NUREG-0535

REVIEW AND ASSESSMENT OF PACKAGE REQUIREMENTS (YELLOWCAKE) AND EMERGENCY RESPONSE TO TRANSPORTATION ACCIDENTS

Draft Report

Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission

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Joint Study Group
U. S. Nuclear Regulatory Commission
U. S. Department of Transportation

Division of Fuel Cycle and Material Safety
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

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Review and Assessment of Package Requirements (Yellowcake) and Emergency Response to Transportation Accidents

Joint Study Group
U.S. Nuclear Regulatory Commission
U.S. Department of Transportation

Part I. Executive Summary

October 1978

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TRANSPORTATION OF RADIOACTIVE MATERIAL

Background

In September 1977, an accident involving a truck shipment of uranium ore concentrate (yellowcake) occurred near Springfield, Colorado. Several tons of yellowcake were spilled on the ground. Although the effects of this spill on the public health and safety were very small,[1/] the unusually large amount of material spilled combined with uncertainties in the overall management of the incident focused public and Congressional attention on the transportation of yellowcake in particular and of all radioactive materials in general. In response, the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT) undertook to review and assess the regulations and practices related to package integrity and to emergency response to transportation accidents involving radioactive materials. An agenda of topics for the study,[2/] given in Table I, was established.

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[1] Letter from A. J. Hazle, Director, Radiation and Hazardous Wastes Control, Colorado Department of Health, to R. P. Pollock, Director, The Citizen's Movement for Safe and Efficient Energy (January 16, 1978).

[2] The general subject areas examined in this study have been recently analyzed, publicly reviewed, and reported in the NRC environmental impact statement "Transportation of Radioactive Materials by Air and Other Modes," NUREG-0170, which was published in December 1977. The present study represents a reexamination of certain specific topics as identified in the study agenda. In particular, the risk analysis of yellowcake and other low specific activity material shipments in NUREG-0170 is here expanded to include consideration of improvements in package requirements and emergency response requirements.

TABLE I. TRANSPORTATION OF RADIOACTIVE MATERIAL STUDY AGENDA

The following is a list of actions related to safety in transportation of radioactive materials which the NRC will evaluate in coordination with DOT. The evaluation will include consideration of feasibility, practicality, authorities and cost-benefits.

(1) A modification of NRC rules to require licensee shippers to prepare and maintain emergency procedures to be followed in the event notification is received that a licensee's shipment is involved in a transportation accident. This will include development of the various elements which the emergency plan should contain. Agreement States would be encouraged to adopt similar requirements.

(2) Require that changes be made in the method of shipping LSA materials including specifically natural uranium oxide, to increase survivability in transportation. A short-term study (about 6 months) will be undertaken to investigate what changes might be made. Changes to be investigated will include: (a) heavier gauge drums; (b) improved drum closure methods; (c) tie-down systems; and (d) type of vehicles to be used.

(3) Require that an information packet accompany each shipment of hazardous materials (radioactive). The package would contain information concerning the hazardous nature of the material in the shipment, the precautions to be taken in the event of leakage or spillage under normal or accident conditions of transport, and notification requirements.*

(4) Require routing control for certain types of shipments; e.g., so as to avoid densely populated areas and adverse road conditions.

(5) Clarify Federal, State, local, carrier and shipper response and responsibilities in the event of an accident.*

(6) Clarify financial responsibility for coping with accidents, including clean-up and recovery.

(7) Develop a system for obtaining up-to-date transportation data; e.g., types, quantities, etc.

(8) Develop a system for advance notification of shipments of radioactive materials.

TABLE I (Continued)

(9) Increase the DOT inspection capability for transportation of hazardous materials.*

(10) Other facets of emergency preparedness not mentioned above.

Time Table

The above study is expected to be completed in about six months. Implementation of recommendations for changes may take a year or longer, where changes in DOT or NRC regulations are necessary.

*In the study, consideration is limited to radioactive materials.

A Study Group comprised of representatives from the NRC and the DOT was formed to consider the items on the agenda and to report on those considerations. The report consists of two parts: an executive summary and a more detailed discussion. In the executive summary, each item is briefly discussed to identify problems, summarize issues, and express conclusions of the Study Group. The recommendations of the Study Group are given at the end of the executive summary.

Discussion

The observations and conclusions of the Study Group for each agenda item are summarized below:

Observations and Conclusions

Item (1) A modification of NRC rules to require licensee shippers to prepare and maintain emergency procedures to be followed in the event notification is received that a licensee's shipment is involved in a transportation accident. This will include development of the various elements which the emergency plan should contain. Agreement States would be encouraged to adopt similar requirements.

Item (5) Clarify Federal, State, local, carrier and shipper response and responsibilities in the event of an accident involving low level radioactive materials.[3/]

[3/] Although the discussion is restricted to low-level radioactive materials, many of the general principles also apply to all radioactive materials.

Items (1) and (5) will be discussed together, since the resolutions of each are interdependent. Four substantially different parties are involved in emergency response to a transportation accident involving any radioactive material: the Federal government, State (including both Agreement States and non-Agreement States) and local governments, the carrier, and the shipper. The responsibilities shared by these parties related to transportation accidents are complex and can be formalized through regulations or guidance for shippers and carriers and through formal agreements among Federal, State, and local agencies. Our present views on the primary responsibilities of each party are given as follows:

(a) The Federal government (primarily the NRC and the DOT) is responsible for regulating safety aspects of carrier and shipper activity; designating prior to an accident responsibilities in emergency response to the accident; supplying guidance and assistance to State and local governments in planning effective response to transportation accidents when they occur; advising response personnel at the scene of an accident on request (this function is primarily executed by the Department of Energy (DOE), see Item (10)); and investigating the causes of an accident, taking steps to prevent recurrence, and enforcing compliance of carriers and shippers with Federal regulations.

(b) State and local governments are responsible for regulating certain aspects of carrier and shipper activity within their borders (vehicle weights, speed limits, routing away from weak roads or bridges, etc.); controlling the scene of an accident, implementing protective action if necessary; and developing emergency response plans for protection of public health and safety. State and local agencies, such as emergency crews, police, health and environmental departments, should have emergency plans both to advise and assist the carrier and to take appropriate control actions at the scene to assure protection of public health and safety. These agencies are expected to exercise their police and emergency powers to control traffic, provide communications, direct evacuation and sheltering actions if necessary, and to assure adequate cleanup of contaminated property.

(c) Ordinarily, the carrier and not the shipper is responsible for proper care of cargo in transit. In common, contract, and private carriage, the shipper is responsible for proper packaging of radioactive material delivered to the carrier for transportation, and the carrier has a right and a responsibility to control such property in transit. Accordingly, the carrier should be responsible for emergency response planning, and the shipper should be responsible for informing concerned persons about the hazardous nature of his radioactive material in situations where emergency response plans would be put into effect.

Under existing Federal regulations, the carrier is responsible for promptly notifying the shipper and the Federal government of any incident involving death, hospitilization, property damage exceeding $50,000, fire, breakage, actual or suspected leakage of radioactive materials or etiologic agents, or in the judgement of the carrier a danger to life; for isolating any spilled radioactive material from personnel contact, pending disposal instructions from qualified persons; and for not placing vehicles, buildings, areas, or equipment in which radioactive materials have been spilled into service or routine occupancy until the radiation dose rate at any accessible surface is less than 0.5 millirem per hour and no significant removable radioactive contamination resides on the surface (in the cases of air and water carriers, only aircraft, holds, compartments, or deck areas are included in this requirement).

In practice, the carrier may have to rely on expertise and services of others to accomplish these duties. The carrier would depend on advice from the shipper (including the procedures in the shipper's plan decribed below), an Interagency Radiological Assistance Program (IRAP) team, or State and local agency teams or representatives who may respond to the accident scene.

To fulfill its responsibility for emergency response actions most effectively, the carrier should be required in the DOT regulations to prepare, maintain, and execute an emergency response plan for these actions. This plan could depend upon advice given by the shipper, IRAP organization, or State and local agencies. Further, it could call for contractual arrangements between the carrier and shipper or between the carrier and other emergency response organizations. The plan should include means to notify shipper and carrier management and government authorities, to arrange the protection and care of any nearby people, and to isolate and clean up any spilled radioactive material.

d) In an accident, the shipper is clearly the most appropriate party for providing hazards information on a shipment of radioactive material. At present, shippers are required by DOT regulations to provide such information for their shipments on the shipping papers. In certain instances, such as for bulk shipments of yellowcake and uranium hexafluoride, shippers also voluntarily provide instructions for responding to emergencies. Prior to his first shipment of fissile or Type B quantities of radioactive materials, the DOT regulations require the shipper to notify each consignee of any special loading or unloading instructions (49 CFR 173.22(b))

To most effectively use its knowledge in emergency response actions, the licensee shipper should be required in regulations to prepare and maintain an emergency plan for promptly conveying hazards information about the shipment to the carrier and government authorities. The shipper plan should describe clearly and simply the hazard associated with the material, a recommended procedure for isolating any spilled material from the populace, precautions for handling each package or spilled material, and equipment required (including new packages) for cleanup and availability of such equipment. The information in the shipper plan should be available at all times that the shipper has a shipment in transit so shipper personnel can knowledgably and promptly inform, say by telephone, non-shipper personnel requesting advice about an accident.

Item (2) Require that changes be made in the method of shipping LSA materials including specifically natural uranium oxide, to increase survivability in transportation. A short-term study (about 6 months) will be undertaken to investigate what changes might be made. Changes to be investigated will include: (a) heavier gauge drums; (b) improved drum closure methods; (c) tie-down systems; and (d) type of vehicles to be used.

Both the NRC and the DOT have authority to prescribe improved package performance standards under normal as well as accident conditions of transportation. At present, low specific activity (LSA) materials, such as yellowcake, are most commonly transported in exclusive-use vehicles, using non-prescription "strong, tight packages" (see 49 CFR 173.392(c)(i)). Shipments of LSA materials in other than exclusive-use vehicles are, however, required to be in packages which must comply with the performance requirements for "Type A" packaging, i.e., designed to withstand prescribed environmental and test conditions for normal transportation. However, neither strong, tight packages nor Type A packages are inherently designed to withstand severe accidents, as would Type B packages. The risk of damage to public health and safety from the transportation of LSA materials is very small although the number of LSA packages shipped each year is large. Assessment of the health and safety consequences of an accidental spill of such material indicates that a requirement for more accident resistant packaging than currently used is not cost-effective. However, transportation experience and incident report data do suggest that the non-prescription strong tight package authorization for LSA material does not in some instances result in desired package performance under normal transportation conditions. Accordingly, the DOT intends to issue in the near future a proposed rule-change which would impose a requirement for use of Type A packages for both exclusive-use and nonexclusive-use shipments of LSA material. This proposed change, which was under consideration prior to the Colorado incident, can be expected to significantly enhance performance of packages used in shipments of LSA materials, and to some extent even their accident resistance.

a. Gauge (wall thickness) of drums

As for requiring heavier gauge drums, the strength of a material generally increases with thickness of the material, especially against uniform axial, internal pressure, external pressure, and crush loading, but not necessarily against impact loading. Since accident experience (Colorado 1977) and package testing (Sandia Laboratories 1976) do not indicate that failure of material walls or seams is significant compared to loss of lids, improving drums by requiring heavier gauge construction does not appear to be necessary or advantageous and should not be required.

b. Drum closure methods

Accident experience and package testing do show that loss of lids on drums used to transport yellowcake contributes to spillage of contents in severe accidents. Improvements in lid closure methods are feasible, but do not improve safety significantly, essentially because any spilled material has low concentration of radioactivity. The minimum annual equipment costs are estimated to exceed the annualized decontamination costs of a severe accident and also to exceed a reasonable annualized expenditure for saving dose from a severe accident. The minimum annual equipment costs can be realized only from effective cost control practices. Thus, such improvements are not cost-effective. For these reasons, requirements for such improvements should not be imposed.

c. Tiedown systems

Current DOT regulations (49 CFR Parts 174, 177, and 393) require restraints against shifting or loss of cargo under conditions normally incident to transportation. For LSA materials, tiedown requirements exceeding those in force are technically feasible, but do not improve safety significantly, since any spilled material has low concentration of radioactivity. Such improvements are not cost-effective because both annual equipment and installation labor costs exceed the annualized decontamination cost of a severe accident and exceed a reasonable annualized expenditure for saving dose from a severe accident. For these reasons, tiedown requirements exceeding those in force should not be imposed.

d. Vehicle types

Requirements for specially designed vehicles must be coupled with requirements for tiedown devices or package closure improvements capable of withstanding the forces generated in severe accidents to realize a reduction in the quantity of LSA material that might be spilled. As the latter improvements are generally not cost-effective, requirements for specially designed vehicles are even less cost-effective.

Item (3) Require that an information packet accompany each shipment of radioactive materials. The package would contain information concerning the hazardous nature of the material in the shipment, the precautions to be taken in the event of leakage or spillage under normal or accident conditions of transport, and notification requirements.

Present DOT regulations (49 CFR 172.200-172.203) require that shipments of radioactive materials be accompanied by a description of each radionuclide contained, its chemical and physical form, its radioactivity, the label category and transport index (measure of external radiation levels), and whether the package is Type A or Type B (accident resistant). A review of accident experience indicates that a change in the DOT regulations to require additional technical descriptive information on shipping papers, vehicle placards, package labels, or other package markings is not likely to be of any significant assistance in the case of a spill or leakage. However, the addition of an emergency telephone number on shipping papers could assist emergency response in the event of an accident and should be required.

Item (4) Require routing control for certain types of shipments; e.g., so as to avoid densely populated areas and adverse road conditions.

Current DOT regulations (49 CFR 397.9) require that "Unless there is no practical alternative, a motor vehicle which contains hazardous materials must be operated over routes which do not go through or near heavily populated areas...." Almost all of the large cities on the limited number of highways over which yellowcake is transported have by-passes which would be considered "practical alternatives" to passing through the city centers. Any yellowcake shipments seen passing through densely populated areas should be reported to the DOT for investigation and possible enforcement action.

State and local agencies currently designate roads with adverse conditions as unsafe for transportation and limit use of such roads if necessary.

The risk to public health and safety from shipments of LSA material, including yellowcake, is very small essentially because of the low concentration of radioactivity distributed throughout the material. In view of the limited number of routes normally used and of the low risk, no additional routing controls appear to be necessary for yellowcake shipments.

For other radioactive materials, the matter of routing control is presently under separate studies: the NRC environmental statement on transportation of radionuclides through urban environs and the DOT public rulemaking proceeding on the routing of highway movements of radioactive materials. The draft NRC environmental statement is expected to be published for comment in 1979. The DOT rulemaking proceeding can be anticipated to take about two years.

Item (6) Clarify financial responsibility for coping with accidents, including clean-up and recovery.

Ultimate financial responsibilty for damages resulting from a transportation accident involving radioactive material depends on the particular circumstances associated with the accident and is usually settled in the courts. If the origin or destination of the radioactive material being transported is an indemnified facility (e.g., a nuclear power plant), then the provisions of the Price-Anderson Act !42 USC 22101 assure a source of funds ($560 million per nuclear incident) for personal injury or property damage resulting from the transportation accident. These funds would be provided by a combination of facility licensee insurance and federal government indemnity. However, transportation of many types of radioactive material, particularly yellowcake, is not covered by the Price-Anderson Act. In the event of an accident involving transportation of these radioactive materials, liability for damages would be determined according to the applicable state tort law.

Aside from the question of ultimate financial responsibility for a transportation accident involving radioactive material, the carrier should be prepared to assume initial costs required to discharge his responsibilities [listed in discussion of Items (1) and (5)] and the State or local agency involved should be prepared to assume initial costs incurred because of protective actions required by the agency as in other emergency situations, e.g., fires, floods, etc.

Item (7) Develop a system for obtaining up-to-date transportation data; e.g., types, quantities, etc.

Collection of radioactive material shipment data does not directly improve transportation safety. However, such information is necessary to estimate, either on a national or regional basis, the risks to society from transportation and the impact of changes in the safety regulations on shipments. A selective survey involving a significant sample of shipments made in the U.S. may be sufficient to satisfy this need for such information. A system for maintaining up-to-date transportation data on all shipments of radioactive material would not contribute more in terms of safety than selective surveys because the volume of shipments is large and does not vary significantly from year to year. If any one type of shipment increases significantly, a specific survey can be conducted to obtain information on that particular type of shipment. Based on experience with a broad base shipment survey conducted in 1975, the cost to obtain up-to-date information for all shipments of radioactive materials in the U.S. appears prohibitively expensive, probably more than one million dollars per year. In our opinion, the benefits derived from expending a million dollars per year are not sufficient to warrant imposition of a system for maintaining up-to-date transportation data. Accordingly, rather than instituting a new information collection system covering all radioactive material shipments, available government and industry sources of such data should be supplemented as required by selective surveys.

Item (8) Develop a system for advance notification of shipments of radioactive materials.

Mere advance notice from a shipper to a State or local agency of a shipment of radioactive material does nothing to improve public health and safety. If the advance notice is coupled with some followup action, such as a police escort of the shipment, independent surveillance of the shipment, or notice to emergency response teams along the route, then safety might be improved. In view of the low overall risk to public health and safety from transportation of radioactive materials, as estimated in a recent NRC environmental statement,[4/] little increase in

[4/] "Transportation of Radioactive Materials by Air and Other Modes," NUREG-0170 (December 1977) safety would result from such actions. Recognizing, however, that some States may desire to obtain such information, the Study Group is not adverse to discussing wth the States the merits of advance notice requirements. However, State or local requirements for advanced notification of shipments of quantities and types of special nuclear material protected in accordance with NRC regulations or DOE directives should not be imposed because such requirements may conflict with certain Federal restrictions related to controlling sensitive information pertaining to such protected shipments.

Item (9) Increase the DOT inspection capability for transportation of radioactive materials.[5]

The compliance efforts of the DOT in transportation of radioactive materials are an integral part of the Department's overall program in compliance and enforcement of the hazardous materials transportation regulations. Radioactive materials therefore are not specially singled out and treated separately in this activity. Experience indicates that such materials have been transported very safely. When measured against actual experience therefore, the present staff level of compliance and enforcement in transportation of radioactive materials is appropriate.

[5] Letter from J. M. Hendrie, Chairman, U.S. Nuclear Regulatory Commission, to the Honorable T. E. Wirth, U.S. House of Representatives (January 10, 1978). This item is addressed by the DOT since it relates solely to their staffing requirements.

Item (10) Other facets of emergency preparedness not mentioned above.

Many activities are focusing on emergency response to accidents in transportation of all radioactive materials. The Federal government conducts an Interagency Radiological Assistance Program. The Department of Energy, as lead agency in this program, operates and maintains extensive capability to respond to radiological accidents. These response teams can advise the State and local agencies and carriers responsible for protective actions on radiological matters. The NRC and the DOT sponsor a training course for response to radiological accidents, including transportation accidents, at the Department of Energy Nevada Test Site. The American National Standards Institute drafted a standard entitled, "Emergency Response Procedures for Highway Transportation Accidents Involving Radioactive Materials," N-692. Communication between Federal and State governments on all aspects of transportation of radioactive materials has been improved through the State surveillance program jointly sponsored by the NRC and the DOT and through the establishment of State Liaison Officers. The State surveillance program in which 12 States have participated serves to familiarize them with transportation of radioactive materials and its emergency response requirements and to augment the Federal inspection capability in a significant way.

Recommendations

The Study Group makes the following recommendations concerning emergency response to transportation accidents involving radioactive materials.

1. State and local agencies, such as emergency crews, police, health and environmental departments, should have emergency plans to both advise and assist the carrier and to take appropriate control actions at the scene to protect public health and safety. The NRC and the DOT should foster development of these plans.

2. Carriers of radioactive material should be required by the DOT regulations to prepare, maintain, and execute an emergency response plan for promptly notifying the shipper and government authorities, controlling the spread of radioactive material in the cargo, segregating the radioactive material from the populace, and cleaning up any spilled radioactive material. This recommendation essentially augments existing regulations, guidance, and environmental impact statements on transportation of radioactive materials.

3. Shippers of radioactive materials should be required in regulations to prepare and maintain an emergency plan for promptly conveying hazards information about the shipment to the carrier and government authorities. The information in this plan should be available at all times that the shipper has a shipment in transit so shipper personnel can respond knowledgeably and promptly when they receive notice of an accident and are asked for advice. This recommendation essentially augments existing regulations, guidance, and environmental impact statements on transportation of radioactive materials.

4. Shippers of radioactive materials should be required in the DOT regulations to show an emergency telephone number on shipping papers and should be encouraged by both DOT and NRC policies to voluntarily include emergency instructions with shipping papers, especially on bulk shipments.

5. Carriers of radioactive materials should be prepared to assume initial costs for their responsibilities and State and local agencies should be prepared to assume initial costs for protective actions involving radioactive material as with other emergencies where protection of public health and safety is involved.

