY-81-576), provides guidelines for control of dose to members of the public resulting from onsite disposal of residual thorium or uranium. They are intended to maintain radiation levels, measured at one meter, less than 10 μR/hr above background and exposure to individual members of the public within 35 mrem/yr.

5. Environmental Protection Agency's proposed guidance on "Dose Limits for Persons Exposed to Transuranium Elements in the General Environment" recommends dose limits to organs equivalent to about 10 mrem/yr effective whole-body dose to individual members of the public.

Although items 3-5 above are not directly applicable to disposal of cement containing cobalt-60 contaminated rebar, they do provide guidance on radiation levels and dose which have withstood some tests of acceptability for members of the public.

Assumptions

1. Based on present data, rebar embedded in concrete in structures under construction has not caused radiation levels to exceed 100 μR/hr at one meter (telecon - C. Tedford to R. E. Cunningham, February 21, 1984).

2. When removed from a structure, much of the contaminated rebar remains bound in a concrete matrix and is considered unsalvagable rubble not suitable for recycle.

3. Dose avoidance by disposal at a licensed radioactive waste disposal site is likely to be small in comparison to other methods of disposal and the cost high. Also, disposal at a licensed site would consume scarce existing radioactive waste disposal capacity.

4. The contaminated rubble placed in a landfill or centralized dump will subsequently be covered, and there is little potential for residential use at the specific disposal location for approximately 10 years.

5. Disposal of contaminated rebar rubble in a landfill or centralized dump is not likely to cause subsequent dose to individuals to exceed a small fraction of dose guidance in items 1 and 2 above and is within dose guidance in Items 4 and 5 above. This assumption is based on consideration of levels of radiation previously measured from contaminated rebar, low occupancy factors in the disposal area for a few years, and shielding provided by cover. (Assumes radiation levels from rebar rubble $\leq$ 100 μR/hr at 1 meter; occupancy factor $\leq$ 0.02; shielding attenuation factor due to cover $\leq$ 0.5.) Also, the nature of the contamination makes it unlikely that measurable leaching of the contaminant will take place during the period of significant decay.

Guidance

Based on the above considerations and assumptions, it is concluded that:

1. Disposal of contaminated cobalt-60 rebar rubble in a covered landfill or centralized dump, with little potential for residential use for approximately 10 years, can be performed with adequate protection of the public health and safety; the added risk from exposure is very small; and such a disposal method is feasible and economically practical.

2. Once emplaced in such a landfill or dump, no further control is necessary for purposes of radiation protection.

If the assumptions stated above for a particular case do not appear to be valid, then refined assessments will be necessary.

FEB 17 1984

MEMORANDUM FOR: Leonard I. Cobb, Chief
Safeguards & Materials Programs Branch
Division of Quality Assurance, Safeguards
and Inspection Programs, IE

FROM: Peter Loysen
Advanced Fuel and Spent Fuel Licensing Branch
Division of Fuel Cycle and Material Safety, NMSS

SUBJECT: RETURN OF COBALT-60 CONTAMINATED STEEL PRODUCTS TO MEXICO

The Office of International Programs (IP) has asked for Mexico's approval of instructions which NRC would issue to United States purchasers of contaminated steel for return to Mexico. This approval is primarily for Mexican customs purposes and the instructions do not deal with specific levels of contamination or radiation from the contaminated steel. When approval is obtained, we recommend that all contaminated steel be included in the return program, regardless of contamination level. In other words, no attempt should be made to sort out low contamination steel for use. This of course does not apply to contaminated rebar that has already been installed and for which guidance was provided by Richard E. Cunningham's memorandum of January 27, 1984; nor does it apply to rebar embedded in concrete removed from structures.

To assist in preparing shipping papers and labels for return shipment, information developed by our Transporation Certification Branch can be used for estimating the curie content of bundles of rods. For a typical 4000-pound bundle of 3/8", 1/2" or 5/8" diameter, 20-foot long rods, a radiation level of 10 mR/hr above background at one meter from the mid-point of the side of a bundle would conservatively contain about 1.25 curies of cobalt-60, assuming uniform distribution. Although there is no convenient way to deal with non-uniform distribution of cobalt-60, taking the measurement one meter from the surface of the bundle will help to minimize errors in the estimates. Care should be taken to avoid radiation from other bundles of rebar at the location when measurements are made. The 10 mR/hr per 1.25 Ci can be scaled linearly.