6. The NRC and the DOT should initiate discussions with States on the merits of advance notice requirements for shipments of radioactive material. If an advance notice requirement is judged necessary, a national requirement is preferred over a conglomeration of State requirements. Precaution against requirements for advance notice of shipments of quantities and types of special nuclear material protected in accordance with NRC regulations or DOE directives should be taken, however, because such requirements may conflict with certain Federal restrictions related to controlling sensitive information pertaining to such protected shipments.

7. Efforts of the NRC and the DOT to cooperate with the States in the surveillance program to evaluate compliance with the Federal regulations for safe transportation of radioactive materials should be expanded to include more States as monetary constraints allow.

8. Since several Federal agencies must evaluate the environmental impacts of transportation of radioactive materials from time to time and since complete survey information is essential to such evaluations, the NRC should at selected times update its shipment survey, in consultation with the DOT and the Environmental Protection Agency.

REVIEW AND ASSESSMENT OF PACKAGE REQUIREMENTS (YELLOWCAKE) AND EMERGENCY RESPONSE TO TRANSPORTATION ACCIDENTS

Joint Study Group

U.S. Nuclear Regulatory Commission

U.S. Department of Transportation

Part II. Study Report

October 1978

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I. PRELIMINARY

In September 1977, an accident involving a shipment of uranium ore concentrate (yellowcake) occurred near Springfield, Colorado. Several tons of yellowcake were spilled on the ground. Although the effects of this spill on the public health and safety were very small,[1/] the unusually large amount of material spilled combined with uncertainties in the overall management of the incident focused public and Congressional attention on the transportation of yellowcake in particular and of all radioactive materials in general. In response, the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT) undertook to review and assess the regulations and practices related to package integrity and to emergency response to transportation accidents involving radioactive materials. An agenda of topics for the study, given in Table I, was established.

These two agencies formed a joint study group to accomplish this review and assessment as reported in this document. The members of the joint study group are named in Appendix I. For continuity of discussion, the report is organized somewhat differently than the agenda. To aid the reader, a key between agenda item and section(s) of the report is given in Table II.

Table I

TRANSPORTATION OF RADIOACTIVE MATERIAL
STUDY AGENDA

The following is a list of actions related to safety in transportation of radioactive materials which the NRC will evaluate in coordination with DOT. The evaluation will include consideration of feasibility, practicality authorities and cost-benefits.

1. A modification of NRC rules to require licensee shippers to prepare and maintain emergency procedures to be followed in the event notification is received that a licensee's shipment is involved in a transportation accident. This will include development of the various elements which the emergency plan should contain. Agreement States would be encouraged to adopt similar requirements.

2. Require that changes be made in the method of shipping LSA materials including specifically natural uranium oxide, to increase survivability in transportation. A short-term study (about 6 months) will be undertaken to investigate what changes might be made. Changes to be investigated will include: (a) heavier gauge drums; (b) improved drum closure methods; (c) tie-down systems; and (d) type of vehicles to be used.

3. Require that an information packet accompany each shipment of hazardous materials (radioactive). The packet would contain information concerning the hazardous nature of the material in the shipment, the precautions to be taken in the event of leakage or spillage under normal or accident conditions of transport, and notification requirements.*

4. Require routing control for certain types of shipments; e.g., so as to avoid densely populated areas and adverse road conditions.

5. Clarify Federal, State, local, carrier and shipper response and responsibilities in the event of an accident.*

6. Clarify financial responsibility for coping with accidents, including clean-up and recovery.

7. Develop a system for obtaining up-to-date transportation data; e.g., types, quantities, etc.

Table I (Cont'd)

8. Develop a system for advance notification of shipments of radioactive materials.

9. Increase the DOT inspection capability for transportation of hazardous materials.*

10. Other facets of emergency preparedness not mentioned above.

Time Table

The above study is expected to be completed in about six months. Implementation of recommendations for changes may take a year or longer, where changes in DOT or NRC regulations are necessary.

*In the study, consideration is limited to radioactive materials.

Table II

KEY BETWEEN AGENDA ITEM AND REPORT SECTION(S)

Agenda Item	Report Section(s)
1. Emergency Planning Requirements	II.B.3
2. Packaging Improvements	II.A.1,2
3. Hazards Information Requirements	II.A.4
4. Routing Controls	II.A.3.a
5. Safety Responsibilities	II.B.3.a
6. Financial Responsibilities	II.B.3.b
7. Up-to-Date Transportation Data System	II.A.3.d
8. Advance Notification System	II.A.3.c
9. Increase in DOT Inspection Capability	II.A.5
10. Other Facets of Emergency Response	II.B.3.d

From its inception in January 1975, the NRC has reviewed the existing regulations and procedures for transportation of radioactive materials. As part of this review, the NRC initiated in June 1975 a public rule-making proceeding regarding the packaging and transportation of radioactive materials. With the technical assistance of Sandia Laboratories, the NRC prepared an environmental impact statement to assess the impacts associated with the transportation of radioactive materials, including relative costs and benefits of alternative modes of transportation. Information derived from research into the accident-resistant properties of packages used for shipping plutonium and information from the NRC's 1975 Radioactive Material Shipments Survey were used in preparing the statement. The draft statement entitled "Transportation of Radioactive Materials by Air and Other Modes," (NUREG-0034), was made available for public comment in March 1976. About 30 letters of comment were received. The final statement (NUREG-0170) was issued in December 1977.[2/]

The study indicates that transportation of radioactive materials is being conducted under the present regulatory system in an adequately safe manner. For example, routine shipments may be expected to add only one latent cancer fatality per year and accidents only one case per 200 years, assuming 1975 accident and shipping rates. By 1985, it is expected that these estimates might increase three-fold as a result of an increased volume of shipments. These rates compare to a nationwide total of 300,000 cancer deaths per year from all causes.

Consequently, many of the general subject areas referenced in the agenda for this joint study have been analyzed, publicly reviewed, and reported in NUREG-0170. The present study represents a reexamination of certain specific topics as identified in the study agenda. Accordingly, the basic document NUREG-0170 is referenced freely in this report. In particular, the risk analysis of yellowcake and other low specific activity material shipments in NUREG-0170 is here expanded to include consideration of improvements in package requirements and emergency response requirements.

Radioactive materials, packaged and offered for transportation, appear in many forms. The radiological hazard posed by the contents of these packages varies over some eight orders of magnitude, depending on how the radiotoxicity is measured. Some materials, such as spent fuel from nuclear reactors, waste generated by reprocessing spent fuel, or irradiated components of nuclear reactors or other fuel cycle facilities, are highly radioactive and must be well-shielded and well-contained by packaging when in the transportation system. In contrast a variety of materials appear at the low hazard extreme of the spectrum and accordingly are not required to be so well-contained when in the transportation system, since factors other than packaging provide assurance of safety.

This report deals primarily with this last category of materials. As may be expected, some of these low hazard materials are found in nature and also are transported in much larger volumes than are materials of greater hazard. These low hazard materials include ores of uranium and thorium, which are basic fuel materials for nuclear reactors, concentrates of uranium or thorium oxides produced from processing those ores, purified uranium or thorium which has not been irradiated, aqueous solutions containing tritiated water, liquid and consolidated wastes, and activated solid materials. In addition, this category of materials has been expanded to include contaminated objects, for example, pipes and machinery which ordinarily would not be radioactive, but which bear radioactive material on their surfaces.

These low hazard materials may appear in many physical forms in the transportation system. Ores and concentrates are commonly shipped in bulk quantities, ores being unpackaged and concentrates being packaged in containers such as 55-gallon drums before being placed in cargo spaces. Larger containers, such as tanks, are also used. Liquids may be shipped in small packages, drums, or tank cars. Consolidated waste or activated solid materials are usually shipped in drums, boxes, or concrete containers. The common forms of lowly radioactive waste generated in the nuclear power industry are evaporator concentrates, spent resins, filters, and miscellaneous solid material such as paper and rags. These wastes are solidified, dewatered, or compressed and shipped as consolidated wastes.

Since these low hazard materials appear in the transportation system in much greater volumes than do materials of relatively greater hazard, and since they do not pose the degree of safety concern that materials of greater hazard present, then for reasonable regulation of the transportation of these materials, the package standards for the low hazard materials are made less stringent than the package standards for higher hazard materials. Such a regulatory stance appears reasonable from both the views of properly protecting the public health and safety and of refraining from imposing undue economic burden on individuals using the transportation system for commerce in these materials.

This stance was adopted many years ago by the regulatory bodies in the United States Federal government and by foreign nations through the International Atomic Energy Agency (IAEA). The IAEA has adopted a significant number of definitions, rules, and advisory concepts which provide for safe transportation of low hazard radioactive materials without requiring exacting package standards. Most nuclear nations have adopted outright or have essentially incorporated the IAEA regulatory system into their regulatory systems. The United States is one of these nations.[3/]

In the United States, the U.S. Department of Transportation (DOT) and the U.S. Nuclear Regulatory Commission (NRC) share the responsibility for regulating safety in the transportation of radioactive materials. Other government entities, such as the U.S. Postal Service, the States, and some local governments, also regulate this activity, but their regulations in most instances are compatible with the regulations of the DOT and the NRC. The DOT and the NRC partition their overlapping responsibilities by means of a Memorandum of Understanding, agreed to in March 1973, but now under revision. The regulations of these two bodies regarding the transportation of such low hazard materials as those discussed above are essentially patterned after the 1967 IAEA regulations. As explained in Reference 3, the IAEA has revised some of these regulations in 1973 and the DOT and the NRC are now in the process of revising their regulations to reflect the changes.

Briefly, the current regulations of the U.S. agencies apply in part to a class of materials called Low Specific Activity (LSA) material, which includes by definition unenriched uranium and thorium ores and concentrates, materials in which the radioactivity per unit mass or per unit volume is less than prescribed limits, and solids bearing surface contamination in less than prescribed densities. The concept underlying the regulation of the safe transportation of these LSA materials is that the concentration of radioactivity is low enough to obviate the requirement for rigorous packaging standards. The low concentration of radioactivity conceptually renders the material "inherently safe," considering radiological effects of the material, because it is highly unlikely, under any circumstances arising in the transportation of these materials, including accidents in which the material is released to the environment, that a person could take in enough material to produce a significant radiological effect. Consequently, only minimal packaging standards are necessary; operational controls may be used to supplement these standards to achieve safety in transportation.

II. ASSESSMENT OF REGULATORY ASPECTS OF TRANSPORTATION ACCIDENTS INVOLVING RADIOACTIVE MATERIAL

A. Preparation of Radioactive Material for Shipment

1. Packaging of Low Specific Activity Radioactive Material

a. Material Form

(1) Bulk material

Bulk solid low-level radioactive material may mean

- o ores of uranium or thorium (material as it comes out of the ground), or
- o concentrates, physical or chemical, of ores of uranium or thorium (material--commonly called yellowcake or greencake-- subjected to physical or chemical extractive processes and which may be granular, fine or chunky, or evaporated precipitate), or
- o extracted product uranium or thorium (material that has been refined, but not enriched or irradiated and which could be monolithic metal or granular solid), or

- radioactive material in which the radioactivity is essentially uniformly distributed with estimated small average value of concentration.

Packaging requirements for this material are minimal because of the small radioactivity involved and because of the solid nature of the material.

Bulk liquid low-level radioactive material may mean

- Radioactive water (tritium oxide) in aqueous solutions, or
- Slurries of ores of uranium or thorium or concentrates of these ores, or
- Aqueous solutions of unenriched, unirradiated uranium or thorium, or
- Aqueous solutions of radioactive source, byproduct, special nuclear, or waste material in which the concentration of radioactivity is smaller than regulatory limits.

Packaging requirements for this material are minimal because of the small concentration of radioactivity involved. Since the liquid form increases the probability of release, some types of shipments require preventive measures, such as use of a Type B package or use of binding materials or enough absorbent material to soak up twice the volume of the liquid radioactive contents of a package. Liquid radioactive material does not differ much from solid radioactive material with respect to health effects. The main difference is that liquid material is more difficult to contain.

(2) Contaminated solids

Contaminated solids may include sections of decommissioned reactor or fuel cycle facility process piping, ventilation ducts, housings, manufacturing equipment, and other components. Such material could also be empty vials of radioisotopes used in the practice of medicine or any number of waste items. Packaging requirements for these materials are the same as those for bulk material. Limits are set on fixed surface contamination, since health effects from contaminated solids released from a package in an accident are limited primarily to radiation field effects and skin contamination transferred by touching the contaminated solids. Under the regulatory requirements, the surface radioactivity is not readily dispersible and the amount of radioactivity is small; consequently, health effects are very small.

b. Package Designs

(1) Philosophy

The required integrity of the packaging should rightly be a function of the hazard that the radioactive material represents to people. The radioactive materials for which packaging improvements are under study in this report are called low-level radioactive materials because either the total quantity of radioactivity within a given lot of material is small or the concentration of radioactivity is small by virtue of the uniform or nearly uniform distribution of radioactivity throughout the material. Small total radioactivity and small concentration of radioactivity both mean small health effects, even with the premise that no threshold exists in the number of health effects predicted from a given dose of radiation. Consequently, packaging requirements for low-level radioactive materials are less stringent than those for materials containing larger quantities of radioactivity.

In 1959, the regulations in force for the safe transportation of radioactive material provided a means whereby radioactive ores, slag or residues from processing could be carried in bulk or in sacks or other packaging subject to a radiation control limit. When the IAEA panel convened in 1959 to review the international regulations for transportation of such LSA materials, both considerable experience and increasing shipping requirements existed.

The panel faced the problem of deriving a definitive basis by which transportation of these materials would be regulated safely but not be unduly restricted. The panel's solution was the concept that LSA materials must be inherently radiologically safe, that is, under any circumstances arising in transportation the possibility must be inconceivable of a person taking in enough radioactive material to cause significant internal radiological health effects. The resulting main purpose of the packaging is to facilitate such handling and transportation.

The initial thinking was that inhalation of more than 10 milligrams (mg) of any radionuclide by any individual during a single exposure was unlikely.[4/] This quantity was considered to be the maximum mass likely to be inhaled in a short time. Inhalation by a working person of this much material requires breathing for 50 minutes an atmosphere laden with 10 mg of the radionuclide for every cubic meter (m^3) of air, assuming the breathing rate for a working person is 20 liters per minute (ℓ/min).

Inhalation by a non-working person of this much material would require twice as much exposure time; for heavy exertion the breathing rate would increase by about 50 percent so the exposure time would decrease from 50 minutes to about 30 minutes.

Such a concentration represents an extremely dusty atmosphere, as might occur inside buildings.[5/] For comparison, a typical dusty industrial atmosphere has a dust concentration of about 0.33 mg/m^3.[6/] and the average dust concentration in metropolitan districts is 1.4 mg/m^3.[7/] Inhalation by a working person of 10 mg of dust in these atmospheres would require exposure times of 25 hours and six hours, respectively. Vigorous agitation of dust producing materials can produce dust burdens of 5000 mg/m^3, but most of the dust settles to the ground within five minutes.[8/] If a working person were to breathe in this atmosphere for five minutes he would inhale about 500 mg of dust.

If the Colorado accident had produced a uniform dusty atmosphere comparable to that produced from vigorous agitation of dust producing materials, the volume of air with this large a concentration can be seen to be small. Assuming all the material spilled on the ground, 7000 lb, was uniformly distributed in a hemisphere above a plane surface with a concentration of 5000 mg/m^3, one finds the radius of the hemisphere to be about 70 m (220 ft or 75 yd).

The earliest reported measurement[8/] of the largest concentration of uranium in air at the site of the accident (enclosed area sample) was about 6.1×10^{-10} microcurie per milliliter (μCi/mℓ), which is equivalent to 2 mg/m^3. During the course of the cleanup operations, this measurement increased to about 3.8×10^{-8} μCi/ml, equivalent to 125 mg/m^3. The largest reported open area measurement was about 3.1×10^{-10} μCi/ml, equivalent to 1.0 mg/m^3. The largest measurement on the perimeter of the working site was about 1.1×10^{-10} μCi/ml, equivalent to 0.3 mg/m^3, which can be compared to the typical dusty industrial atmosphere above. However, this concentration is a peak value. The arithmetic average of all 26 perimeter measurements reported is about eight percent of this peak value.

Considering the long exposure times required to inhale 10 mg of a radionuclide for the low atmospheric concentrations actually measured in the 1977 Colorado yellowcake accident, the initial thinking of the IAEA panel about the small chance of such inhalation is confirmed for this case. However, the IAEA panel eventually chose an arbitrary upper limit of one mg for possible individual inhalation as the basis for defining LSA materials in the 1961 IAEA regulations. The reason for this change in basis had to do with differences in dose commitment assumptions in establishing the radiotoxicity classification scheme for radionuclides.[4/]

The 1973 revision of the IAEA regulations introduce further changes in the definition of LSA material. Each radionuclide is individually classified by radiotoxicity instead of by groups of radionuclides. Generally speaking, the concentration limits for most LSA materials are increased, since the previous concentration limits for each transport group were restricted by the most radiotoxic member. This relaxation is compensated by a decrease in the volume permitted in the definition of LSA material to the minimum volume to which the material can be reduced under conditions likely to occur in transportation, such as dissolution in water with subsequent recrystallization, precipitation, evaporation, combustion, abrasion, etc. The environmental impacts of these changes are judged to be negligible.[9/]

In the United States, both the NRC and the DOT have authority to prescribe improved package performance standards under normal as well as accident conditions of transportation. At present, low specific activity (LSA) materials, such as yellowcake, are most commonly transported in exclusive-use vehicles, using non-prescripton "strong, tight packages" (see 49 CFR 173.392(c)(i)). Shipments of LSA materials in other than exclusive-use vehicles are, however, required to be in packages which must comply with the performance requirements for "Type A" packaging, i.e., designed to withstand prescribed environmental and test conditions for normal transportation. However, neither strong, tight packages nor Type A packages are inherently designed to withstand severe accidents, as would Type B packages. The risk of damage to public health and safety from the transportation of LSA materials is very small although the number of LSA packages shipped each year is large. Assessment of the health and safety consequences of an accidental spill of such material indicates that a requirement for more accident resistant packaging than currently used is not necessary. However, transportation experience and incident report data do suggest that the non-prescription strong tight package authorization for LSA material does not in some instances result in desired package performance under normal transportation conditions. Accordingly, the DOT intends to issue in the near future a proposed rule-change which would impose a requirement for use of Type A packages for both exclusive-use and nonexclusive-use shipments of LSA material. This proposed change, which was under consideration prior to the Colorado incident, can be expected to significantly enhar performance of packages used in shipments of LSA materials, and to some extent even their accident resistance. In the following discussion, ways to improve the accident resistance of LSA packages, particularly yellowcake drums such as were involved in the Colorado accident, are considered.

(2) Drums

One packaging design for transporting low-level radioactive material is a metal drum. In the Colorado accident, 55-gallon steel drums with lids secured by bolted steel ring closures were used for a shipment by Exxon Minerals Company of bulk solid uranium concentrate, commonly called yellowcake, which is LSA material by definition. Twenty nine of the 50 drums failed in the accident by loss of the lid. [illegible] 12,000 lb of the 40,329 lb total load were actually spilled, so that failure of 58 percent of the drums resulted in a spill of 30 percent of the load. The average loss from each opened drum must have been about 414 lb, meaning that the average release fraction from each drum was about 52 percent, since the average content of each drum was about 800 lb. Undoubtedly some of the drums might have been severely smashed and possibly ruptured, say by failure of a wall seam or bottom weld, but the lid loss is clearly the mechanism chiefly responsible for such a large release fraction.

(a) Closures

Tests have been carried out to study ways of improving drum closure methods to prevent such spills in accidents.[10] These tests were conducted on a drum of slightly different design than the strong industrial drum involved in the Colorado accident, but significant error will probably not be introduced in applying the results of these tests to an ordinary 55-gallon steel drum.

Most of the tests in the program consisted of free drops of the loaded drum from a height of 30 feet (9 meters) onto a flat, essentially unyielding surface with the drum oriented in such a way as to maximize the probability of maximum damage. The package design must also pass a thermal test in which the package is exposed to a thermal radiation environment of 1475F (802C) temperature for 30 minutes. However, since thermal tests for each container were not feasible in the program, a failure criterion was established by which the package would be considered failed if the Celotex packing material within the drum was visible after the drop test, since it would then be vulnerable to a fire in a real accident. This failure criterion allows use of the test results for nonspecified industrial drums, since failure of only the drum component of the test package is indicated.

Sufficient testing was performed to determine the maximum or minimum values of weight of the package required to observe this failure criterion.

Different methods of drum closure were tested; these methods are described as follows:

1. Standard lid with bolted lock ring;

2. Standard lid and bolted lock ring with a steel sheet extension welded onto the inner side of the lid and which fits inside the drum (Figure 1);

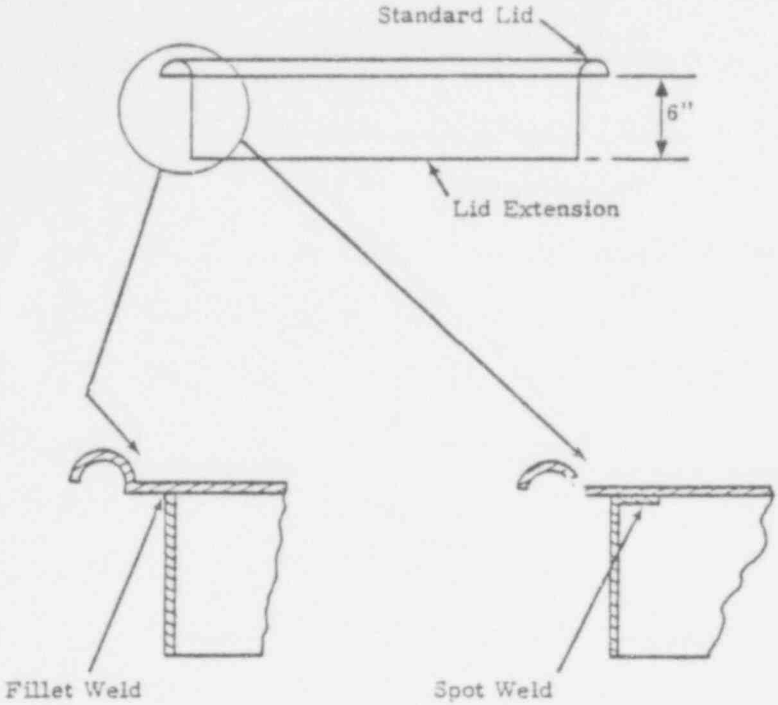


Figure 1. Attachment of 6-Inch Extension to Standard Lid

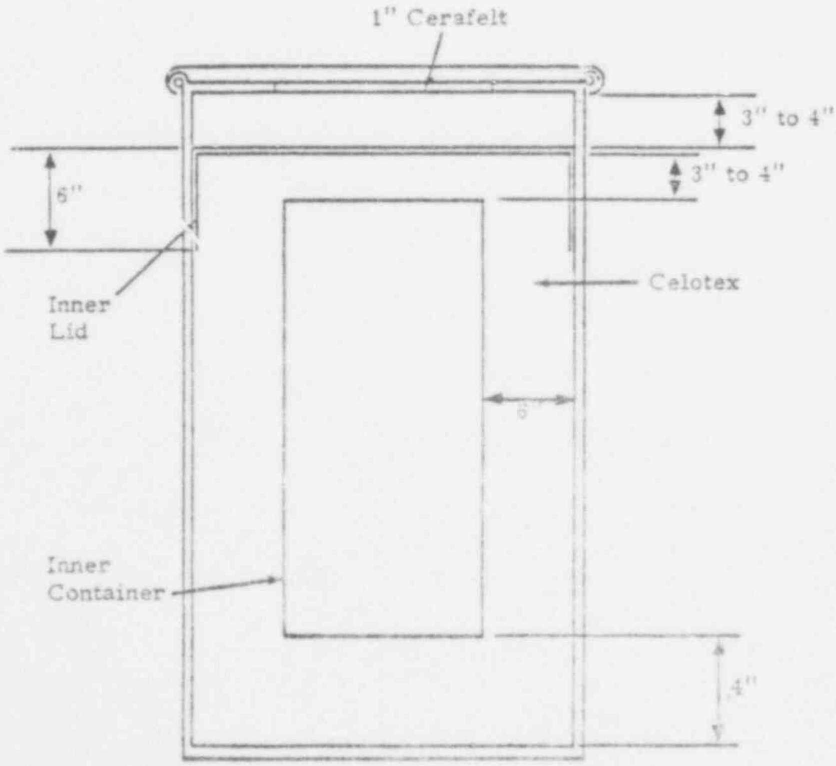


Figure 2. Packaging with 6-Inch Internal Lid

3. Standard lid and bolted lock ring with an inner lid inside the drum. The inner lid is a flat steel sheet with a steel sheet extension of varying width welded onto the underside of the inner lid (Figure 2);

4. Standard lid fastened to drum with varying number of equally spaced C-clampswith and without the bolted lock ring (Figures 3a,3b);

5. Standard lid with a modified bolted lock ring, either by clips welded to the underside of the lock ring, by clips welded to the top and bottom of the lock ring and alternately spaced, or by a steel sheet extension fitting around the outside of the barrel and welded onto the underside of the lock ring (extended lock ring; Figures 4a,4b)

6. Standard lid with a bolted extended lock ring with moulded rubber gasket fitted tightly over the lid/container interface and compressed underneath the extended lock ring (Figure 5).[11/]

Crush tests were also conducted on specimens representing closure methods 1-4. These tests consisted of applying static loads to loaded drums lying on the side, noting deflections and structural reactions with increasing loads until the failure criterion of visible internal packing was obtaned. The load was evenly distributed over the drum by means of an aluminum plate.

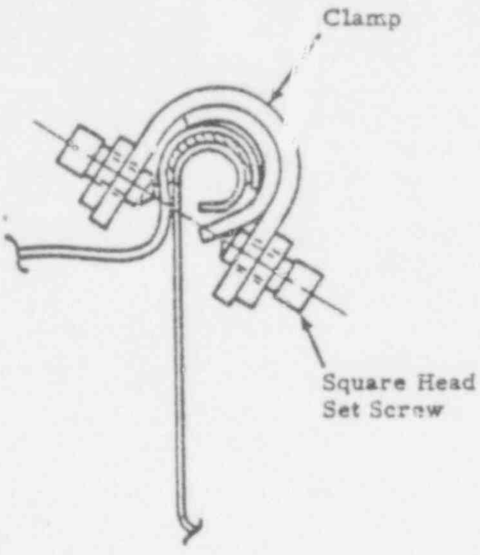


Figure 3a. C-Clamp With Lock Ring

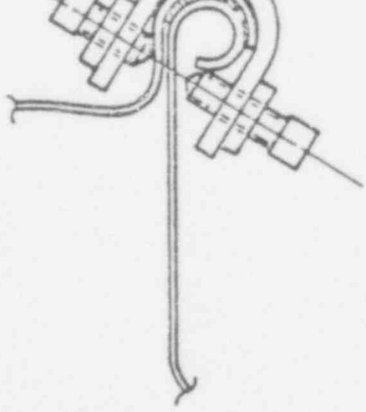
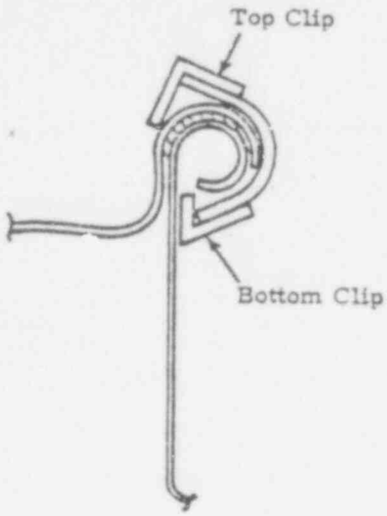


Figure 3b. C-Clamp Without Lock Ring



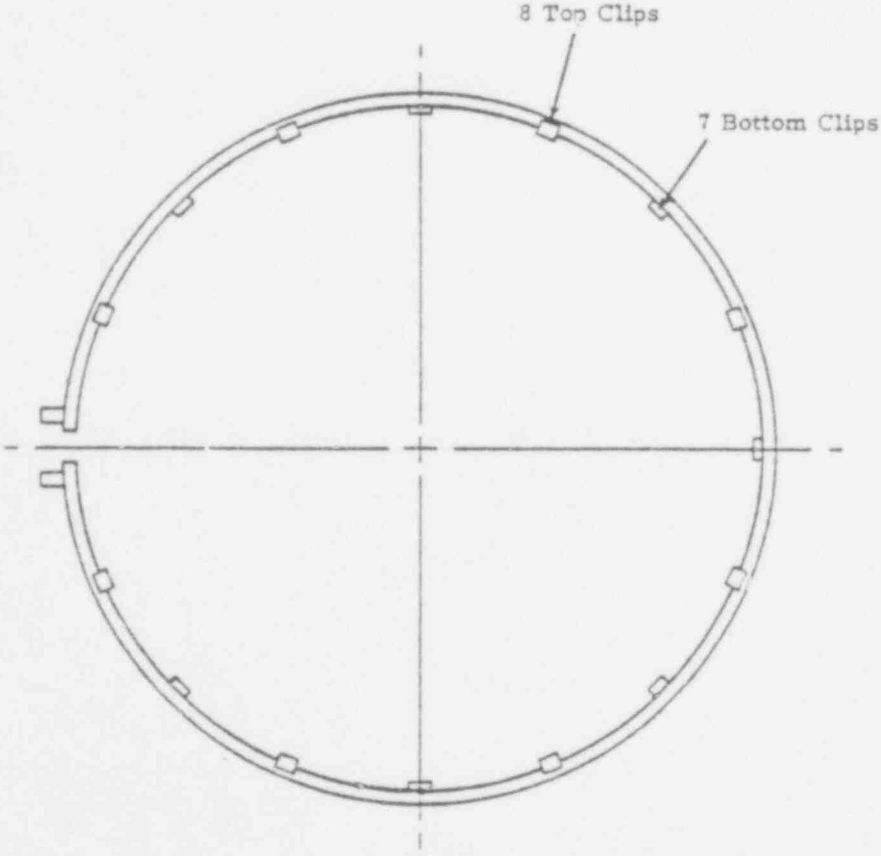
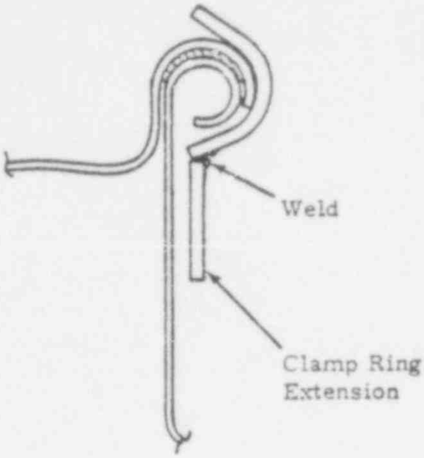


Figure 4a. Details of Top and Bottom Clips Welded to Lock Ring



4b. Extension of Lock Ring

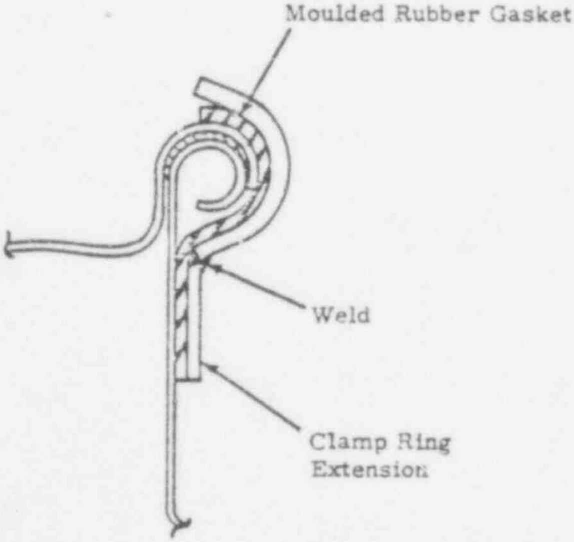


Figure 5. Sketch of Drum Closure Design
(U.S. Reg. Pat. No. 3,790,020)

The test results are summarized in Table III for our assessment purposes here. More complete discussion of the tests, packages, and closure designs is given in Reference 10.

For comparison, two drums which would be considered strong industrial packaging were subjected to the 30-foot drop test. At package weights of 800 and 600 pounds, the lock ring and lid were completely pushed off the drum, a severity of failure that was not experienced by the DOT Specification 17C drums in any of the other tests. These two data points suggest that packages meeting Type A package standards (normal transportation conditions) are significantly more accident resistant than are strong industrial packages. The magnitude of the weight for failure, however, is approximately the same for the 17C and industrial containers, so these data points also weakly support the hypothesis that these 17C test results can be transferred adequately to a strong industrial drum.

The Sandia report lists several conclusions and rates the different closure methods according to several criteria. These conclusions and ratings are reproduced in Tables IV and V.

These conclusions and ratings indicate that feasible means to increase accident resistance of LSA drums are available. Such simple closure method improvements would not prevent accidental spills entirely, but they would limit the accidentally spilled material to small quantities.

Table III

SUMMARY OF TEST RESULTS AND COST INFORMATION ON CLOSURE DESIGNS FOR DRUMS CONTAINING RADIOACTIVE MATERIAL[a]

Closure Design				Estimated Unit Cost ($)	
Modification to Standard Lid	Modification to Standard Lock Ring	Package Weight (lbs) for Failure Criterion[b] to be Observed in Impact Test[c]	Static Force (lbs) for Failure Criterion to be Observed in Crush Test[d]	100 Unit Order	1000 Unit Order
1. None	None	> 600	110,000		
2. Extension shirt, 6-inch	None	>1500	120,000 (failure at bottom of drum)	45.00	33.75
3. None, plus skirted inner lid	None				
a. 4-inch skirt		975	-		
b. 6-inch skirt		>1000	120,000 (failure of bottom of drum)	60.00	45.00
4. None	C-clamps				
	a. 6 C-clamps with lock-ring	>1000	105,000	15.00	15.00
	b. 12 C-clamps with no lock ring	1000	-	9.00	9.00

[a] Adapted from Otts, John V., "Special Closure for Radioactive Shipping Container," SAND 75-0517, Sandia Laboratories, Albuquerque, NM 87115, (March 1976).

[b] If the internal packing material was visible after the impact or crush test, the package was considered failed, since it then would be vulnerable to fire.

[c] Thirty foot (9m) drop of the loaded package onto a flat, essentially unyielding surface, with package in orientation deemed to produce the most damage.

[d] Static load applied to loaded drums lying on the side, the load being evenly distributed over the drum by means of a aluminum plate.

Table III (Continued)

Closure Design				Estimated Unit Cost ($)	
Modification to Standard Lid	Modification to Standard Lock Ring	Package Weight (lbs) for Failure Criterion[b] to be Observed in Impact Test[c]	Static Force (lbs) for Failure Criterion to be Observed in Crush Test[d]	100 Unit Order	1000 Unit Order
5. None	Clips and extension skirt				
	a. 6 clips underneath standard lock ring	700	-	45.00	33.75
	b. No clips with extended lock ring	700	-	45.00	33.75
	c. 8 clips alternately above and below standard lock ring	750	-	60.00	45.00
6. None	Extended lock ring plus inserted moulded rubber gasket (U.S. Reg. Pat. No. 3,790,020)	>1000		14.00[e]	12.60[e]

[e]Correction to Reference a included in a letter from Harry H. Fine Associates to Mr. Charles E. MacDonald, U.S. Nuclear Regulatory Commission, dated May 4, 1978.

Table IV

CONCLUSIONS OF SANDIA DRUM TEST STUDY[a]

1. The critical container weight of a standard 17C closure is 600 pounds.

2. The critical container weight of a standard 17C container, neglecting closure, is a minimum of 1000 pounds.

3. The "six-inch lid extension" technique strengthens the 17C closure to a critical container weight of 1500 pounds minimum.

4. The "six-inch internal lid" technique strengthens the 17C closure to a critical container weight of 1000 pounds minimum. A four-inch internal lid protects to 1000 pounds maximum.

5. The "C-clamp" technique strengthens the 17C closure to:

    a. 1000 pounds minimum with six C-clamps over the lock ring, and

    b. 950 pounds maximum with 12 c-clamps and no lock ring.

6. The "clip" technique, using eight clips on the top and bottom of the lock ring, strengthens the closure to 800 pounds maximum. The technique was not pursued beyond this point.

7. The closure manufactured under U.S. Reg. Pat. No. 3,790,000 strengthens th 17C closure to a critical container weight of 1000 pounds minimum.

8. The 17C lid closure fails a crush test at 110,000 pounds static load, while the 17C container bottom fails at 120,000 pounds.

9. Both the "six-inch lid extension" and "six-inch internal lid" techniques extend the 17 C closure failure beyond the container bottom capability of 120,000 pounds static load.

10. Using six C-clamps and lock ring, the "C-clamp" technique fails to improve the normal lid closure crush limit of 110,000 pounds.

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[a]Otts, John V., "Special Closure for Radioactive Shipping Container," SAND 75-0517, Sandia Laboratories, Aubuquerque, NM 87115 (March 1976).

Table V

CLOSURE TECHNIQUES RATED BY CATEGORIES[a]

	Impact Protection	Static Protection	Added Cost	Redesign Required	Ease of Assembly	Vulnerability to Operator Error
6" Lid Extension	1[b]	1	2	No	1	1
6" Inner Lid	2	1	3	No	2	1
6 C-Clamp on Lock Ring	3	2	1	No	3	2
(Moulded Rubber Gasket & Extended Lock Ring[c]	2	?	1	No	3	2

[a] Otts, John V., "Special Closure for Radioactive Shipping Container," SAND 75-0517, Sandia Laboratories, Albuquerque, NM 87115 (March 1976).

[b] Category 1 is the best of three categories.

[c] This closure was designed and patented under U.S. Reg. Pat. No. 3,790,020.

The risk to public health and safety from accidents to shipments of LSA materials is quite small. In NUREG-0170 (Table 5-9, p. 5-34), the highest such risk is represented by an annual expectation of $7. \times 10^{-4}$ latent cancer fatalities per year for 1975. This risk derives from transportation accidents to shipments of packages of mixed fission products and mixed corrosion products (MF + MC (LSA) in Table 5-9). The corresponding risk from yellowcake shipments (U_3O_8 in Table 5-9) is nearly ten times smaller. This discussion illustrates that the value of taking regulatory action to protect against accidents involving LSA shipments can vary depending on the details of the shipments, but in no case is the existing accident risk or the consequences of a single accident so high that action need be taken without regard for its cost-effectiveness.

The cost-effectiveness of requiring these improvements in drum closure methods may be examined by comparing the cost of the improvements with the possible savings in radiological dose and with the cost of decontaminating the area affected by the spill. In this cost-benefit analysis, different parties pay the costs or reap the benefits. The shipper might be assessed the cost of improving drum closures, but the public as well as carrier and rescue personnel, who might be Federal, State, local government, or possibly shipper employees are saved the radiological doses from spills that the closures would minimize; the carrier is saved most of the cost of decontamination from the resulting minimization of spills.

Costs of Improving Drum Closures

Cost of all improved packages for one shipment

From Table III, the cost of improving drum closures varies from \$12.60-\$60 per drum. This cost is significant when compared to the probable price range of \$10-\$20 for a single drum. The drum contains valuable material, but this value does not enter the cost effectiveness consideration because none of the material would be lost in an accident in which the spilled material is recovered. In the standard shipments model developed in NUREG-0170, a standard shipment of drummed yellowcake was estimated to hold 40 drums. In the Colorado accident, the trailer was loaded with 50 drums, which is probably as large a shipment as occurs. The cost of providing all improved packages for one shipment is then \$500-\$3000.

Cost of all improved packages for one year

Since every shipment does not encounter an accident, more than one shipment's worth of drums must be improved to realize the savings in cleanup costs or radiological dose. If enough drums were improved for one year of shipments, which was estimated in the standard shipments model of NUREG-0170 as 5.4×10^4 drums by truck and 6.6×10^4 drums by rail, or 120,000 drums in all, the cost would be 1.5-7.2 million dollars.

Some of these improved drum closures could be used more than once. For a projected mill capacity of 1000 tons of ore daily,[19/] about 25 shipments are required per year. If the cost of improving drum closures is incurred only for the first of these shipments, then the optimal first-year cost is \$60,000-\$290,000. The actual range of first-year costs probably lies between these extreme ranges. If a typical improved drum closure is used for ten shipments, the first-year drum closure improvement cost would be \$150,000-\$720,000.

Cost of all improved packages for one severe accident

If the improved drum closures could be used under normal conditions indefinitely without replacement, the costs for a year's supply of improved closures would be incurred initially and the costs for improved closures in the damaged shipment would be incurred after each severe accident. However, if an improved drum closure can only be used 10-25 times, as assumed above, then a year's supply of improved drum closures must be purchased each year or more often. Since the severe accident rate implies that the time between such accidents is about ten years,[20/] the annualized cost of improving drum closures is represented by the first-year cost discussed above plus one tenth the cost of providing all improved drum closures in the damaged shipment (assuming the entire shipment is damaged in the accident). For the assumed optimum case, the annualized cost would thus range from \$60,050 to \$290,300.