For bundles of rebar that are already loaded on a truck, the bundles need not be removed for individual measurement, but some adjustments in the estimation of curie content are necessary to account for additional attenuation. If the bundles are in one layer on the truck bed, the radiation level at one meter above the center may be used as before to estimate the curie content of the load (or divided by the number of bundles to get the curie content per bundle). If the bundles are in two layers, the curies per mR/hr at 1 meter from the center for the load should be increased by a factor of 1.9, three layers by a factor of 2.8.

Original signed by
Peter Loysen

Peter Loysen
Advanced Fuel and Spent Fuel
Licensing Branch
Division of Fuel Cycle and
Material Safety, NMSS

Distribution:

FC Central File	FSturz	PLoysen
NMSS R/F	JLaFleur, IP	CEMacDonald
FCAF R/F	DNussbaumer, SP	
JPartlow	RECunningham	

APPENDIX F

SAMPLING OF NEWS COVERAGE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
Office of Public Affairs
Washington, D.C. 20555

No. 84-20
Tel. 301/492-7715

FOR IMMEDIATE RELEASE
(Wednesday, February 8, 1984)

NRC STAFF REQUESTING STATE ASSISTANCE IN CHECKING POTENTIALLY RADIOACTIVE TABLE BASES

The Nuclear Regulatory Commission staff is requesting the assistance of state health departments and other agencies in checking potentially radioactive metal table bases which were manufactured in a Mexican foundry and distributed by a St. Louis, Missouri, firm.

The cast iron table bases were distributed by Falcon Products, Inc., of St. Louis between about December 10, 1983, and January 25, 1984, when the potential contamination problem was discovered.

Falcon Products indicated the bases were manufactured beginning December 10, 1983, by Falcone de Juarez of Juarez, Mexico, and some of the scrap metal used in the castings has been found to have radioactive contamination. The source of the radioactive contamination is believed to be a medical radiation therapy device (with a cobalt 60 radiation source) which was among scrap metal obtained from a Mexican scrap dealer's yard. Some of the contaminated scrap iron was also used by another Mexican foundry to produce reinforcing steel bars used in construction.

The radioactive cobalt contamination is fixed in the metal and cannot be spread beyond the table base.

The NRC staff believes that the use of any of the contaminated table bases constitutes unnecessary radiation exposure and therefore should be avoided. As a result, the NRC staff is advising that table bases with detectable radiation (above natural background levels) not be used. Falcon Products has indicated it will replace any of its products which are found to be radioactively contaminated.

Falcon Products has determined that 1500 customers received its table bases during the time period from December 10 1983, through January 25, 1984. The listing of these customers is being provided by the NRC to state agencies with the request that state personnel check the table bases for possible contamination.

Customers receiving the table bases are located throughout the country. According to Falcon Products, all of its products are sold to commercial, industrial, and institution customers and are not sent to retail outlets for residential use.

Falcon Products has been responsive and cooperative with the NRC throughout the inquiry into the contamination problem. The company has retained a radiation consultant to identify and isolate all contaminated castings remaining at the Falcon facility in Missouri. The company has also established controls to assure that no additional contaminated material is shipped from its Mexican foundry or from its St. Louis facility.

Most of the contaminated bases have been located at the Missouri facility, but some additional ones may have been among those shipped to customers. To date, contaminated bases have been located in storage at customers' facilities in Nevada, Ohio, Iowa, and Nebraska; in a truck stopped en route by Illinois State Police; and at Falcon warehouses in California and Tennessee. More than 100 surveys by the NRC and several state agencies have not identified any additional contaminated bases.

According to Falcon Products, the table bases consist of three parts -- a cross-shaped or circular base, a tubular post, and a fingered connector which attaches the base to a table top. The bases come in various sizes -- the weight of the bottom piece ranges from 15 to 40 pounds. All the segments are gray cast iron. Most have been painted black, but other colors have been used as well.

NRC surveys of bases at the Falcon plant have shown that bases manufactured during the time period in question range from having no detectable radiation to a maximum of 100 milliroentgens per hour at localized spots on the surface of a few castings. Most of the contaminated castings had radiation measurements of less than 10 milliroentgens per hour at the surface. The radiation levels at a distance from the surface would be significantly lower.

The surveys also found that the cobalt contamination in the iron is not uniform and the radiation levels vary on different parts of the same casting.