Savings in Radiological Doses

In the Colorado accident, a total of 44 persons were exposed to uranium and 126 samples of urine were taken. Nine of these samples showed concentrations larger than the detectable limit of 10 micrograms uranium per liter of urine (μg/ℓ), but the maximum concentration was 18.1 μg/ℓ.[8/] For comparison, the normal concentration in individuals with no known exposure to uranium has been found to vary from 0.03-0.3 μg/ℓ.[12/] In guidance now under development,[13/] a value of 130 μg/ℓ obtained within two weeks following a single intake of yellowcake is used to indicate possible chemical damage to kidney tissue. This value roughly corresponds to a blood content of 2.7 mg uranium, which corresponds to a weekly average of the limiting concentration for kidney damage (3 μg uranium/g kidney). In the literature, "one case of acute inhalation exposure 'seemed to produce albuminuria [water soluble protein in the urine]' where the urinary excretion rate was 2 mg/ℓ, which is equivalent to 4.2 mg instantaneously injected into the blood."[14/] Other estimates of blood content ranging from one mg to 14 mg with either no observed effects or observed effects judged as safe have been discussed in the literature.[14/]

The maximum concentration detected translates to a lung dose commitment (total radiation dose-equivalent to the lung that will be received from an intake of radioactive material during the 50-year period following the intake) of about 450 millirem (mrem),[15/] a small lifetime dose. The total population lung dose from this accident is estimated to be 7.5 man-rem. To convert these lung doses to whole body doses, we note that inhalation of one microcurie (mCi) of yellowcake dust results in a lung dose of 47.3 rems and a whole body dose of 1.17 rem.[16/] Applying this ratio to the lung doses above, the largest individual whole body dose is found to be 11 mrem and the total population whole body dose is found to be 0.19 man-rem.

The NRC regulations provide that until better information becomes available, measures taken to reduce population exposure from nuclear reactors need not cost more than $1,000 per man-rem.[17/] In the case of the Colorado accident then, improvements in drum closure methods are not cost-effective unless they are sure to save 0.2 man-rem for each accident of the Colorado severity and do not cost more than $200 for each such accident. The corresponding annualized reasonable expenditure for saving radiological dose is $20.

Savings in Cleanup Costs

The cost of cleaning up the Colorado accident has been estimated at $150,000-$200,000.[18/] The annualized cost for each such severe accident would be $15,000-$20,000.[20/]

Cost-Benefit Comparison

Comparison of the annualized costs discussed above for improving drum closures to the estimated total costs of cleanup for the Colorado spill of yellowcake indicates that such an improvement could be cost-effective only if the least expensive closure method is used and if individual drum closures are reused sufficiently often. The actual management of drums may work against these efficiencies. For example, some drums of yellowcake may be stored temporarily at the conversion plant rather than returned empty back to the mill, as is necessarily assumed in these estimates. Such storage would either require that new drums be outfitted with new closures or that the improved closures be removed from the drums going into storage and reused on drums actually in transit. The stored drums must then be outfitted with standard closures. All these extra operations would increase the costs.

In summary, on comparing the optimum annualized drum closure improvement cost range of $60,050-$290,300 to the annualized estimated cleanup cost range of the Colorado accident, $15,000-$20,000, and the corresponding annualized reasonable expenditure for saving radiation dose, $20, the improvement of drum closures does not appear to be cost-effective.

(b) Gauge

The strength of a package constructed with a specific shape and material is defined by failure criteria associated with different types of loading. Since many types and combinations of loads can be produced in a transportation accident, it is not possible to give specific statements about strength as a function of gauge thickness but, in general, strength of a material increases with thickness of the material. For a thin walled cylindrical vessel (e.g., a drum), the strength with respect to uniform axial and internal pressure loads increases linearly with thickness. The buckling of long thin cylinders with respect to axial loads also varies linearly with thickness but for external pressure loads, the buckling varies with the cube of thickness. Under accident crush conditions, the deformations of a thin-walled cylinder would usually be local and the bending strength of the cylinder would be most significant. Bending strength of a material generally increases with the square of the thickness of the material. Under impact loading, increase in strength with wall thickness is probably not as important as for these static loads. For drop tests of drums of LSA material, a much greater fraction of the energy absorbed by the package during impact may go into deformation of the contents than of the drum walls. The effect of increasing wall thickness may thus not be significant.

2. Shipment Configuration

a. Tie-Down Systems

For an exclusive use shipment of packaged LSA material, the DOT requires bracing to prevent leakage or shift of lading under conditions normally incident to transportation (49 CFR 173.392(c)(5,6)) and prohibits any loose radioactive material in the vehicle. Usually these requirements are met by close packing of closed packages. No tie-down system is specifically required to meet these requirements.

Assuming the Colorado shipment was braced according to DOT rules, the bracing was partially effective in keeping some of the barrels in the truck. If tiedowns had been required, all the barrels would likely have remained in the truck. Would the top of the truck have been punctured? If not, then even if the barrels had spilled their contents, the contents would have stayed in the truck. If so, then the tiedown requirements would not be as effective as planned because material would still be spilled on the ground, although the amount of spillage would probably be decreased from that which actually occurred in the Colorado accident.

Two possible simple arrangements of restraining apparatus are considered here. Other arrangements are conceivable but probably would be more complicated and thus less cost-effective. One arrangement is a bar or cable placed across the top of a row of drums in each layer of drums within the cargo space of the vehicle. Another arrangement is a bar or cable separating groups of drums, say two rows in each layer, to spread crushing forces evenly among a number of drums thereby preventing damage to drums loaded in the front of the vehicle from the crush loads of those pushing forward from the rear.

Either arrangement of such restraining apparatus is estimated to cost $1,000 for a single vehicle (truck or rail car), but could be reused perhaps 25 times a year (for a typical uranium mill) and may last 20 years. In the standard shipments model of NUREG-0170, the number of yellowcake shipments is estimated to be 3,000 for 1975 and 12,000 for 1985. Assuming a constant rate of increase and assuming that restraining devices are required, the number of vehicles that would have to be outfitted the first year (1975) is 120 and for each of the first 20 years afterward is 36. During the second 20 year period, the number of annual installations would include the linear increase of shipping and also be increased by the number of installations made 20 years before (see Table VI). For example, in 1995 the number of installations would be 156 and in each successive year of the second 20 year period, the number of installations would be 72. Consequently, the annual cost of such restraining devices would vary from $120,000 in the first year to $36,000 in each of the second to twentieth years to $156,000 in the twenty first year to $72,000 in each of the twenty second to fortieth years and so on.

However, the cost of the apparatus is probably not the deciding factor in determining the cost-effectiveness of such a system. The crucial costs would probably be the manpower needed to install the apparatus, which may vary from 1 hour (for both ends of the trip) for a rudimentary system where the restrainers could be connected quickly and the separators are simply set in place, to perhaps 5 hours where the apparatus is carefully bolted in place and perhaps prestressed to provide an engineered tiedown system clearly capable of withstanding accidents. At an average cost of $5 an hour for three persons, the rudimentary system could be installed for $15 per shipment and the engineered system could be installed for $75

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TABLE VI

ESTIMATED ANNUAL COSTS FOR YELLOWCAKE
SHIPMENT RESTRAINING SYSTEMS

Year	No. Shipments	No. Systems Installed	Equipment Costs ($K)	Installation Costs ($K) Rudimentary ($15/Shipment)	Installation Costs ($K) Engineered ($75/Shipment)
1975	3,000	120	120	45	225
1976	3,900	36	36	58	292
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
1985	12,000	36	36	180	900
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
1994	20,100	36	36	302	1,508
1995	21,000	156	156	315	1,575
1996	21,900	72	72	328	1,642
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.

per shipment. The estimated equipment and installation costs are summarized in Table VI. None of these estimates includes the effects of inflation, which would increase the costs.

As estimated earlier, the population lung dose commitment from the Colorado accident is 7.5 man-rem. In NUREG-0170, the annual expected number of latent cancer facilities from accidents to yellowcake shipments is estimated to be 8.2×10^{-5} for 1975 and 3.4×10^{-4} for 1985. These estimates correspond to annual population lung doses of 3.7 and 15 man-rem, respectively. The corresponding annual population whole body doses are 0.09 and 0.38 man-rem, respectively. According to the NRC guide of not spending more than $1,000 per man-rem to save that much dose, the tiedown systems are not cost-effective unless they are sure to save 0.09 man-rem per year for 1975 and 0.38 man-rem for 1985 and do not cost more than $90 per year for 1975 and $380 per year for 1985.

If a transportation accident as severe as the Colorado accident occurs no more often than once every ten years, as predicted from the known accident rates, then the annualized cleanup costs taken from the Colorado experience, averaged over that recursion period, would be $15,000-$20,000 per year. From the foreging discussion, the annual costs of tiedown systems clearly exceed this range of values. Therefore, requiring tiedown systems for yellowcake or LSA material shipments does not appear to be a cost-effective alternative.

b. Vehicle Design

The elements of vehicle design of chief interest in this study pertain to whether the cargo space is open, closed, or partially closed. A partially closed cargo space is exemplified by a truck bed with high walls but no top. The DOT requires that unpackaged bulk LSA material be transported in a closed vehicle consigned to the exclusive use of the consignor (shipper), but for packaged bulk material a closed vehicle cargo space is not required.

If requirements for tie-down systems were to be introduced without concomitant hardening of the package designs, then requirements for closed vehicles might also be desirable to minimize spillage from the vehicle. For the restraining systems discussed above, the vehicle may impose an additional structural constraint. For example, trucks in normal transportation usage may be able to accommodate the rudimentary quick-connect system of bar or cables, but may have to be specially designed to accommodate the engineered prestressed system. The use of specially designed trucks could be very expensive. We have not developed information on this factor since the engineered tiedown system does not appear to be cost-effective, at least not for yellowcake shipments.

3. Shipment Planning

a. Routing Control

The Department of Transportation (DOT) has broad authority to regulate safe transportation of all hazardous materials, including radioactive materials, in interstate and foreign commerce. Routing control as related to safe transportation is within DOT's broad authority.

The Interstate Commerce Commission (ICC) regulates economic aspects of surface carriers, approving or disapproving routes and rates requested by carriers. The approval is based on public interest and on noninterference with other carriers.

The NRC regulates the receipt, possession, use and transfer, including transportation, of byproduct, source, and special nuclear materials. In view of the regulatory controls exercised over common and contract carriers by the DOT, the NRC exempts these carriers from its regulations. In terms of routing control, the NRC could impose routing requirements on its licensees and thus indirectly control the carrier routing. Otherwise, rule changes would be required for the NRC to remove the carrier exemptions and directly control carrier routing.

The shipper licensee may control routing when he transports his own material or when a contract carrier transports his material. The shipper may not be able to control the routing of a common carrier because a shipper-specified route may or may not be authorized by the ICC for that carrier. The ICC classification recognizes two general types of common carriers: regular route carriers and irregular route carriers. Regular route carriers have fixed routes and, in general, fixed schedules. Irregular route carriers are authorized to transport goods between origin and destination with no restrictions on routing. If a carrier wants additional routes, he may request ICC approval on either temporary (emergency) or permanent bases.

The DOT's motor carrier safety regulations (49 CFR 397.9) require that

> Unless there is no practicable alternative, a motor vehicle which contains hazardous materials must be operated over routes which do not go through or near heavily populated areas, places where crowds are assembled, tunnels, narrow streets, or alleys. Operating convenience is not a basis for determining whether it is practicable to operate a motor vehicle in accordance with this paragraph.

Although the intention of the requirement is well defined, it is not known how vehicle operators implement this requirement. Furthermore, only token efforts are made to determine whether carriers are observing the requirement. Almost all of the large cities on the limited number of highways over which yellowcake is transported have by-passes which would be considered "practical alternatives" to passing through the city centers. Any yellowcake shipments seen passing through densely populated areas should be reported to the DOT for investigation and possible enforcement action.

In terms of safety, it is desirable to have shipments of radioactive material transported along routes which present minimum risk. Two of the shipment variables which directly bear on risk are the population environment of an accident and the probability of a severe accident. Consequently, two ways to minimize risk are to route shipments to avoid densely populated areas and to avoid adverse road conditions.

It is not practical to prohibit all shipments of radioactive material from all densely populated areas because the benefits from the use of the material frequently occur in the cities (e.g., in hospitals and universities). Furthermore, it is not necessarily true that routing around densely populated areas would have the effect of reducing risk, as will now be discussed.

In NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes," one alternative to the present transportation system considered was the restriction of radioactive material transportation to avoid high population zones by routing shipments around cities and routing air shipments into suburban airports rather than urban airports. This alternative produced very small changes in the estimated radiological risk, but relatively large increases in the estimated monetary costs of delivering the packages.

NUREG-0170 also showed that the consequences of greatest severity accidents involving major releases of highly toxic radioactive materials, such as plutonium or polonium in densely populated areas (extremely low probability events) could produce serious injuries and up to 150 latent cancer fatalities over a 30-year period. Because such shipments are infrequent and made in accident resistant packages, such a major release is very improbable, and thus contributes little to the national average annual impact of transportation activities. Selective routing of high-consequence shipments might be useful in reducing consequences of severe accidents and apprehension about such accidents, but would have very little effect on the overall risk.

It is desirable for shipments of radioactive material to avoid routes that are designated dangerous by local or state authorities, for example, highways covered by snow and ice, highways covered by oil or other chemicals, routes under attack during civil unrest, highways with load limitations, weak bridges, narrow passages, or roads under flood or landslide. Routing restrictions regarding local temporary conditions are generally imposed by local authorities and are not considered further here.

Based on the detailed assessment in NUREG-0170, the risk to public health and safety from shipments of LSA material, including yellowcake, is very small essentially because of the low concentration of radioactivity distributed throughout the material. In view of the limited number of routes normally used and of the low risk, no additional controls appear to be necessary for yellowcake shipments.

For other radioactive materials, the matter of routing control is presently under separate studies: the NRC environmental statement on transportation of radionuclides through urban environs and the DOT public rulemaking proceeding on the routing of highway movements of radioactive materials. The draft NRC environmental statement is expected to be published for comment in 1979.[20a/] The DOT rulemaking proceeding can be anticipated to take about two years.[20b/]

b. Speed Control

One of the fundamental causes of transportation accidents is excessive speed. All State and local governments post speed limits to control both the accident rate and the severity of accidents that do happen. The Federal government supports State speed limits on its system of interstate highways through its funding of State maintenance programs on these highways. The possibility of additional Federal controls on speed has been suggested in Congress.[21/] However, in view of the existing speed limits and the excellent safety record for transportation of radioactive materials under these limits, any additional regulations or licensing conditions on this matter appear to be unwarranted.

c. Advance Notification

The DOT has the authority to require carriers or shippers to notify the DOT of shipments of radioactive materials in interstate and foreign commerce. The NRC has the authority to require its licensees to do the same for shipments of NRC licensed materials. State and local jurisdictions can also, under their police powers for protecting their citizens, require shippers or carriers to notify them in advance of shipments of radioactive materials passing through their respective jurisdictions.

In the 1960's, the Atomic Energy Commission (AEC), on a trial basis, required licensees to notify it in advance of each shipment of spent fuel. The AEC in turn notified each State through or into which each shipment would go. After a few months, the procedure was discontinued because the States seldom used the information and soon expressed lack of interest in that information. The effort required to administer this notification system was significant for the small number of shipments involved, primarily because of frequent changes in the timing and routing of the shipments.

The NRC currently requires licensees to notify NRC Regional Offices seven days in advance of licensed shipments containing certain quantities and types of special nuclear materials (10 CFR 73.72). After such notification, the Regional Office may inspect these shipments for compliance with the applicable Federal regulations.

Recently, several States have required advance notification of certain shipments. They have imposed such requirements through State legislative or other procedures or in some cases obtained such commitments through informal agreements with individual reactor operators. State or local requirements for advanced notification of shipments of quantities and types of special nuclear material protected in accordance with NRC regulations or DOE directives should not be imposed; such requirements may conflict with certain Federal restrictions related to controlling sensitive information pertaining to such protected shipments.

In the IAEA regulations for the safe transport of radioactive materials (1973 revision), advanced notification of the national competent authority is required for transporting through or into a country shipments of large Type B packages for which only unilateral approval is required, all Type B packages for which multilateral approval is required, Fissile Class III packages, and packages transported under special arrangements.[21a/] The DOT is working on amendments to its regulations to make them consistent with the 1973 IAEA regulations. A requirement for advanced notification of international shipments similar to the IAEA requirement will likely be proposed by the DOT.

Advance notification may or may not affect safety, depending on the subsequent actions taken by State or local jurisdictions in response to such notification. For example, upon notification, if the State takes action such as to provide police escort, to notify State and local health authorities, or even to keep a close watch on the shipment, the notification could reduce the likelihood of an incident and could assure early response of emergency crews if an incident did occur. However, based on the assessment of NUREG-0170, such improvement in safety would be small. On the other hand, if no action is taken, the notification would merely represent a transfer of information and no improvement in safety would result.

The cost of notification would be high if all types of shipments were included in the procedures. About 2.5 million packages of radioactive material are shipped each year in the United States.[24/] However, shipments of small quantities or shipments with limited potential consequences even though released, such as those on which this report is focused, could be excluded from such a requirement. Due to the documented[22/] large number of shipments of low-level radioactive material compared to shipments of high-level radioactive material, notification for shipments of low-level radioactive material does not appear cost-effective.

d. Up-to-Date Transportation Data System

Collection of shipment data does not directly improve transportation safety. However, such information is necessary to estimate, either on a national or regional basis, the risks to society from transportation and the impact of changes in the safety regulations on shipments. An occasional survey involving a significant sample of shipments made in the U.S. may be sufficient to satisfy this need for such information. A system for maintaining up-to-date transportation data would not contribute more in terms of safety than a selected survey because the volume of shipments is large and does not vary significantly from year to year. If any type of shipment increases significantly, a separate survey may be conducted to obtain information on that specific type of shipment.

The NRC has the authority to require licensees to report data on shipments of licensed materials. However, any reporting requirement must be cleared through the General Accounting Office (GAO). The GAO will consider each request for approval on criteria such as: the need and purpose for requesting the information, availability of that information from other sources, justification for each item requested, the burden on industry in providing the information, and the cost to the Federal government for collecting the information.

In 1975 the NRC contracted with the Pacific Northwest Laboratory (PNL) to conduct a one-time survey of radioactive material shipments in the U.S. The data have been used in NUREG-0170[22/] as the basis for evaluating the environmental impact of the transportation of radioactive materials.

An ongoing study of the environmental impact of transportation of radioactive material through urban areas will also use the information extracted from the data collected from the PNL survey. Both regional and national information may be obtained from the data base through the computer program system maintained at Sandia Laboratories.

As part of the NRC safeguards program, a Nuclear Material Information System (NMIS) is maintained at the Oak Ridge National Laboratory by the Department of Energy (DOE). Each licensee who transfers one gram or more of special nuclear material, 1,000 kg or more of source material or certain quantities of byproduct materials, must complete Form NRC 741 and submit copies to the DOE Oak Ridge Operations Office and to the shipper within 10 days after the material is received (10 CFR 70.54). In addition, advance notification of NRC Regional Offices is required for shipments containing strategic quantities of special nuclear material (10 CFR 73.72).

The cost to obtain up-to-date information for all radioactive material shipments in the U.S. appears to be prohibitively expensive. A previous one year shipment survey conducted in 1975 cost $165,000 in contract funds, not including the cost to the industry in providing the requested information. This study contacted about one seventh of NRC and Agreement State licensees. Except for special nuclear materials and source materials for which the survey period was one year, the survey period for byproduct materials varied from one week (for shippers with large shipping activities) to six months (for shippers with infrequent shipping activities). For a continuous system to collect up-to-date shipment information, the contract cost is estimated to exceed one million dollars annually. Accordingly, a system for maintaining up-to-date transportation data should not be imposed.

4. Hazards Information

A basic aspect in the management of the on-scene situation during hazardous materials transportation incidents is the communication of information to interested parties on the type of hazardous material, its properties, and the health and safety hazards of the material. One means by which basic information on hazardous materials shipments is conveyed is given by Hazardous Materials Communications requirements of 49 CFR Part 172. These regulations require that shipments of radioactive materials be accompanied by a description of each radionuclide contained, its chemical and physical form, its radioactivity, the label category and transport index (measure of external radiation levels), and whether the package is Type A or Type B (accident resistant). These requirements involve a system of labels for packages, placards for vehicles, shipping paper description and other package markings. In general, however, these requirements do not specify the inclusion of detailed information concerning the nature of the material or precautions to be taken in the event of its leakage or spillage. The question discussed here is whether there should be a regulatory requirement that each shipment of radioactive materials be accompanied by an information packet, with the packet containing information concerning the hazardous nature of the material, precautions to be taken in the event of leakage or spillage in normal or accident conditions, and notification requirements.

In many cases, however, detailed handling instructions are provided voluntarily by the shippers such as in the Colorado yellowcake spill (See Appendix II). Another example is in the case of U.S. government shipments of uranium hexaflouride where it is customary for the shippers to actually post a set of instructions on the side of the transport vehicle. These types of instructions can and have been very instrumental in providing early detailed information on how to handle the material in a spill. Clearly, however, early information on how to contact the shipper can also accomplish the same result.

For radioactive materials shipments the DOT regulations (49 CFR 172.203(d)) contain an extensive list of required information (See Appendix III). This information is in addition to that required for all hazardous materials shipments pursuant to 49 CFR 172.200 through 172.202 (See Appendix III). Examination of those sections indicates that considerable additional shipping paper detail is already required for radioactive materials that is not required for other hazardous materials.

It is not clear from the history of past incidents involving low-level radioactive materials that a lack of detailed information beyond that already available from shipping paper descriptions has been a serious contributing factor to either the severity of the event or to its management.

The Department of Transportation has previously considered the adoption of a Hazard Information System (HI) which would enhance the communication of information on the nature of the hazards of a material during normal and accident conditions of transportation. The first proposal in 1974 for a HI system scheme was withdrawn in 1975 in favor of a request for public advice on that system and on a number of alternative schemes. A large number of public comments have also been received. At the United Nations (UN), the Group of Experts on Transport of Dangerous Goods has been considering the adoption of an HI system for several years. It now appears that the UN group will not adopt a formal HI number scheme but will base its emergency response information needs on the UN Serial Number which is assigned and peculiar to each listed hazardous material.

The foregoing discussion serves to illustrate the complexity of the matter. In this particular issue, the question really involves more than the HI system itself, i.e., whether to require something additional to labels, placards and shipping paper descriptions, in the form of a HI code number, but going beyond that to require provisions for an "instruction sheet" on the hazards of the material involved. In the Colorado yellowcake incident, the shipper had provided such information (See Appendix II), and the availability of this data sheet was reportedly very helpful in enabling the sheriff, first arriving at the scene to contact the shipper quickly for early advice and instructions.

There does not appear to be a need to amend DOT regulations at the present time to include requirements for shippers to provide, and carriers to maintain during transport, emergency personnel detailed instructions on the hazards of low-level radioactive materials. The existing requirements for inclusion of shipping paper descriptions appear to be adequate. Efforts by shippers to provide such information voluntarily, especially in the case of bulk cargos, should however be encouraged. The future development and implementation of a regulatory requirement for additional communications on the hazards of the materials by means of the UN Serial Number may provide another means of supplementing the information currently provided by shipping papers. However, the addition of an emergency telephone number on shipping papers could assist emergency response in the event of an accident and should be required.

5. Inspection of Regulatory Compliance

Both the NRC and the DOT conduct programs of inspection and enforcement to assure compliance with their respective regulations. Overlaps in responsibilities and activities of the two agencies in regulating the safe transportation of radioactive materials are addressed in a Memorandum of Understanding to avoid unnecessary duplication of regulation. This Memorandum of Understanding is now under revision.

a. NRC Inspection and Enforcement

The NRC Office of Inspection and Enforcement approaches this aspect of regulation by means of two types of inspection--preventive or routine inspections and reactive inspections. During these routine inspections, NRC inspectors may observe work in progress, check records of all types, interview people, and, where appropriate, make direct measurements. Transport activities subject to inspection include quality assurance during package fabrication, use of packaging techniques, procedures for opening and closing packages, package maintenance, records of shipments, and reports of incidents and defective packages.

Reactive inspections are conducted by the NRC Office of Inspection and Enforcement in response to information received by NRC regarding transport conditions or occurrences involving NRC licensed material. Such information may come from routine NRC inspections, from an NRC licensee, or from a member of the public. The NRC response to the information depends upon the significance of the particular condition as determined by NRC's independent investigations.

Since 1973, the NRC and its predecessor agency, the Atomic Energy Commission (AEC), through its Office of State Programs, has been conducting with the DOT a State Surveillance Program. Under this program, individual State and local governments contract with the NRC to inspect packages of radioactive material, the vehicles in which they are shipped, and the facilities in which they are handled. Twelve States and local governments have participated in this program. The program provides a means for these governments to become familiar with transportation of radioactive materials and with the Federal regulations and provides significant inspection assistance to the Federal government. The primary program objectives are: (1) to obtain data on the physical condition of packages containing radioactive material and the degree of compliance with existing regulations, (2) to gather information and data concerning radiation levels in the transportation systems work places, (3) to determine radiation doses received by personnel in such work places, and (4) to obtain data on the extent personnel comply with instructions and regulations for handling radioactive material packages.

In general, the surveillance programs do not indicate a significant health or safety hazard to cargo handlers or members of the public due to the transportation of radioactive materials. Compliance with the DOT regulations is observed in most cases. In those reported instances of non-compliance, none of the violations had any immediate health and safety significance. These programs have detected a problem with the routine exposure of employees of freight forwarder firms. The participating States recommend that the program continue.[23/]

b. DOT Compliance Assurance

The general objectives of the DOT radioactive materials compliance assurance program are to assure that such shipments are offered in compliance with the regulations, and that packagings are manufactured, marked, and maintained as prescribed in the regulations. These compliance objectives are fulfilled by the programs of the modal operating administrations of DOT (i.e., the Federal Aviation Administration, Coast Guard, Federal Railway Administration, and Federal Highway Administration), supplemented by the efforts of the Materials Transportation Bureau (MTB). Specifically, one of the MTB's compliance objectives is to perform inspection, compliance, and surveillance in the areas not covered by the DOT operating administrations in their normal operations, particularly intermodal shippers and packaging or container manufacturers, sellers, reconditioners, and repairers. This involves a specialization of personnel in the areas of multi-modal regulations and container manufacturer's requirements.

The operational approach taken in the MTB's hazardous material compliance program is believed to be representative of that taken by the other DOT operating administrations. It is basically as follows:

<u>Analysis Activity</u>

Analysis of compliance information for indication of noncompliance. The (HMI) Hazardous Materials Incident Reports (DOT Form 5800.1) are the primary source of data. Indications of carrier violations are transmitted to the appropriate operating administration. Indications of shipper violations are handled by the MTB or forwarded to the appropriate modal operating administration. Other sources of information include MTB field operations, complaints from the public, and information from other agencies such as NRC.

Inspection Activity

Information is gathered during compliance surveys of shippers and container manufacturers as well as by observations of shippers, consignees, and carriers to detect noncompliance.

Investigation Activity

Information is developed from HMI reports, field operations and complaints from the public.

Enforcement Activity

Civil forfeiture and criminal cases, as well as compliance orders, are prepared and issued as cases warrant.

Accident Investigation

Such activity is principally in selected cases, sometimes where technical expertise is needed concerning the material or packaging involved.

The compliance efforts of DOT in transportation of radioactive materials are an integral part of the Department's overall program in compliance/enforcement of the hazardous materials transportation regulations. Radioactive materials therefore are not specially singled out and treated separately in this activity. As mentioned earlier, these efforts are carried out in the programs of the modal operating administrations, supplemented by the MTB program. In Table VII, the personnel resources of the Department for 1976-1977 are indicated.

TABLE VII

DOT COMPLIANCE AND ENFORCEMENT ACTIVITIES

Operating Administrations	Compliance and Enforcement Person-Hours		Full-Time Hazardous Materials Inspectors		Part-Time Hazardous Materials Inspectors				Total Inspector Person-Years	
	1976	1977	1976	1977	1976		1977		1976	1977
					No.	% Time	No.	% Time		
Coast Guard	249,840	193,680	0	0	694	20	717	15	138.8	107.6
Federal Aviation Admin.	115,200	117,360	22	20	109	39	129	35	64	65.2
Federal Highway Admin.	62,280	62,280	9	9	128	20	128	20	34.6	34.6
Federal Railway Admin.	54,540	40,140	18	16	82	15	42	15	30.3	22.3
Materials Trans. Bureau	1,800	9,360	0	5	4	25	3	6	1	5.2
Totals	483,660	422,820	49	50	1,017	-	1,019	-	268.7	234.9

Experience in transportation of radioactive materials indicates that such materials have been transported very safely. At the present time, the volume of radioactive shipments is about 2.5 million packages per year in the U.S.A.[24/] During the period 1971-1975, i.e., the first five years of operation of the DOT's hazardous materials incident reporting system (HMI), more than 32,000 HMI reports were submitted by carriers for all types of hazardous materials. Only 144 reports, or 0.45 percent, were indicated to involve radioactive materials.[25/] By comparison, 16,406 reports involved flammable liquids and 10,672 involved corrosives, or 51 and 33 percent of the total, respectively. Of the 144 radioactive materials reports, only 36 reports indicated any release of materials from its containment, or unusual radiation levels. The majority of the incidents involved only minor leakage and radioactive contamination.

When measured against actual experience therefore, the DOT believes that the present level of compliance/enforcement in transportation of radioactive materials is appropriate, as is the integration of such efforts into its overall hazardous materials program.

B. Transportation of the Radioactive Material

1. Review of Past Events

Since 1975, three incidents have drawn particular attention, two in North Carolina and one in Colorado. The first was a truck incident involving a load of low specific activity material being shipped from the Millstone

Nuclear facility in Connecticut to Savannah River. When the driver pulled into a truck stop in North Carolina he noticed that the lid of one of the crates was loose. He immediately called the State Highway Patrol who in turn called a representative of the Radiological Health office of North Carolina. This office responded to the scene and determined that a leakage had occurred of about three tablespoons of water which was slightly radioactive and came from condensation on some of the metal parts in the box. The radiological health officer was slightly contaminated but was able to clean himself off by washing. The lid was then put back on the crate and the truck proceeded on its way.

This incident is a good example of the problem of maintaining perspective in transportation accidents involving radioactive materials. News stories sent back to Connecticut indicated that a relatively large amount of radioactivity was released and that the radiological health officer was "deluged" with contaminated water. The elected officials in Connecticut became concerned because the shipment originated there. An NRC inspector, however, indicated that in his professional judgment the amount of radioactivity released was insignificant. The State radiological health officer concurred with this opinion. In this example, concern was generated by lack of adequate communications and understanding rather than by health consequences; in short, perspective was lost. Connecticut subsequently urged the NRC and the DOT to improve reporting of incidents involving nuclear wastes. The actual response capabilities of the State, the shipper, or the carrier were not questioned.

The second incident involved a derailment of 29 cars from a Seaboard Coastline train at 7:30 a.m., on March 31, 1977, near Fort Bragg and Rockingham, North Carolina. Included in the shipment were four 16-ton casks of unenriched uranium hexafluoride enroute to the Paducah, Kentucky, gaseous diffusion plant. The UF_6 casks were slightly damaged in the accident and in the resulting fire, but no radioactivity was released. A large number of agencies responded to this incident.

The Division of Civil Preparedness of North Carolina was notified at 8:30 a.m. of this accident and the Radiation Protection Branch of the North Carolina Department of Human Resources was notified at 8:45 a.m. After preliminary inquiries to the designated consignee, Union Carbide in Paducah, Kentucky, and to the carrier, Seaboard Coastline in Raleigh, the North Carolina Radiation Protection Emergency Team departed by Highway Patrol helicopter, arriving at the accident site at 11:00 a.m. Before this Team arrived, however, the following groups of people had arrived: (1) State Highway Patrol, (2) County Sheriff, (3) Civil Preparedness Area Coordinator, (4) Seaboard Coastline officials, (5) Fire Department, (6) ambulance and rescue squad, (7) news reporters, and (8) the Fort Bragg Emergency Ordinance Disposal Team.

As assessment and recovery operations proceeded, the following groups of people arrived at the accident site: (1) Energy Research and Development Administration (ERDA) team from Oak Ridge, Tennessee, (2) ERDA team from

Savannah River in South Carolina, (3) South Carolina Division of Radiological Health Mobile Laboratory, (4) EPA representative from Atlanta, (5) NRC representative from Atlanta, (6) National Transportation Safety Board representative from Washington, (7) North Carolina Department of Natural and Economic Resources, Fayetteville Regional Office representative, (8) Union Carbide representative from Oak Ridge, Tennessee, and (9) Transnuclear, Inc., representative (shipper).

The biggest problem noted in the response to this accident was the lack of adequate communications. In addition, a critique of responses following the accident revealed that (1) without fail all Federal, State and local agencies are willing and anxious to respond and provide available resources to cope with radiation accidents, (2) the prior development of written emergency response plans and standard operating procedures does dramatically improve the speed and effectiveness of response by all agencies concerned, (3) failure to continually update and periodically test emergency plans and standard operating procedures does detract from an agency's ability to respond during emergencies, (4) formal critique of response to actual radiation accidents represents an effective means of identifying weaknesses and improving emergency response capabilities, and (5) more exercises are required, especially ones involving the activation of the State Emergency Operating Center in conjunction with field units. No one mentioned that shippers should develop a response capability.

The third incident was the spilling of considerable amounts of yellowcake (uranium oxide) in Colorado in September of 1977 when the truck carrying the material collided with three horses. This incident precipitated this study and is described more fully below. Although no radiological casualties resulted from this incident, some people thought the general response to the accident was inadequate and that the material should have been transported in better packaging.[26]

2. Description of the Colorado Accident

A transportation accident occurred near Springfield, Colorado, about one o'clock the morning of September 27, 1977, which involved a spill of radioactive material called yellowcake (uranium oxide concentrate).[26,27] A tractor rig with enclosed trailer struck three horses and overturned. The trailer was loaded with 50 steel drums of yellowcake being shipped from a uranium mill at Highland, Wyoming, to a plant at Gore, Oklahoma, for conversion to a form suitable for enrichment and fabrication into fuel for nuclear power reactors.

The driver and his companion were pinned inside the tractor. After they were extricated, they were taken by ambulance to a nearby hospital where they were decontaminated and treated for cuts and fractures. As learned from later bioassays, the drivers did not show uranium in urine samples.

As a result of the truck's overturning and subsequent sudden stop when it slid into an excavated sump for a drainage culvert, 32 of the 50 drums were thrown through the top of the trailer near the front. These drums came to rest on the shoulder of the highway. Drum lids, which were secured to the drums by bolted steel ring closures, came off 17 of the 32 drums which left the trailer. Lids also came off 12 of the 18 drums which remained in the trailer.

A total of about 12,000 pounds of concentrate spilled from the opened drums. About 5,000 pounds of this spilled material was contained in the overturned trailer. The remaining 7,000 pounds were spilled on the ground within an area of 3,000 to 4,000 square feet.[21]

The bill of lading in the truck was accompanied by written detailed emergency instructions, which had been prepared by the shipper of the yellowcake, Exxon Minerals Company. In Reference 27, Exxon indicates that it prepares such emergency instructions for each of its yellowcake shipments. These instructions directed the individuals who arrived first at the scene, personnel from the Baca County Sheriff's Office, to notify the shipper and to cover the spilled material with tarpaulins or heavy plastic sheeting to prevent airborne dispersion. Before any shipper personnel departed for the accident site, the Sheriff's Office advised them that the spill was completely covered with no short-term risk of air dispersion.

The shipper dispatched Highland Mill personnel by commercial airline from Casper, Wyoming, at 7:50 a.m. on the 27th with several large boxes of emergency equipment. The shipper dispatched a truck with 20 drums and additional equipment shortly thereafter. The first shipper personnel arrived at the accident site at 3:30 p.m. on the 27th.

The spill was more extensive than initially reported to the shipper, so the amount of equipment that the shipper took to the accident site was inadequate for cleanup of the spill. Because the risk of the material spreading into the environment was minimized, however, sufficient time was available and was taken to plan the cleanup.

The Colorado Department of Health also responded to the accident site. After being notified of the accident at 4:00 a.m. on the 27th, the Department dispatched personnel to the accident site at 10:00 a.m. and arrived there at 2:30 p.m.[28/] The initial protective actions of covering the spilled yellowcake; notifying all interested parties, including the local police agency, the State radiological health agency, the shipper, the carrier, and the cognizant Federal agencies; and directing traffic around the scene of the accident had been done. The remaining job was to clean up the spilled yellowcake and to decontaminate and restore the scene to its original condition.

The cleanup was not started as soon as possible. A planning meeting was held the evening of September 27, in the Baca County Sheriff's office in Springfield, Colorado.[8/] The cleanup procedure decided on was to pick up the yellowcake and topsoil with a front end loader and transfer it to new drums, using water spray to control dust and hand shovel transfer if windy conditions were encountered. Workers were to use protective clothing and respiratory equipment. An air sampling program was to be conducted to aid evaluation of air concentrations of uranium dust.

On the morning of September 28, the Colorado Department of Health established requirements for the cleanup operation. The yellowcake was to be hand shoveled into new drums within a portable shelter covering about 100 sq. ft. of spill area. The portable shelter was constructed of lumber and plastic sheeting. The spill area outside the housing was to remain covered. Contamination surveys, continual air monitoring, respiratory protection, and personnel monitoring were to be performed. Cleanup was to continue until background radiation levels were achieved. To prevent spread of the yellowcake, a dike and wind break were to be constructed around the spill. To comply with these requirements, however, the cleanup operation was delayed until the afternoon of September 30.

Work progressed slowly. By the evening of October 2, five drums of dirt and yellowcake had been barreled[28/] and eleven drums of the 50 on the shipment had been recovered.[8/] Vacuum cleaning and ventilation equipment was ordered October 3 to speed the cleanup. That day was also taken for more planning and for rest. On October 4, a snow fence lined with plastic sheeting was set up to reduce wind velocity in the work area and the vacuum cleaning and ventilation equipment was installed.[8/]

Calm weather and a light mist on October 5 allowed work to proceed outside the portable shelter.[8/] All the 32 drums outside the trailer were recovered by the end of that day. Work on October 6 and 7 concentrated on the yellowcake spilled in the trailer. All 50 drums of the shipment were recovered and removed to the storage area by the end of work on October 7.

During October 8-10, final decontamination of the truck, the spill area, and the equipment was done. Topsoil replacement and grass reseeding was completed by the Colorado Department of Highways.[8/] Final surveys indicated several areas with readings ranging from 20 μR/hr to 100 μR/hr, which were subsequently decontaminated. The acceptable standard consistent with NRC guidance[29/] is 60 μR/hr.[28/] After all operations, the average exposure in the area was less than 20 μR/hr with a few spots reading up to 30 μR/hr.[28/] All equipment was decontaminated to standards required for further unlimited use.[8/] The Colorado Department of Health representative released the entire spill area for unrestricted use the afternoon of October 10.

The results of the air sampling program are discussed in Section II.A.1.b(1) on philosophy of package designs. The arithmetic mean of all the 26 measurements[8/] reported for the boundary of the work area from September 30 to October 10, which value is of most significance for public health and safety, was about 9×10^{-12} μCi/mℓ. The magnitude of annual average air concentration of soluble uranium dust in an unrestricted area from likely effluents of NRC-licensed operations incident to the possession, use, or transfer of soluble uranium must not exceed 5×10^{-12} μCi/mℓ (10 CFR 20.106). The accidental concentration averaged over a short period of time compares well with the limiting concentration that might be expected under normal conditions averaged over a year. This comparison illustrates the limited hazard associated with an accidental spill of yellowcake.

The results of the urinalysis program to detect uranium intake of persons involved in response to the accident are discussed in Section II.A.1.b(2) on improvements to drum closure methods. Clear interpretation of the health effects from uptake of uranium signified by urine concentration measurements does not directly follow from a limited number of samples, such as were taken in this program bioassay program, but experience indicates that no observable health effects would be expected from small urinary concentrations as were meaured in this bioassay program.

3. Emergency Response

a. Safety Responsibilities

Ordinarily, the carrier and not the shipper is responsible for proper care of cargo in transit. In common, contract, and private carriage, the shipper is responsible for proper packaging of radioactive material delivered to the carrier for transportation, and the carrier has a right and a responsibility to control such property in transit. Accordingly, the carrier should be responsible for emergency response planning, and the shipper should be responsible for informing concerned persons about the hazardous nature of his radioactive material in situations where emergency response plans would be put into effect.

Under DOT, NRC, and State regulations, the shipper is responsible for complying with all applicable regulations in packaging, labeling, marking and otherwise preparing any goods for transportation.[30/] For hazardous materials, DOT regulations require the shipper to certify on the shipping papers that the goods are properly identified, packaged and prepared for carriage and to inform the carrier of any special precautions for the goods.

The activities involved in responding to transportation accidents are divided among several agencies and persons. For purposes of this discussion, the response can be broken down into four phases: the initial phase, the confinement phase, the cleanup phase, and the cost recovery phase.

(1) Initial Phase

During the first fifteen to thirty minutes after the accident occurs, emergency action may be required for saving lives, attending to the injured and identifying the threat and the action required to prevent further damage to life or property. Local public safety officials invariably are the persons who exercise this responsibility. The carrier has a responsibility for action in this initial phase, as in all phases, including notifying the DOT,[31/] the shipper, and the driver's own management at the earliest practicable moment. However, the driver and helper are often victims in the accident and may not be able to act. Others may report the accident. Furthermore, in some cases sufficient information of the details about the cargo to assess the hazard may not be immediately available.