(A milliroentgen is a standard measure of radiation exposure. For comparison, the annual radiation exposure from natural sources ranges from 100 to 200 milliroentgen per year, while a chest x-ray involves an exposure of 20 to 50 milliroentgens.)

Customers who received the Falcon bases during the December-January period will likely be contacted by appropriate state agencies. They may also request surveys from their state agency or from one of the NRC's regional offices. NRC offices are located in King of Prussia, PA; Atlanta, GA; Glen Ellyn, IL; Arlington, TX; and Walnut Creek, CA.

#

APPENDIX G

U.S. DEPARTMENT OF TRANSPORTATION EXEMPTION TO FALCON INDUSTRIES INC.

U.S. Department
of Transportation

**Research and
Special Programs
Administration**

400 Seventh Street, S.W.
Washington, D.C. 20590

DOT-E 9218

1. Falcon Industries Inc., St. Louis, Missouri is hereby granted an emergency exemption from those provisions of this Department's Hazardous Materials Regulations specified in paragraph 5 below to offer for transportation and transport radioactive material in solid form in commerce subject to the limitations and special requirements specified herein. This exemption authorizes the transportation of solid cast iron articles contaminated with cobalt 60, and provides no relief from any regulation other than as specifically stated..

2. BASIS. This exemption is based on information received via telephone by Mr. Wendell Carriker on February 3, 1984 and determined to be essential for protection of life and property.

3. HAZARDOUS MATERIALS (Descriptor and class). Solid cast iron manufactured articles containing low concentrations of cobalt 60.

4. PROPER SHIPPING NAME (49 CFR 172.101). Radioactive material, low specific activity, n.o.s., UN 2912.

5. REGULATION AFFECTED. 49 CFR 172.203(d), 173.425.

6. MODES OF TRANSPORTATION AUTHORIZED. Motor vehicle.

7. SAFETY CONTROL MEASURES. See paragraph 8 of this exemption.

8. SPECIAL PROVISIONS.

a. This exemption is issued for the purpose of transporting contaminated solid cast iron articles from various locations to Falcon Industries, Inc., St. Louis, Missouri.

b. Packagings are not required for solid cast iron articles when transported in exclusive use, closed motor vehicles operated by Falcon Industries personnel under the supervision of their radiation safety specialist (Eli Port).

c. Packages or articles must be marked or tagged "Radioactive-LSA."

d. Each motor vehicle must be placarded on front, rear, and each side with RADIOACTIVE placards.

e. Shipping papers must contain the following:

"Radioactive material, low specific activity, UN 2912, cobalt 60 transported under DOT-E 9218."

Also, a list of cast iron articles and their pickup locations must be attached to the shipping papers.

9. REPORTING REQUIREMENTS. Any incident involving loss of contents must be reported to the Office of Hazardous Materials (OHMR) as soon as practicable. Also, a list of cast iron articles and their pickup locations must be submitted to OHMR as soon as practicable.

10. EXPIRATION DATE. March 6, 1984.

Issued at Washington, D.C. on February 3, 1984 (5 PM).

2/3/84 5:00PM
(DATE)

Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

Address all inquiries to: Associate Director for Hazardous Materials Regulation, Materials Transportation Bureau, Research and Special Programs Administration, U.S. Department of Transportation, Washington, D.C. 20590. Attention: Exemptions Branch.

Dist: FHWA

APPENDIX H

STATE OF NEW MEXICO REQUEST FOR AERIAL SURVEYS

HEALTH ENVIRONMENT department

STATE OF NEW MEXICO
ENVIRONMENTAL IMPROVEMENT DIVISION
P.O. Box 968, Santa Fe, New Mexico 87504-0968
(505) 984-0020

Steven Asher, Director
RADIATION PROTECTION BUREAU

TONEY ANAYA
GOVERNOR

ROBERT M. NEILL
SECRETARY

ROBERT L. LOVATO MAPA
DEPUTY SECRETARY

JOSEPH F. JOHNSON
DEPUTY SECRETARY

February 23, 1984

Mr. L. Joe Deal
Director of Radiation Controls
PE-222
U. S. Department of Energy
Washington, D. C. 20545

Dear Mr. Deal:

We request that the U. S. Department of Energy (DOE) perform an aerial survey for pellets containing cobalt-60 in the parts of New Mexico bordering the El Paso area and that the DOE install roadblock detectors at El Paso area entry points along the United States-Mexico border to monitor traffic crossing the border.