These reporting requirements do not necessarily provide radiological monitoring assistance in the event of a transportation accident. To obtain such assistance, any person may call upon the services of the Interagency Radiological Assistance Plan (IRAP) operated by the U.S. Department of Energy or the State radiological health department. The DOT requirements for shipment description on the shipping papers accompanying the shipment provide certain basic information which can be used as a lead to obtaining chemical hazards information from Chemical Transportation Emergency Center (CHEMTREC) via an "800" number. Both the IRAP and CHEMTREC services are described below in Sections II.B.3.c and d, respectively.

State and local police and emergency crews are usually recognized as the parties most likely to take early action in a transportation accident. They have authority and responsibility for protecting the health, safety, and welfare of the general public, and will take necessary actions, for example to control traffic, extinguish small fires, call firemen, rescue the injured, etc. At this early stage, State and local capabilities to handle radiation incidents or incidents with materials of unknown hazard are often tested, since assistance from persons having specialized radiological knowledge or chemical safety expertise is rarely available during the early period following the incident. For this reason local emergency response planning must provide for the proper initial emergency actions. Some State and local police and emergency response crews are trained and equipped with simple radiation detection instruments and are aware of CHEMTREC, IRAP or other resources of information. These capabilities may be part of any local or regional plan.

(2) Confinement Phase

In addition to assuring that the shipper and the DOT are notified in the event of fire, accident, breakage, or suspected radioactive contamination, the carrier must also segregate packages and spilled radioactive materials from personnel contact and assure that vehicles, area, or equipment in which radioactive material may have spilled, are not placed in service again until they have been decontaminated and surveyed.[31/] In carrying out his responsibility for cleanup and decontamination, the carrier most often must utilize the technical services of others, such as State health department personnel, nearby technicians from hospitals or military installations, etc., or other radiological safety experts. In any event the regulations place on the carrier the burden of responsibility for cleanup.

State and local police equipped and trained to monitor radiation can help to identify the location and extent of any existent radiation hazard. These agencies are expected to exercise their police and emergency powers to control traffic, provide communications, direct evacuation and sheltering actions if necessary. The IRAP teams mentioned earlier are also available as a secondary advisory resource.

The shipper is required by DOT regulations to provide the carrier, when shipment is made, information on any special precautions required for safe shipment of his material. If called in case of an accident, the shipper is also expected to provide whatever details about his shipment that are necessary for its safe control and cleanup. Since the shipper could be involved in a liability suit later, he may offer assistance in confining and cleaning up any accident involving his shipment.

In the highly unlikely event where a release of radioactive material in a transportation accident necessitates a decision concerning evacuation of persons from certain areas, the decision and subsequent actions would be made by responsible local public safety officials. These same officials also make similar decisions as a result of transportation accidents involving other hazardous materials.

(3) Cleanup Phase

This phase includes the removal of any radioactive material, contamination, or other residue of the accident to restore as nearly as possible or as practical the scene of the accident to its original state. The carrier has the basic responsibility to see that cleanup is completed.

Under existing Federal regulations, the carrier is responsible for promptly notifying the shipper and the Federal government of any incident involving death, hospitalization, property damage exceeding $50,000, fire, breakage, actual or suspected leakage of radioactive materials or etiologic agents, or in the judgement of the carrier a danger to life; for isolating any spilled radioactive material from personnel contact, pending disposal instructions from qualified persons; and for not placing vehicles, buildings, areas, or equipment in whcih radioactive materials have been spilled into service or routine occupancy until the radiation dose rate at any accessible surface is less than 0.5 millirem per hour and no significant removable radioactive contamination resides on the surface (in the cases of air and water carriers, only air craft, holds, compartments, or deck areas are included in this requirement).

Since, in many cases, the carrier will have neither technical expertise, nor the experience and equipment to handle radioactive or hazardous materials, the carrier may find it necessary to contract with others to perform certain functions in the cleanup. In many cases, the shipper will provide such expertise and equipment; however, the basic burden of assuring that such provisions are made remains with the carrier. Since in most releases of radioactive material, handling of unshielded, uncontained radioactive material (repackaging, disposal, or removal) is necessary, some responsible person must be present who is experienced and equipped to handle the radioactive material. Such experience would normally be evidenced by an NRC or State license to perform such cleanup and handling activities. That person would need the authority of the carrier to take necessary and appropriate actions at the scene and might be the consignor-licensee, the consignee-licensee, or someone licensed for such activity and working under contract to the consignor, carrier, or consignee.

The State or local government agencies, such as emergency crews, police, health and environmental departments, are expected to exercise their police and emergency powers to direct cleanup of both public and private property.

General standards for cleanup are being developed by the Environmental Protection Agency (EPA). Some contamination limits are given in the DOT regulations for vehicles, facilities, and equipment. General standards for exposure control and contamination limits are given in the NRC regulations and regulatory guides.

(4) Cost Recovery Phase

The cost of cleanup and any liability for damages to life or property resulting from a transportation accident are borne in most cases initially by the carrier. Furthermore, in most cases, the fixing of such costs and of the real responsibility for them will be determined in the courts. In more than 20 years of experience with transportation of radioactive materials, only 12 incidents have been reported to the nuclear insurance pools. Of these incidents, nine did not result in any personal injury claims. Further discussion of the cost recovery phase is included in Section b below.

In summary, present regulations do not include definitive requirements for emergency response to transportation accidents involving radioactive materials. State and local government authorities, under their inherent police powers, have the ultimate decision making responsibility to protect the public. The carrier has certain basic responsibilities for confining the immediate threat and for notifying the public authorities. The shipper has no specific responsibilities for sending expert personnel to the accident scene but is expected to provide on request expert advice on the hazards of the shipment and any necessary precautions.

b. Financial Responsibilities

(1) Applicable Federal Statutes

The present provisions of the Price-Anderson Act[32/] furnish a statutory basis for private funds and government indemnity, up to an aggregate amount of $560 million, to pay public liability claims resulting from certain transportation accidents involving radioactive materials. Although carriers may purchase $140 million in third party liability insurance from the nuclear insurance pools (Suppliers and Transporters Form), they are not required by the NRC or the DOT to purchase any insurance. The insurance and indemnity applicable to transportation accidents is ancillary coverage having its basis in the financial protection agreements[33/] executed by Commission licensees. This insurance and indemnity protection afforded the public while radioactive materials are in the course of transportation to or from an indemnified facility is part of the coverage of the Price-Anderson Act.[34/] Federal law requires that any person issued a construction permit for or a license to operate a producton or utilization facility[35/] have and maintain financial protection and government indemnity as required by the NRC.[36/] For nuclear power plants having a rated capacity of 100 electrical megawatts or more, the amount of financial protection that must be maintained by licensees of these plants must equal the maximum amount of liability insurance available at reasonable cost and on reasonable terms from private sources.[37/] For all other Commission licensees, the Commission in the exercise of its licensing and regulatory authority and responsibility may require, but is not compelled by statute to require, that other classes of licensees have and maintain financial protection in such amounts as the Commission considers appropriate to cover public liability claims.[38/] Whenever the Commission requires a licensee to have and maintain financial protection, the licensee must execute an indemnity agreement with the Commission.[39/]

Prior to the most recent amendments to the Price-Anderson Act[40/], the Commission had never exercised its discretionary authority to require licensees (other than production or utilization facility licensees specifically required by statute) to maintain financial protection and government indemnity. However, the NRC regulations implementing these amendments require that plutonium processors and fuel fabricators licensed, pursuant to 10 CFR Part 70, to possess or process specified quantities of plutonium have and maintain $125 million in financial protection.[41/] Since then the amount of financial protection required of these licensees has increased to $140 million.[42/]

Neither persons delivering radioactive materials to a carrier for transport ("shippers") nor carriers, exempted from Commission licensing requirements[43/] because they are regulated by the Department of Transportation, have been specifically required to have and maintain financial protection and government indemnity solely on the basis that radioactive material licensed by the Commission or an Agreement State is being transported from point X to point Y. For the provisions of the Price-Anderson Act to apply to the transportation of radioactive material in the postulated hypothetical situation, an indemnified production or utilization facility or a plutonium processing and fuel fabrication plant (for which the NRC, in the exercise of its discretionary authority, requires that financial protection be maintained) would have to be located at either point X or point Y. If this condition were not met, any damages resulting from an accident during the transportation of radioactive material from point X to point Y could not be matched by funds otherwise available under the Price-Anderson Act. Generally, the transportation of special nuclear material (i.e., plutonium and certain isotopes of enriched uranium)[44/] between two Commission licensees authorized "to transfer or receive in interstate commerce, transfer, ...acquire, possess, own, [or] receive possession of..." such material[45/] is not covered by the Price-Anderson Act.

The NRC staff is currently studying the issue of whether Price-Anderson coverage should be extended, pursuant to the Commission's discretionary authority, to other areas of NRC-licensed activities. Upon completion of this study and consideration of the staff's recommendations, the Commission will take such action as it deems appropriate.

After enactment of the 1975 amendments to the Price-Anderson Act, the Commission published in the Federal Register[46/] a notice of intent to implement the provisions of the new law through the rule making process.

The Commission invited public comments and suggestions with respect to eight specific issues. The notice stated that the Commission was particularly interested in receiving views, together with the bases therefor, on, among other issues, the extension of Price-Anderson to specifically cover the transportation of radioactive materials. The notice stated:

> 8. Under the present Price-Anderson system, no separate insurance contracts or indemnity agreements are issued to cover transportation of nuclear materials. Carriers are, however, covered under the "omnibus" feature of licensee financial protection and indemnity. It has been suggested that transportation be separately covered. The Commission invites comments with respect to any advantage to the public and/or the carrier that would result from such coverage by the Price-Anderson Act, as contrasted with present coverage under the omnibus features of the Price-Anderson Act. In this respect, deficiencies, if any, in public protection under present coverage should be identified.
>
> Interested persons are invited to submit written comments and suggestions, with supporting documentation, on the foregoing matters, or on any other matters pertinent to the subject matter of this notice.47/

Twenty three sets of comments were received in response to this notice. Of those commenters addressing the transportation issue, none expressed the need for or desirability of covering transportation by separate insurance and indemnity agreements. When the proposed rule to implement the 1975 amendments to the Price-Anderson Act was published on September 20, 1976 (41 Fed. Reg. 40511), the following statement appeared in the preamble to the proposed rule:

> 9. Under the present Price-Anderson system, no separate insurance contracts or indemnity agreements are issued to cover liability

arising from the transportation of nuclear materials. Carriers are, however, covered under the "omnibus" feature of licensee financial protection and indemnity--that is, transporters are covered for liability with respect to nuclear incidents occurring during shipments to or from all existing indemnified facilities.

It has been suggested that transportation be separately covered. The Commission has considered whether any advantage to the public or the carrier would result from such coverage and whether there are any deficiencies in public protection under the present coverage.

Comments received on this issue generally expressed the view that the "omnibus" provisions of licensee financial protection plus indemnity coverage are adequate. Additionally, it was felt that if areas of difficulty with the existing system were identified, remedies to such areas should be developed within the existing framework rather than be developed within the context of a separate additional system of policies and indemnity agreements for transportation. No contrary views were received.

Concerns had been expressed previously about the existence of potential gaps in the existing system in such situations as transportation of materials. The Commission believes that these concerns do not warrant changing the existing system by initiating separate transportation coverage, because present coverage under the "omnibus" provision of existing financial protection and indemnity is extensive. Additionally, Suppliers and Transporters' liability coverage is available to a maximum of $125 million.

Another consideration against extension of coverage to transportation of nuclear materials is an insurance industry concern that such coverage may lead to pyramiding of coverage. Currently, transporters are covered through the "omnibus" provisions of the financial protection and indemnity agreement with facilities. If, during transportation, an accident arose which involved multiple indemnity agreements because of multiple transporters, a confused legal situation might ensue. It might be difficult to determine which policy or agreement applied.

One expressed concern--that it would be difficult to relate injuries occurring as a result of exposures to radioactive material, without accident, to particular shipments--is overstated. It is difficult to see how this situation would be rectified by separate transportation coverage.

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> Finally, the Commission's discretionary authority to provide indemnity coverage extends only to materials licensees. Common carriers are exempted from licensing under present Commission regulations. In order for the Commission to indemnify such carriers either new authority under the Price-Anderson Act would have to be provided by Congress or common carriers would have to be licensed.
>
> Consequently, the Commission does not intend to extend separate coverage under the Price-Anderson Act to transportation of nuclear materials.[48/]

The Price-Anderson Act does not preempt applicable State tort law. Only in the event of an extraordinary nuclear occurrence (ENO)[49/] does the Act require that facility licensees waive certain defenses[50/] (e.g., short statute of limitations, contributory negligence and assumption of risk) that would otherwise be available to the licensee, thereby creating a situation where the licensee is, in effect, subject to a strict liability standard. In the event of an ENO, the Act also provides for consolidation of all claims resulting from the nuclear incident in the U.S. district court in the district in which the incident occurred.[51/]

(2) Liability in Situations to Which the Price-Anderson Act Does Not Apply

As previously discussed, Price-Anderson coverage does not apply to all, or even to most, shipments of radioactive materials. Should a transportation accident resulting in the release of radioactive material occur, there would be no sure source of funds (except for insurance carried by the shipper or carrier) available to pay public liability claims arising from the accident. The applicable State tort laws would determine the respective liabilities of the shipper and carrier.

c. Role of the Federal Government

(1) Response and Advice

The Interagency Radiological Assistance Plan (IRAP) was developed in 1961 by an interagency committee of Federal agency representatives as a means for providing rapid and effective radiological assistance in the event of a peacetime radiological incident.52/ The IRAP provides a means whereby the participating Federal agencies may coordinate their radiological emergency related activities with those of State and local health, police, fire, and civil defense agencies. The plan provides operating guidelines for interagency radiological emergency operations and training and is intended to use existing Federal, State and local capabilities to most effectively protect the public health and safety from radiological hazards.

The IRAP is coordinated by the Department of Energy (DOE) because of its extensive resources in the national laboratories. Response teams consisting of Federal personnel are located at all of the national DOE laboratories and at laboratories and offices of other Federal agencies scattered across the country. When any individual needs help in a radiological matter he can call the nearest Regional Coordinating Office of the DOE to contact the IRAP. The IRAP representative then takes the information and decides what action is needed. If necessary, the IRAP representative will actually send a team to respond to the incident to help and advise the authorities in charge. This plan has been used many times since its inception in 1961.

(2) Guidance

The NRC is involved with the DOT and six other Federal agencies in a cooperative Federal effort to provide guidance and training to State and local governments for radiological incidents involving fixed facilities and transportation accidents.[53/] The NRC is the lead agency in the program and is responsible for:

- o Issuance of guidance to other Federal agencies concerning their responsibilities and authorities in radiological incident emergency response planning and in providing planning assistance to State and local governments.

- o Development and promulgation of guidance to State and local governments in coordination with other Federal agencies for the preparation of radiological emergency response plans.

- o Review and concurrence in such plans. (Proper correlation among State, local government, licensee, and national plans is an element of this review.)

- o Determination of the accident potential at each licensed fixed nuclear facility.

- Issuance of guidance for establishment of effective systems of emergency radiation detection and measurement.

The Department of Transportation is responsible for:

- Providing guidelines, in cooperation with NRC and other Federal agencies, and consistent with NRC guidance, for the development of that portion of State and local emergency plans pertaining to transportation incidents involving radioactive materials.

- Assistance to State and local governments in emergency planning for such transportation incidents.

The guidance on planning for transportation accidents has not yet been developed in final form. In the interim, the NRC and the DOT advocate the use of guidance developed by the Western Interstate Nuclear Board and Region VIII of the Conference of Radiation Control Program Directors.[54/] This guidance is currently being updated by the DOT and is scheduled for publication in revised form before the end of calendar year 1978. In addition, the DOT is scheduled to publish by end of calendar year 1978 an operations manual for use by those emergency personnel who actually respond to radiation emergencies. A proposed standard for emergency response plans to accidents in the transportation of radioactive materials is being developed by the American National Standards Institute with review and comment by the pertinent Federal agencies.[55/]

The NRC has a contract with Sandia Laboratories to develop scenarios for transportation accidents involving radioactive materials. This program is designed to expand the data base from which practical emergency plans and response procedures can be developed at the State and local government level. To provide a greater data base than presently exists, the following tasks will be performed:

- o Selection of Transportation Accidents - A limited number of potential transportation accidents involving radioactive materials will be selected to provide a complete spectrum of accidents. The selection will be based on the likelihood of the accident involving radiation exposure of individuals, magnitude of radiological consequences, nature of radiological hazard and pathway of exposure to man, physical and chemical form of radioactive material, and location of the accident.

- o Characterization of Radiological Environment - The radiological environment resulting from transportation accidents involving radioactive material will be characterized in terms of:

  - o Time-dependent airborne and ground surface concentrations of radioactive materials.
  - o Potential radiation doses to individuals and the potential pathway of exposure.

- o Size of area likely to be contaminated above levels of concern.

- o Post-Accident Responses - Following a transportation accident involving radioactive materials, the possible actions to be taken by responsible officials will most likely be limited to recovery measures. Therefore, the time in which recovery measures should be initiated following the different transportation accidents utilized in the previous task will be estimated.

The information obtained from these tasks will be used to write a series of accident scenarios which will describe mechanistically the postulated accidents and their consequences.

As part of an overall Radiological Emergency Preparedness Program, the Office of Standards Development in the NRC is studying the role of the States in preparedness, particularly in responding to transportation accidents. The general goal of the Preparedness Program is to increase the expertise of the States in managing transportation related nuclear emergencies and to decrease their dependence on Federal assistance in this area. The primary thrust of the program is to identify those elements necessary to provide a minimum "adequate" response capability; and to suggest to the States the steps they should take to bring their capability to the desired level. The program has three steps:

(a) Survey of current State capabilities.

(b) Evaluation of needs based on transportation patterns, accident scenarios and other related factors.

(c) Development of recommendations to the States, based on cost-benefit analyses.

A contract to accomplish the first step has been established.

Finally, the EPA, as one of the agencies with which NRC and DOT have been coordinating their emergency planning activities, has published a "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents." The manual will eventually have eight chapters covering all types of radiation emergencies, and Chapter 8 is devoted to Protective Acton Guides for transportation incidents. According to the EPA, the first draft of Chapter 8 will be available for interagency review by the end of calendar year 1978.

(3) Training

Several Federal agencies are developing a series of training programs for State and local government emergency response personnel. These programs are geared for response to radiological emergencies and are furnished at no cost to the State and local government personnel. Initially, the funding came from several of the involved Federal agencies, but beginning in FY 1979 the entire funding will be provided by the NRC.

One of the courses developed to date is an eight-day course on radiological emergency response operations. The curriculum includes such topics as basic concepts of nuclear science, biological and medical implications of radiation, air sampling techniques, area monitoring and control, protective action guides, DOT regulations, sample collection and analysis, anti-contamination equipment and procedures, and emergency team organization and procedures. The first three days consist of classroom lectures which provide the participants with basic information on radiological emergencies. These sessions are primarily intended for individuals with little or no health physics expertise but also serve as a review for the more experienced individuals. The second part of the course consists of field exercises. Students break up into teams and respond to simulated radiologcial emergencies involving a nuclear power plant, a transportation accident, and an industrial accident.

The course is conducted at the Department of Energy's Nevada Test Site and was originally scheduled to be presented 10 times per year. However, because of the demand, the NRC is increasing the frequency of presentation to 16 times per year. To date, approximately 200-250 State and local emergency response personnel have attended the course (class size is limited to 20 students per session).

The Department of Transportation, through a contract with the National Fire Protection Association, has developed a 20-hour training course for firemen and policemen who would be responding to transportation accidents involving any hazardous material. Because of the demand for more specific training on radiation emergencies, however, a supplement is being developed to that course which will deal primarily with radiation hazards. A contract was recently awarded by the DOT and the work should be completed by September 1979.

d. Other Facets of Emergency Response

The chemical industry through a system called Chemtrec[56/] maintains information on hazardous chemicals. Although it possesses limited information on radioactive materials, it will refer a caller to the nearest IRAP regional coordinating office for more extensive information. This service provides a telephone number[57/] for receipt at all times of direct-dial toll-free calls from any point in the continental United States. Separate numbers are maintained for receipt of calls originating within the District of Columbia and outside the continental U.S. This service by design is confined to dealing with transportation emergencies.

Chemtrec can usually provide hazard information warnings and guidance when given only the name of the product and the nature of the problem. For more detailed information and assistance, especially if the product is unknown, the caller must provide as much information as possible: his name and the callback telephone number, the location of the problem, the shipper or manufacturer, the container type, the rail car or truck number, the carrier name, the consignee name, and local conditions.

In the Colorado accident, the Colorado Department of Health considered the shipper to be responsible for emergency actions and for cleanup of the spill because the shipper is most knowledgeable of the hazards of the material, is most capable of handling the material, and has most vested interest in the material.[1/] This State agency recommended that the NRC amend its rules to require licensee shippers (specifically uranium mill operators) to have an emergency response plan and an emergency response team which could be transported immediately to the site of an accident involving material owned by the mill.[26/]

Other States do not necessarily hold the same view. South Carolina for example recently wrote that it is generally satisfied with the arrangements that currently exist for the transportation of radioactive materials, that the containers developed under NRC and DOT regulations are adequate, that this activity is adequately regulated and more restrictive regulations are not necessary, and that no documentation exists of problems to justify consideration of special routes.[58/] In addition, the Vermont Agency of Transportation has recommended the development of a State centralized hazardous material emergency response capability within the Department of Public Safety.[59/] No mention is made of any need to require an emergency response capability of a shipper.

Several aspects of transportation of radioactive materials have recently been reviewed in a study sponsored by the DOE,[60/] including the principal

Federal activities affecting transportation of radioactive materials, the State and local activities that may affect such transportation, transportation of these materials by rail, emergency response planning and implementation, transportation safeguards and security, insurance issues, and labor relations.

With respect to emergency response, the report states that although elaborate plans of response to transportation accidents are now being formulated, it appears that the primary responsibility may very well rest with local policemen and fire departments who are the ones most likely to be the first on the scene. In the unlikely event of a transportation accident that involves a serious release of radioactive material, even a few minutes are important. Thus, greater efforts are needed to assure that local response capabilities are upgraded.

A study[61/] performed for the State of Illinois on highway transportation of hazardous materials indicates that emergency response coordination is a most critical area needing State attention. A review of State regulatory programs throughout the country and of the Illinois experience in particular revealed that the response to an emergency becomes less effective from lack of response coordination, inadequate crowd control, lack of accurate information, and conflicting goals and instructions of participating officials.

With respect to radioactive materials, the Illinois report concludes that normal highway transportation hazard to the Illinois general public is essentially zero. It further concludes that worst case releases of radioactive materials are nearly impossible. In the event of such releases, the catastrophic consequences popularly feared and often alleged will not ensue. The resulting deaths, injuries and property damage will not begin to approximate the casualties and damage that have actually and frequently accompanied accidents involving bulk transportation of other kinds of hazardous materials, man-caused disasters, and natural disasters.

The Illinois report also found that the safe transportation of nuclear materials relies primarily on packaging integrity under both normal and accident conditions. It states that the safety standards of the Nuclear Regulatory Commission and the Department of Transportation do not rely on restriction of routing and similar measures to assure safety in transport.

Outside Illinois, various State and local authorities have proposed or taken action to impose various routing restrictions and prohibitions on the highway movement of radioactive material, ostensibly to increase safety. Apart from the legal status of such actions, the report states that these restrictions cannot be justified as safety enhancing measures. The contractor's investigation indicates no need in Illinois for the enactment of legislation or promulgation of regulations to restrict or prohibit highway transportation of radioactive materials in the interests of health and safety.

A second important finding of the report is that from the perspective of highway transportation, State agencies are well aware of, and have responded promptly to, surveillance, enforcement, emergency response, and related requirements called for by existing traffic and shipping practices. These agencies have further developed close and effective working relationships with Federal regulatory agencies in improving existing regulations and in designing new regulations.

The NRC has received a petition[62/] to modify its rules and require licensee shippers to prepare and maintain emergency procedures to be followed in the event of a transportation accident. As the present study addresses these topics, the NRC has decided to hold the petition in abeyance until the results of this study have been considered. The NRC environmental statement on transportation of radionuclides through urban environs and the DOT public rulemaking proceeding mentioned in II.A.3.a. are also expected to influence the disposition of this petition.

In conclusion, various individuals and government entities have different opinions about emergency response to transportation accidents involving radioactive materials. In our opinion, the shipper should not be responsible for the safety management of transportation accidents or for cleaning up spills of radioactive material that might result from such accidents, but should be responsible for proper packaging and for communicating hazards information if requested.

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34. 10 CFR 140.92.

35. See 42 USCA §§ 2014(v), (cc).

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44. 42 USCA § 2014(aa).

45. 43 USCA § 2073(a). See also 10 CFR Part 70.

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GLOSSARY

Agreement State: An Agreement State is one entering into an agreement with the NRC by which the NRC relinquishes its authority under the Atomic Energy Act of 1954, as amended, to regulate within the borders of the State the receipt, possession, use and transfer (including transportation) of source material (including yellowcake) byproduct material, and subcritical configurations of special nuclear material.

Byproduct Material: Radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to producing or using special nuclear material (See 10 CFR 30.4(d))

Conversion Plant: A facility for producing uranium hexafluoride (UF_6) from yellowcake (U_3O_8).

Curie: A unit of radioactive decay defined as 3.7×10^{10} disintegrations per second.

Enriched Uranium: Uranium in which the U-235 content has been increased above its natural abundance of 0.72% by weight (see "Natural Uranium").

Evaporator Concentrate: The radioactive residue left after evaporating the water from contaminated liquid wastes.

Fuel Facility: A place where nuclear reactor fuel is manufactured or fuel materials are processed.

Latent Cancer Fatality: A radiation induced cancer death which occurs more than one (often many years) year after exposure to the radiation.

Low Specific Activity Material (LSA): Material in which radioactivity is distributed essentially uniformly in small limited concentrations. LSA material includes natural uranium compounds, low level reactor wastes, and contaminated solids. (See 10 CFR 71.4(g)).

Modal: Refers to the transportation vehicle--rail car, truck, barge, aircraft, etc.

Natural Uranium: Uranium which contains the natural abundance of U-235, 0.72% by weight. Also called "Unenriched".

Radiography: The examination of the structure of materials using radiation from sealed radioactive sources.

Radionuclide: An atom (such as Co-60 or U-235) which is radioactive.

Radioactivity: The property of emitting particles, such as alpha or beta particles, or radiation, such as gamma radiation, from an atomic nucleus, such as uranium.

REM (Roentgen Equivalent Man): A unit of dose equivalent which is numerically equal to the dose in rads (a unit of absorbed dose for any ionizing radiation; one rad is 100 ergs energy absorbed per gram of absorbing substance) multiplied by appropriate modifying factors.

Resins: Ion exchange substances used in nuclear power plants to remove unwanted radionuclides from the primary system water. After use, resins may be highly radioactive.

Source Material: Uranium or thorium in any physical form, including ore containing more than 0.05% by weight of uranium or thorium. Source Material does not include Special Nuclear Material (See 10 CFR 40.4(h)).

Special Nuclear Material: Plutonium, U-233, U-235 or any material artifically enriched in these nuclides (See 10 CFR 70.4(m

Spent (or Irradiated) Fuel: Special nuclear material which is not readily separable from other radioactive material and which has a total external radiation dose rate in excess of 100 rems per hour at a distance of one meter (three feet) from any accessible surface without intervening shielding.

Type A Package: A package containing a limited quantity of radioactive material, and designed to withstand the rigors of normal transportation.

Type B Package: A package designed to contain its radioactive contents, which exceed the radioactive contents of a Type A package, and to maintain adequate radiation shielding effectiveness under normal transportation conditions and also in the event of a severe accident during transportation.

Uranium Hexafluoride: The uranium compound used in the enrichment process.

Yellowcake A uranium ore concentrate, consisting mostly of uranium oxide (U_3O_8). It is usually yellow-green in color.

Appendix I. Joint Study Group Members and Advisors

Nuclear Regulatory Commission

D. A. Nussbaumer (Chairman), Assistant Director for Material Safety and Licensing, Division of Fuel Cycle and Material Safety, Office of Nuclear Material Safety and Safeguards (ONMSS)

C. V. Hodge (Technical Coordinator), Transportation Branch, ONMSS

R. F. Barker, Chief of Transportation and Product Standards Branch, Office of Standards Development (OSD)

H. E. Collins, Assistant Director for Emergency Preparedness, Office of State Programs (OSP)

E. E. Jakel, Regulations Division, Office of the Executive Legal Director

Advisors

A. N. Tse, Transportation and Product Standards Branch, OSD

D. R. Hopkins, Transportation and Product Standards Branch, OSD

C. E. MacDonald, Chief of Transportation Branch, ONMSS

R. W. DeFayette, OSP

I. P. Dinitz, Antitrust and Indemnity Group, Office of Nuclear Reactor

Department of Transportation

A. W. Grella, Chief of Research and Development Management Division, Materials Transportation Bureau, Office of Hazardous Materials Operations

Appendix II

INSTRUCTIONS FOR EMERGENCY ACTION INCLUDED IN THE SHIPMENT WHICH WAS ACCIDENTALLY SPILLED IN COLORADO SEPTEMBER 27, 1977

YOUR CARGO IS Uranium Concentrate

THIS MATERIAL:

1. Is not explosive.
2. Will not burn.
3. Is a naturally radioactive material of low specific activity. It should not be inhaled, eaten, or allowed to get into an open wound.
4. Can be approached without danger of injury from external radiation.

IN THE EVENT OF ACCIDENT, AS SOON AS POSSIBLE:

1. Take preliminary precautions below. Display these instructions as necessary to local authorities on the scene to obtain their help (see 2 below).
2. Call (or have local authority call for you) the Manager, Administrative Superintendent or Purchasing Agent, EXXON COMPANY, U.S.A., Telephone (307) 358-3244, Douglas, Wyoming collect. If possible have local law or civil authority participate in call.

4. Make no other statements or phone calls except on instructions from your dispatcher or EXXON COMPANY, U.S.A.

PRELIMINARY PRECAUTIONS

CONTAINERS ARE NOT LEAKING, and are not seriously damaged. Container may or may not be thrown from vehicle. Vehicle may or may not be damaged.

1. Caution people not to tamper with the containers. Use civil authorities to help you if necessary.
2. It is not necessary to have a specific distance between humans and the containers or truck, but for ease of controlling the situation, ask people to stay back 10-15 feet.

Appendix II (Cont'd)

3. If closed containers are lying on the road, obtain assistance from whatever civil authority is available to move containers to the side of the road.

4. Assure local authorities that there is no danger in handling closed containers.

CONTAINERS ARE LEAKING OR DAMAGED TOO SERIOUSLY to be moved. Truck or railroad car may or may not be damaged.

1. Caution humans to stay away from the material. Keep them at a distance of at least 25 feet. Extreme distance is not necessary. Use civil authorities to help if necessary.

2. Assure local authorities that there is no danger from radiation but that people should avoid breathing any dust from the material.

3. Avoid trackage of material by humans or vehicle. Obtain help from local civil authorities if necessary to reroute traffic around the spill area.

4. Keep material from running into streets, gutters, sewers, etc., if possible. A simple method for doing this might be to dig a trench around the material or throw up an earthen dike several inches high.

5. Prevent the material from being scattered by the wind by carefully covering it with canvas or dirt.

6. Avoid breathing dust from the material. When covering the material, obtain a simple respirator if possible. If none is available, work the material in such manner as not to stir up excessive dust.

FIRE involving vehicle or in immediate vicinity of vehicle

1. Isolate the vehicle from other humans and property if possible. Use civil authorities for help.

2. Obtain fire fighting help from local group.

3. The material you are hauling will not burn.

Appendix II (Cont'd)

4. Keep fire away from uranium containers if possible.

5. Use respirator if necessary to avoid breathing smoke from any fire involving your cargo because of possibility of airborne particles, if the drums are ruptured.

6. Do not spray water into open or leaking containers. There is no reaction with water but a heavy stream of water will spread the material and make cleanup more difficult.

APPENDIX III

DEPARTMENT OF TRANSPORTATION REGULATIONS (49 CFR) PERTAINING TO HAZARDS INFORMATION ACCOMPANYING A SHIPMENT OF RADIOACTIVE MATERIALS

Subpart C—Shipping Papers

SOURCE: Amdt. 172-29A, 41 FR 40677, Sept. 20, 1976, unless otherwise noted.

§ 172.200 Applicability.

(a) *Description of hazardous materials required.* Except as otherwise provided in this subpart, each person who offers a hazardous material for transportation shall describe the hazardous material on the shipping paper in the manner required by this subpart.

(b) *Exceptions.* This subpart does not apply to any material that is—

(1) An ORM-A, B, or C, unless it is offered or intended for transportation by air when it is subject to the regulations pertaining to transportation by air as specified in § 172.101; or

(2) An ORM-A, B, or C, unless it is offered or intended for transportation by water when it is subject to the regulations pertaining to transportation by water as specified in § 172.101; or

(3) An ORM-D unless it is offered or intended for transportation by air.

§ 172.201 General entries.

(a) *Contents.* When a description of hazardous material is required to be included on a shipping paper, that description must conform to the following requirements:

(1) When a hazardous material and a material not subject to the requirements of this subchapter are described on the same shipping paper, the hazardous material description entries required by § 172.202 and those additional entries that may be required by § 172.203

(i) Must be entered first, or

(ii) Must be entered in a color that clearly contrasts with any description of a material not subject to the requirements of this subchapter on the shipping paper except that a description on a reproduction of a shipping paper may be highlighted, rather than printed, in a contrasting color (The provisions of this paragraph apply only to the basic description required by § 172.202(a) (1) and (2).) or

(iii) Must be identified by the entry of an "X" placed before the proper shipping name in a column captioned "HM".

(2) The required shipping description on a shipping paper and all copies thereof used for transportation purposes, must be legible and printed (manually or mechanically) in English.

(3) Unless it is specifically authorized or required in this subpart, the required shipping description may not contain any code or abbreviation.

(4) A shipping paper may contain additional information concerning the material provided the information is not inconsistent with the required description. Unless otherwise permitted or required by this subpart, additional information must be placed after the basic description required by § 172.202(a) (1) and (a) (2).

(i) When appropriate, the entry "IMCO" may be entered immediately following the class in the basic description.

(ii) For a material meeting the definition of more than one hazard class, the additional hazard class or classes may be entered after the hazard class in the basic description.

(b) *Name of shipper.* A shipping paper for a shipment by water must contain the name of the shipper.

[Amdt. 172-29A, 41 FR 40677, Sept. 20, 1976, as amended by Amdt. 172-29B, 41 FR 57067, Dec. 30, 1976]

§ 172.202 Description of hazardous material on shipping papers.

(a) Each description of a hazardous material on the shipping paper must include—

(1) The proper shipping name prescribed for the material as required by § 172.101.

(2) The class prescribed for the material as required by § 172.101. When the words of the proper shipping name are identical (excluding the entry "n.o.s.") with the words of the class, the inclusion of the class is not required.

(3) [Reserved]

(4) Except for empty packagings, the total quantity (by weight, volume, or as otherwise appropriate) of the hazardous material covered by the description.

(b) The basic description specified in paragraphs (a)(1) and (a)(2) of this section must be shown in sequence except that the technical name of the material may be entered between the proper shipping name and the class. For example: "Gasoline, Flammable liquid"; or "Flammable solid, n.o.s."; or "Corrosive liquid, n.o.s. (caprylyl chloride), corrosive material."

(c) The total quantity of the material covered by one description must appear before or after, or both before and after, the description required and authorized by this subpart.

APPENDIX III (Cont'd)

(1) Abbreviations may be used to specify the type of packaging and weight or volume. For example: 40 cyl. Nitrogen, Non-flammable Gas–800 pounds; 1 box Cement, liquid n.o.s., Flammable liquid, 25 lbs.

(2) The type of packaging may be entered in any appropriate manner.

§ 172.203 Additional description requirements.

(a) *Exemptions*. Each shipping paper issued in connection with a shipment made under an exemption must bear the notation "DOT-E" followed by the exemption number assigned and so located that the notation is clearly associated with the description to which the exemption applies.

(b) *Limited quantities*. The description for a material defined as "limited quantities" in this subchapter must include the words "Limited Quantities" or "Ltd. Qty." following the basic description.

(c) *Blasting caps*. The description for a shipment of blasting caps must have an entry stating the number of caps in the shipment, either before or after the basic description.

(d) *Radioactive material*. (1) The description for a shipment of radioactive material must include the following additional entries as appropriate:

(i) The name of each radionuclide in the radioactive material that is listed in § 173.390 of this subchapter. Abbreviations, e.g., "⁹⁹Mo" are authorized.

(ii) A description of the physical and chemical form of the material, if the material is not in special form.

(iii) The activity contained in each package of the shipment in terms of curies, millicuries, or microcuries. Abbrevations are authorized.

(iv) The category of label applied to each package in the shipment. For example: "RADIOACTIVE WHITE–I."

(v) The transport index assigned to each package in the shipment bearing RADIOACTIVE YELLOW–II or RADIOACTIVE YELLOW–III labels.

(vi) For a shipment of fissile radioactive materials—

(A) The words "Fissile Exempt," if the package is exempt pursuant to § 173.396 (a) of this subchapter, or

(B) If not exempt, the fissile class of each package in the shipment, pursuant to §173.389(a) of this subchapter; and

(C) For a Fissile Class III shipment, the additional notation: "Warning—Fissile Class III Shipment. Do not Load More Than * * * Packages per Vehicle." (Asterisks to be replaced by appropriate number.) "In loading and Storage Areas, Keep at Least 20 Feet (6 Meters) from Other Packages Bearing Radioactive Labels."

(D) If a Fissile Class III shipment is to be transported by water, the supplementary notation must also include the following statement: "For shipment by water, only one Fissile Class III shipment is permitted in each hold."

(vii) For a package approved by the U.S. Energy Research and Development Administration (ERDA) or U.S. Nuclear Regulatory Commission (USNRC), a notation of the package identification marking as prescribed in the applicable ERDA or USNRC approval. (See § 173.393a of the subchapter.)

(viii) For an export shipment or a shipment in a foreign made package, a notation of the package identification marking as prescribed in the applicable International Atomic Energy Agency (IAEA) Certificate of Competent Authority which has been issued for the package. (See § 173.393b(a)(3) of the subchapter.)

(e) *Empty packagings*. For other than a tank car, the description on the shipping paper for an empty packaging containing the residue of a hazardous material may contain the word(s) "EMPTY": or "EMPTY: Last contained * * *" followed by the name of the hazardous material last contained in the packaging. This entry may be before or after the basic description. For empty tank cars, see § 174.25(c) of this subchapter.

(f) *Transportation by air*. When a package containing a hazardous material is offered for transportation by air and this subchapter prohibits its transportation aboard passenger-carrying aircraft, the words "Cargo-only aircraft" must be entered after the basic description.

(g) *Transportation by rail*. (1) The shipping paper for a rail car containing a hazardous material must contain the notation "Placarded" followed by the name of the placard required for the rail car.

(2) The shipping paper for each specification DOT 112A or 114A tank car (without head shields) containing a flammable compressed gas must contain the notation, "DOT 112A" or "DOT 114A," as appropriate, and either "Must

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APPENDIX III (Cont'd)

be handled in accordance with FRA E.O. No. 5" or "Shove to rest per E.O. No. 5."

(h) *Transportation by highway*. Following the basic description for a hazardous material in a specification MC 330 or MC 331 cargo tank made of quenched and tempered steel, there must be entered for—

(1) *Anhdyrous ammonia*. (i) The words "0.2 per cent water" to indicate the suitability for shipping anhydrous ammonia in the cargo tank as authorized by § 177.817 of this subchapter. or

(ii) The words "NOT FOR Q AND T TANKS" when the anhydrous ammonia does not contain 0.2 per cent or more water by weight.

(2) *Liquefied petroleum gas*. The word "Non-corrosive" or "Non-cor" to indicate the suitability for shipment of the "Non-corrosive" liquefied petroleum gas offered for transportation by cargo tank as authorized by § 173.315(a)(1) Note 15 of this subchapter.

(i) *Transportation by water*. (1) Each shipment by water must have the following additional shipping paper entries:

(i) Identification of the type of packages such as barrels. drums, cylinders, and boxes,

(ii) The number of each type of package including those in a freight container or on a pallet, and

(iii) The gross weight of each type of package or the individual gross weight of each package.

(2) The shipping paper for a hazardous material offered for transportation by water to any country outside the United States must have in parenthesis the technical name of the material following the proper shipping name when the material is described by a "n.o.s." entry in § 172.-101. For Example: Corrosive liquid. n.o.s. (caprylyl chloride), Corrosive material. However, for a mixture, only the technical name of any hazardous material giving the mixture its hazardous properties must be identified.

[Amdt. 172-29A, 41 FR 40677, Sept. 20, 1976, as amended by Amdt. 172-29B, 41 FR 57067, Dec. 30, 1976]

POOR ORIGINAL

APPENDIX IV

SOME CORRESPONDENCE CONCERNING THE COLORADC ^CCIDENT

A. Letter from R. D. Siek, Associate Director of Environmental Programs, Colorado Department of Health, to S. Meyers, Director, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission (October 3, 1977).