As you know, a teletherapy source in Juarez, Mexico, containing approximately 400 Ci of cobalt-60, was breached sometime toward the end of November. The breaching resulted in the release of the majority of the cobalt-60, which was in the form of some 6000-7000 pellets. The pellets, which contain 50 to 70 mCi of cobalt-60 each, are small (about 1mm in both dimension and length) and, if inadvertently attached to the shoes or tires of an individual traveling into the United States, potentially could be transported into this country.

Because the external radiation levels near these pellets are high, and because approximately 100 Ci of the original 400 Ci have not yet been located, we feel that a comprehensive radiation survey of the affected area is needed on an urgent basis to ensure that no untoward radiation exposures are occuring from any of these pellets. The EG & G Aerial

Measurement System is very well suited to perform the type of survey that would be needed.

We understand that an aerial survey by DOE for the El Paso area is now being requested by the State of Texas. If permission is granted by the Mexican authorities, the survey would be extended into Juarez and possibly as far south as Chihuahua. Because some of the El Paso suburban area crosses the state boundary, parts of New Mexico also would be included in the survey.

This letter is to formally request that these adjacent areas in New Mexico be surveyed. The areas in question, which are outlined on the enclosed map, are a small extension of the survey to be performed in El Paso.

We believe that a survey of the El Paso/Juarez area, including the designated section of New Mexico, would provide the information needed to evaluate the present distribution of pellets and the potential for the spread of pellets. Further surveillance activities in New Mexico will be based on the result of this survey.

We, therefore, request that an aerial survey for gamma radiation of energies characterizing cobalt-60 be performed for the area shown on the enclosed map as soon as reasonably possible. We request that the minimum detectable activity of cobalt-60 be 30 mCi, calculated assuming that the probabilities of Type I and Type II uncertainties are 5%.

A related concern is that pellets may still be entering the United States from Mexico. Although commercial vehicles are being monitored for cobalt-60 at the border, pedestrian traffic and private vehicles are not. In order to ensure that pellets are not inadvertently transported into the United States, we request that roadblock detectors be installed by the DOE at the El Paso ports of entry as soon as reasonably possible that would monitor all traffic crossing the border, including pedestrians and private vehicles.

Because of the potential for radiation exposure, we attach considerable urgency to our requests for the aerial survey and for increased monitoring at the border. We do feel that it is preferable to include Juarez in the aerial survey, and that a limited delay while permission for the Juarez survey is being obtained from the Mexican authorities is justified. However, if this permission is not obtained within the next few days we believe that the survey should be performed as soon as possible on the American side of the border. This should be complemented by comprehensive monitoring at the border to ensure that no pellets enter the United States, particularly areas after they have been monitored.

Finally, I would like to take this opportunity to thank you and your staff for the excellent assistance they have provided to us during this

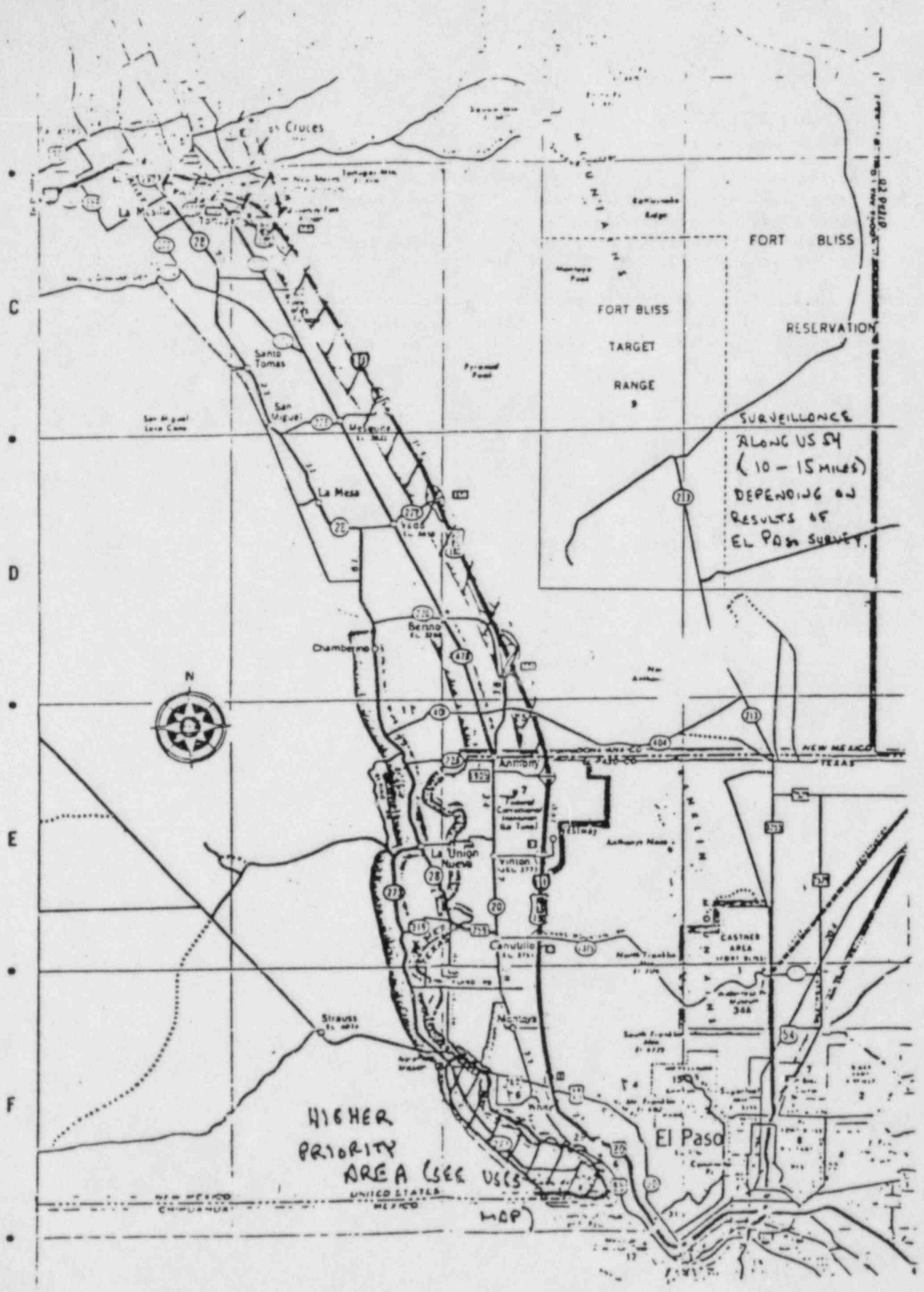
entire incident. The technical support from Los Alamos National Laboratory, arranged effectively and efficiently by Dave Foster and his group at JNACC, greatly assisted us in first identifying the radioisotope in the rebar, and locating sites where contaminated rebar was present. Your assistance has been greatly appreciated.

Thank you for your consideration of our request. We look forward to continued close cooperation with DOE on this and other important matters. If you have any questions, please contact Tom Buhl of my staff at (505) 984-0020.

Sincerely yours,

Steven Asher
Director
Environmental Improvement Division

SA/mp


FORT BLISS
FORT BLISS
TARGET
RANGE
RESERVATION
SURVEILLANCE
ALONG US 54
(10 – 15 MILES)
DEPENDING ON
RESULTS OF
EL PASO SURVEY.
HIGHER
PRIORITY
AREA (SEE USGS
MAP)
El Paso
Anthony
La Union
Canutillo
Chamberino
Santa Tomas
San Miguel
La Mesa
Mesquite
Strauss
Montana
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APPENDIX I

EVALUATION OF RADIATION DOSE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

FEB 16 1984

MEMORANDUM FOR: Region III Files

FROM: B. S. Mallett, Chief, Materials Licensing Section

SUBJECT: TABLE BASES CONTAMINATED WITH COBALT-60 AND DISTRIBUTED BY FALCON PRODUCTS, INC., ST. LOUIS, MISSOURI

I performed a site visit on February 14, 1984, to determine exposure rates at various distances from a contaminated table base (the base was identified on February 9, 1984, by staff from the Illinois Department of Nuclear Safetty as having an exposure rate of approximately 100 mR/hr at the surface).

Instruments Used

1. Eberline Model E-520 GM survey meter with energy compensated probe.
   - Calibrated on 1/14/84 against cobalt-60
   - Serial No. of meter = 1786
   - Serial No. of probe = 601162

2. Ludlum Model 19 Micro R meter (NaI probe)
   - Calibrated on 12/30/83 against cobalt-60
   - Serial No. of meter = 30761

3. Eberline Model PIC-6A portable ion chamber.
   - Calibrated on 12/14/83 against cobalt-60
   - Serial No. of meter = 2302

Interview

1. purchased table bases from Falcon Products, three of which were found contaminated with radioactive material and removed from service to a storage area on February 9, 1984.

2. The three tables were in use from approximately January 8, 1984 - February 9, 1984.

3. All three tables are 200 series bases.
   . Table No. 1 has a base spread of 22x22 inches.
   . Table No. 2 has a base spread of 22x30 inches.
   . Table No. 3 has a base spread of 30x30 inches.

4. Customers utilized the tables for approximately 0.5-1.0 hour per individual. offers one meal that lasts approximately two hours. This is the longest "setting" for any meal offered.

5. The large round table, No. 3, had the highest exposure and was the "most used" table in the restaurant. The owner and his wife utilized Table No. 3 for approximately one hour per day, seven days per week, for the period January 8 - February 9, 1984.

6. The owner's brother assembled all three tables. The time of assembly was approximately three hours.

7. Table No. 3 took the most time to assemble - approximately two hours.

8. The assembly of a table involves placing the formica table top on the floor, attaching "spider" to the top with 8 screws, placing the center column into spider, placing legs or base onto column and fastening the column and legs to spider with a long bolt and nut.

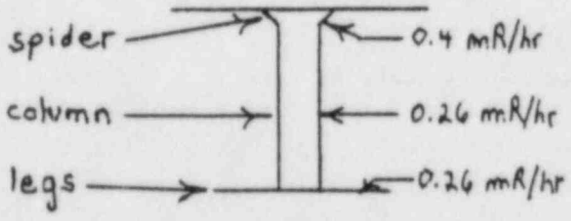
9. The time to assemble Table No. 3 was two hours due to the installer having difficulty in threading a nut onto the bolt that holds the table legs to the column.

10. B. Mallett spent approximately one hour within six feet of the table and approximately 0.5 hours within three feet of the legs - similar to distance for an individual sitting.

Data

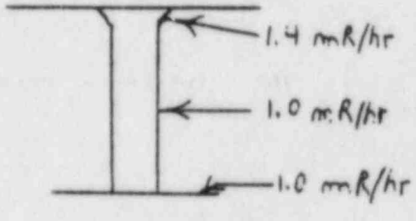
Table 1: Approximate levels of radiation for Table Nos. 1 and 2 (measured with Eberline E-520). (Levels taken at contact with surface.)

Table No. 1



Background - 0.26 mR/hr

Table No. 2

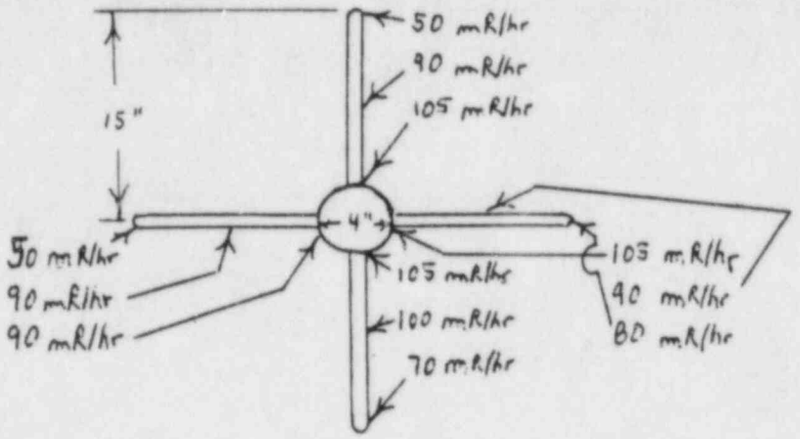


Background - 1.0 mR/hr

Data (cont'd)

Table II: Approximate Radiation Profile for Table No. 3

A. Levels taken with Eberline PIC-6A at contact with table legs:



NOTE: Radiation all seemed to be in legs since the levels measured tapered off dramatically as went up column and around spider.

B. Dimensions of "mock up" profile.

Note: Table top diameter is 42"

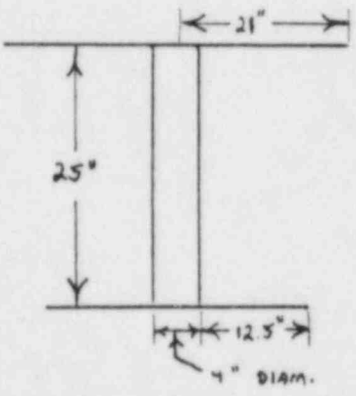
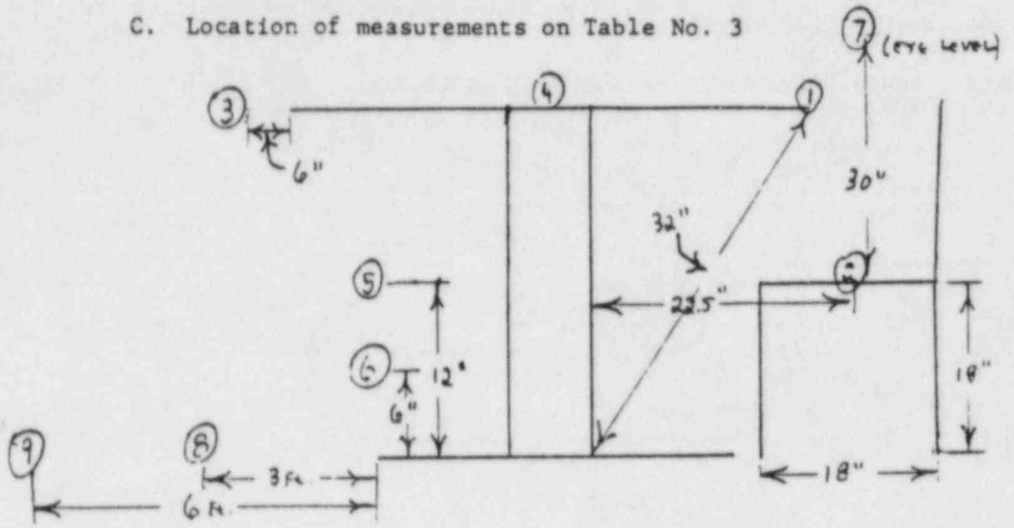


Table II (cont'd):

C. Location of measurements on Table No. 3



Readings (mR/hr)

	Position No.	µR meter	PIC-6A	Eberline E-520
	1	2.4	2.6	2.6
	2	3.0	3.4	3.4
	3	2.0	2.0	2.0
	4	2.4	2.4	2.6
	5	-	17	16
	6	-	35	50
	7	1.3	-	1.0
Readings taken w/meter on floor	8	1.2	1.5	1.4
	9	0.3	-	0.4

Bruce S. Mallett

B. S. Mallett, Chief
Materials Licensing Section

cc: P. Loysen, NMSS
L. Cobb, IE
W. Axelson, RIII
D. Wiedeman, RIII

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

1. REPORT NUMBER (Assigned by TIDC, add Vol. No., if any)
NUREG-1103

2. TITLE AND SUBTITLE
Contaminated Mexican Steel
Importation of Steel Into the United States That Had Been Inadvertently Contaminated With Cobalt-60 as a Result of Scrapping of a Teletherapy Unit

3. LEAVE BLANK

4. DATE REPORT COMPLETED
MONTH: December YEAR: 1984

5. AUTHOR(S)
Safeguards and Materials Programs Branch

6. DATE REPORT ISSUED
MONTH: January YEAR: 1985

7. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Division of Quality Assurance, Safeguards and Inspection Programs
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Washington, DC 20555

8. PROJECT/TASK/WORK UNIT NUMBER

9. FIN OR GRANT NUMBER

10. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Same as 7. above.

11a. TYPE OF REPORT
Technical

b. PERIOD COVERED (Inclusive dates)

12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

This report documents the circumstances contributing to the inadvertent melting of Co-60 contaminated scrap metal in two Mexican steel foundries and the subsequent distribution of contaminated steel products into the United States. The report covers the tracing of the source to its origin, response actions to recover radioactive steel in the United States, and return of the contaminated materials to Mexico. Information outside of this scope is recounted as necessary, e.g., details of the incident on the Mexican side of the border. The incident resulted in very significant radiation exposures to more than 100 Mexican citizens but no known significant exposure to citizens of the United States.

14. DOCUMENT ANALYSIS - a. KEYWORDS/DESCRIPTORS
Cobalt-60 teletherapy incident
materials incident
Mexican incident

b. IDENTIFIERS/OPEN-ENDED TERMS

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(This page) Unclassified
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