B. Letter from S. Meyers, Director, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission, to A. J. Hazle, Director, Radiation and Hazardous Wastes Control, Colorado Department of Health (December 14, 1977).

C. Letter from A. H. Hazle, Director, Radiation and Hazardous Wastes Control, Colorado Department of Health, to S. Meyers, Director, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission (January 13, 1978).

D. Lettr from A. J. Hazle, Director, Radiation and Hazardous Wastes Control, Colorado Department of Health, to R. P. Pollock, Director, The Citizen's Movement for Safe and Efficient Energy (January 16, 1978).

E. Letter from A. J. Hazle, Director, Radiation and Hazardous Wastes Control Division, to the Honorable Gary Hart, U.S. Senate (November 1, 1977) and enclosure: "Radiation Inciden Report: Uranium 'Yellow Cake' Spill, September 27, 1977, Southeastern Colorado," Colorado Department of Health.

F. "Fact Sheet - Transportation of Radioactive Material - Natural Uranium Oxide (Yellowcake)," U.S. Nuclear Regulatory Commission.

G. Letter from G. Ortloff, Regulatory Affairs Manager, Exxon Minerals Co., U.S.A., to S. Meyers, Director, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission (December 12, 1977).

H. "Clean-up of Natural Uranium Concentrate Spilled in a Transportation Accident near Springfield, Colorado on September 27, 1977," Exxon Mineral Company, U.S.A., Technical Report (March 1978).

COLORADO DEPARTMENT OF HEALTH

4210 EAST 11TH AVENUE · DENVER, COLORADO 80220 · PHONE 388-6111
Anthony Robbins, M.D., M.P.A. Executive Director

October 3, 1977

Sheldon Meyers, Director
Division of Fuel Cycle and Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Truck Accident, September 27, 1977, which released 21 tons of yellowcake near Springfield, Colorado

Dear Mr. Meyers:

On September 27, 1977, the Colorado Department of Health sent a response team to a site about 15 miles north of Springfield, Colorado on U.S. Highway 287. A Leeway Trucking Co. tractor/enclosed trailer rig had hit three horses and rolled on its side about 1:00 a.m. that morning. The truck was enroute from the Exxon Mill at Highland, Wyoming to the Kerr-McGee Plant at Gore, Oklahoma with a load of 42,000 pounds of yellowcake. About 30 of the barrels penetrated the side and top of the trailer and ruptured on the ground. Most of the other 20 barrels remaining in the trailer also ruptured. It took about 2 hours to cut the cab open and remove the injured drivers. They were taken by ambulance to Southeast Colorado Hospital at Springfield, Colorado where they were decontaminated and treated for cuts and fractures. Upon advice from the Exxon Corporation, Baca County Sheriff's Officers had the truck and the adjacent spill area (about 50 x 100 ft.) covered with plastic tarpaulins soon after the accident. Two people from the Exxon Mill arrived at the scene about 3:30 p.m. on September 27, 1977 with one Geiger counter. They had the misconception that cleanup would be supervised and carried out by the Colorado Health Department Personnel. They were not only improperly instructed but inadequately trained and equipped for their mission. An Exxon Co. Industrial Hygienist who arrived on September 28, 1977 was similarily inadequate for the mission. Colorado Health Department personnel requested that cleanup not proceed until Exxon furnished adequately trained and equipped personnel. This included someone equipped with and knowledgeable in the use of the gamma scintillometer and alpha survey

Sheldon Meyers, Director
October 3, 1977
Page 2

meters, and also trained in the fitting and use of respirator equipment. In response to this, Exxon sent a Certified Health Physicist and respirators the evening of September 29, 1977. Cleanup commenced on September 30, 1977 in accordance with the following recommendations from the Colorado Department of Health.

1. Personnel be properly suited, and fitted with respirators. (This is a very windy area).

2. Provisions be made at the site for decontamination of personnel and storage of contaminated clothing.

3. The yellowcake be moistened enough to prevent blowing while being hand shoveled into new barrels.

4. The old barrels be put into larger containers instead of being patched up with tape as per Exxon's request.

5. A truck or other construction be placed upwind of the site as a windbreak.

6. The truck be decontaminated at the site prior to removal.

7. The site be decontaminated to background levels as measured with a calibrated scintillometer per Nuclear Regulatory Commission Criteria.

Colorado Department of Health personnel will be at the site until this cleanup is completed.

The Colorado Department of Health recommends that the U.S. NRC reappraise its licensing and regulatory program for uranium mills in order to insure the following:

1. All mill licensees be made aware of their responsibility for immediate response to control and cleanup of their materials in transit.

2. All mill licensees submit to the U.S. NRC or appropriate agreement state authority an acceptable emergency response plan for transportation accidents. Such plans should include at least the following:

A. A training program for a response team.

B. Provision of adequate clothing and survey equipment for a response team.

C. Arrangement for transport of the response team to an accident scene.

D. Arrangement for an adequate number of trucks and empty containers to be dispatched on very short notice to an accident scene.

E. Provision for personnel and equipment to handle such problems as covering spills, constructing windbreaks, constructing water diversions (including pumping systems), and handling such other logistical problems as decontamination, sanitation, security and communication facilities.

F. Establishment of an adequate company command structure to ensure that the plan is promptly and effectively executed.

3. Shipments of uranium and thorium concentrates be made in containers adequate to withstand the hazards of truck and rail transport. It appears that the containers involved in this accident were completely inadequate.

4. Provisions be made for prompt reimbursement for expenses incurred by state and local agencies who respond and assist at the scene of accidents involving fuel cycle material. Expenses at this particular accident include so far:

A. State Highway Patrol cars convoyed traffic on a detour for over a week during cleanup operations.

B. County Sheriff's personnel provided site security round the clock for over a week.

C. The County Sheriff provided covering tarpaulins for the truck and contents.

D. The State Highway Department provided equipment on standby to dig diversion ditches in case of a rainstorm.

E. The State Department of Military Affairs provided tents to serve as decontamination and shower facilities.

F. The State Health Department personnel incurred transportation and per diem expenses for over a week.

It is fortunate that this accident occurred in a remote, dry, level, open location. If it had occurred near a water course, in a metropolitan area, or in a mountain area, the problems would be compounded many fold. While many individuals responded with common sense to this accident, it is clear that preparedness for such an eventuality was inadequate. The Colorado Department of Health requests the Nuclear Regulatory Commission to take immediate steps to close this gap in their administration of the Nuclear Fuel Cycle.

Sincerely,

R.D. Siek
Associate Director of
Environmental Programs
Office of Health Protection

RDS:wsr

CC: A.J. Hazle, Colorado Department of Health
Gerald Ortloff
c/o Highland Uranium Operation
Exxon Corporation
Box 3020
Douglas, Wyoming

DEC 14 1977

Mr. R. D. Siek
Associate Director of
Environmental Programs
Office of Health Protection
Colorado Department of Health
4210 East 11th Avenue
Denver, Colorado 80220

Dear Mr. Siek:

Thank you for your letter of October 3, 1977, describing the actions taken by your office in response to the recent transportation accident near Springfield, and recommending various steps to improve future emergency response. Your recommendations are being considered by the Nuclear Regulatory Commission (NRC).

The NRC and DOT have initiated a program to identify and study areas where possible improvements in the safety of transporting uranium oxide and other low-level radioactive material might be achieved. We have developed a list of areas to be studied which considered those areas recommended in your letter. We have reviewed this list with Congressman Wirth and understand that he plans to send the list to the Governor with a request for comments from Colorado. We would appreciate receiving a copy of your report and other information dealing with the yellowcake accident and copies of any photographs taken at the accident scene, particularly those showing the condition of the drums. We are referring here to information that you may not as yet have furnished to Mr. Wayne Kerr.

We note that the Colorado Department of Health is an active member of the American National Standards Institute N692 task group which prepared a draft proposed standard, "Emergency Procedures for Highway Transportation Accidents Involving Radioactive Materials." We would like to know if you are in agreement with the draft proposed standard and if you have implemented any part of it in your emergency response program. We would also appreciate receiving your comments on the respective roles and interfaces among Federal, State, local and licensee programs for emergency response.

We will keep your office informed of the progress and results of our study.

Sincerely,

Original signed by
SHELDON MEYERS

Sheldon Meyers, Director
Division of Fuel Cycle and Material Safety

COLORADO DEPARTMENT OF HEALTH

4210 EAST 11TH AVENUE · DENVER, COLORADO 80220 · PHONE 388-6111

Anthony Robbins, M.D., M.P.A. Executive Director

January 13, 1978

Sheldon Meyers, Director
Division of Fuel Cycle and Material Safuty
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Meyers:

Thank you for your letter of December 14, 1977, to Mr. R. D. Siek regarding the Springfield, Colorado uranium spill, our report and photographs which were sent to Mr. Wayne Kerr several weeks ago. Mr. Siek is no longer with our Department, therefore, I will attempt to answer the questions raised in your letter.

Mr. Jim Montgomery of my staff is chairman of the American National Standards Institute N692 task group and expects to be submitting the final standard for publishing within the next few weeks. We are, of course, in agreement with the draft proposed standard and have been conducting our emergency response program in accordance with the standard for several years.

It should be noted that the Standard addresses procedures to be followed by emergency response personnel in the event of an accident. Other ANSI Standards will have to appropriately address the transportation and packaging of radioactive materials.

Mr. Montgomery is a member of the Inter-agency Task Force on Emergency Response which is working with the Office of State Programs to address the subject of Federal, State and local interfacing for emergency response. The position of this Task Force will hopefully reflect the views of our Department and, as such, should be responsive to the second to last sentence in your December 14, 1977 letter.

If we can be of further assistance, please contact this Division

Sincerely,

Albert J. Hazle, Director
Radiation and Hazardous
Wastes Control

AJH:JLM:er

630 360

COLORADO DEPARTMENT OF HEALTH

4210 EAST 11TH AVENUE · DENVER, COLORADO 80220 · PHONE 388-6111
Anthony Robbins, M.D., M.P.A. Executive Director

January 16, 1978

Mr. Richard P. Pollock, Director
The Citizens' Movement for
Safe and Efficient Energy
P.O. Box 1538
Washington, D. C. 20013

Dear Mr. Pollock:

This will acknowledge receipt of your letter of November 3, 1977, which included a copy of an investigation report on the September 27, 1977 accident which involved uranium concentrate.

It is the purpose of this letter to provide additional information to clarify some of the statements made in your investigation report.

The local emergency personnel and the State Patrol who were first to arrive on the scene did an excellent job of rescuing the injured truck driver and passenger, covering the spilled yellowcake to prevent its spread, and securing the names and addresses of all persons who had stopped at the accident and might have been contaminated. This list of names was later used by the Exxon Company to contact everyone who had assisted at the accident.

The Exxon Company had provided the trucking company with written instructions concerning the nature of the cargo and listed exactly what actions were to be taken in the event of an accident. These instructions were included with the shipping papers.

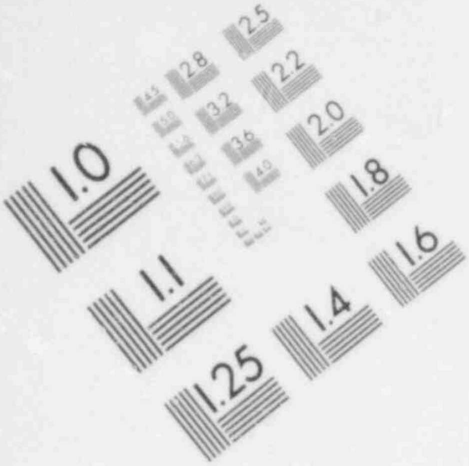
One of the Highway Patrolmen, and perhaps others who responded to the accident had attended a hazardous materials workshop presented in cooperation with this Division in the southeastern part of the state. Because of the frequency of the highway use in this part of Colorado by trucks carrying yellowcake, the handling of accidents involving yellowcake was discussed in detail at that workshop by Departmental staff.

The "general rules" to follow in emergency response are written in booklets provided by this Division to the local emergency personnel (see attached).

Each incident to which the Department must respond is unique and no specific

IMAGE EVALUATION TEST TARGET (MT-3)

6″



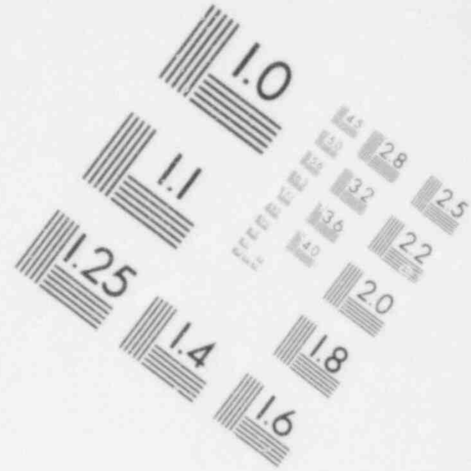
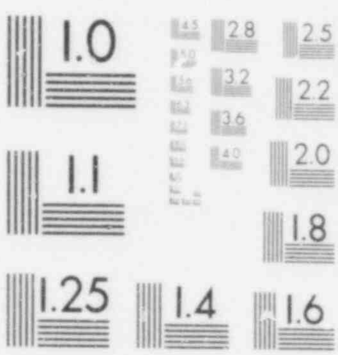
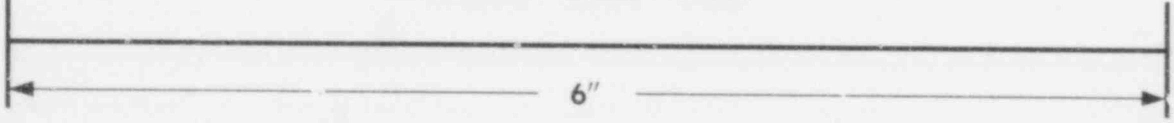
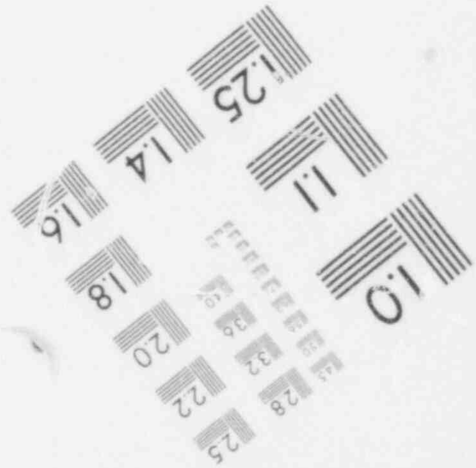


IMAGE EVALUATION TEST TARGET (MT-3)







Mr. Richard P. Pollock
January 16, 1978
Page 2

written instructions can be given to the Health Physicists regarding all possible accidents . However, there is basic knowledge and training which Divisional personnel possess which applies to handling all aspects of the accident and cleanup.

A letter has been sent to each producer of uranium concentrate by this Department to notify them of the need to have equipment and personnel to respond immediately to such an accident, should their material be involved. Each producer's response plan will be reviewed by the Department for adequacy.

The initial notification of this Division by the State Patrol Dispatcher at 4:00 A. M. was incomplete and follow-up details were to be provided as they became available. No further information concerning the severity of the accident were received until after 8:30 A. M. that morning. It was not until the Health Physicists arrived at the scene that the magnitude of the accident was known.

The Exxon Company was notified that a total of six to twelve barrels had been damaged, and their response was to send two people with protective clothing, respirators, a Geiger-Mueller Survey Meter, one air sampler and twenty barrels.

The two Exxon people who responded were misinformed as to their responsibility for cleanup, having been sent to assist the State of Colorado in doing the cleanup. After being informed that they (Exxon) would do the cleanup, they took immediate action to comply.

There was no "quarreling" between state officials and the firms involved. There were discussions between Health Department personnel and Exxon representatives concerning responsibility and cleanup techniques to be used. These were not arguments, but were statements of the Department's position and then discussing how these requirements could be carried out. The Exxon people were very cooperative in meeting all demands. They complied with all requests and requirements as set by the Colorado Department of Health.

The trucking company had financial responsibility for cleanup of the accident, however, the Department considered Exxon as the agency responsible for cleanup for the following reasons:

1) Exxon had personnel who were accustomed to working with yellowcake and knew of its hazards and the precautions to take in its handling.
2) The Exxon Company had personal protective gear and the equipment to use in the cleanup.
3) The Exxon Company had about $1.5 million in yellowcake spilled along the roadway.

Mr. Richard P. Pollock
January 16, 1978
Page 3

The trucking company provided payment for all rental and purchases of equipment used during cleanup.

On September 27th, the day of the accident, the Exxon Company employed several local men to assist in the cleanup. However, it was the position of the Department that:

1) The cleanup should not be attempted with a "front-loader" because of the continual wind in the area.
2) Adequate survey meters should be available to define the contamination area and to determine the adequacy of cleanup.
3) Continual air monitoring would be done during the cleanup operation.
4) Cleanup personnel would wear anti-contamination clothing and "fitted" respirators. This required a Health Physicist or someone knowledgable in fitting respirators.
5) Personnel monitoring, i.e., bioassays, would be required on all persons involved in the initial rescue and in the cleanup.
6) A dike was to be constructed around the spill to prevent rain from washing across the area and spreading contamination.

Exxon decided it would be easier to use it's own personnel for cleanup rather than the local personnel and brought about twelve employees from the Highland Uranium Mill in Wyoming.

Since the spill was contained, with no risk of spreading into the environment and no radiation hazard to personnel, it was best to proceed slowly and deliberately with the cleanup to prevent the situation from becoming a larger problem.

The first newspaper coverage was an article in the Pueblo Chieftan the morning of the day after the accident (September 28).

The Colorado Department of Health press release was issued on September 30, with general facts about the accident, initial response, plans for cleanup, and informing people that bathing and washing of clothes would remove surface contamination (see attached).

Appropriate action has been taken within the Department to hasten press releases should a similar situation re-occur.

The final evaluation of whether the Department's decision and action were justified should be made on the basis of cleanup results.

1) There were no personnel exposures which approached any established limits.

Mr. Richard P. Pollock
January 16, 1978
Page 4

2) The spill was contained within the original accident area with no contamination of additional land during cleanup as confirmed by the continual air monitoring and radiation surveys.
3) The spill site was decontaminated to background levels, i.e., after cleanup, the spill site radiation levels were the same as adjacent non-involved areas.

We hope that this helps clarify some of the statements which have been made regarding the Springfield accident.

We share the expressed concerns regarding increasing numbers of hazardous materials shipments on heavily traveled highways and through metropolitan areas.

Sincerely,

Albert J. Hazle, Director
Radiation and Hazardous
Wastes Control

AJH:er

cc: Tom Vernon, M.D.
Enclosure
Gearld D. Orhoff, Regulatory Affairs
Exxon, Houston, Texas

A. W. Grella, Office of Hazardous Materials
Department of Transportation, Washington D. C.

Carlton Kammerer, Director, Office of Congressional Affairs
Nuclear Regulatory Commission
Washington, D. C.

E. Morris Howard, Director
Nuclear Regulatory Commission, Region IV
Arlington, Texas

COLORADO DEPARTMENT OF HEALTH

4210 EAST 11TH AVENUE · DENVER, COLORADO 80220 · PHONE 388-61

Anthony Robbins, M.D., M.P.A. Executive Direct

November 1, 1977

The Honorable Gary Hart, Chairman
United States Senate
254 Russell Senate Office Bldg.
Washington, D.C. 20510

ATTN. Kevin Cornell

Dear Senator Hart:

Pursuant to your request we are enclosing the summary report of the Colorado Department of Health on the uranium concentrate truck accident near Springfield, Colorado on September 27, 1977.

Mr. Cornell of your office also requested the Department's comments on the U.S. Nuclear Regulatory Commission's (NRC) report to you dated Octobe 12, 1977 and signed by Carlton Kammerer.

1. On page 2 of their summary report they state that "the hazard to personnel is therefore relatively low since significant quantities must be taken into the body before damage to tissue occurs". The ingestion and inhalation hazard of "yellow cake" as both a heavy metal poison and as a radioactive hazard is such that stringent precautions are required for those who routinely handle it in processing under controlled conditions. These precautions include the use of protective clothing, respirators, and restricted work periods. It was several days before such protective equipment was available for the uncontrolled conditions at the Springfield accident.

POOR ORIGINAL

IV-13

2. On page 5 several statements are made about the "high improbability" of a person having an intake of as much as 10 or 17 milligrams of uranium concentrate due to a transportation accident. In the Springfield accident situation finely powdered uranium concentrate was spread over an area of several thousand square feet and as deep as a foot. This was far worse than previous estimates of a maximum credible accident provided in several NRC Environmental Impact Statements. One rescue worker reportedly fell on his face in this material during early rescue efforts. In view of Colorado's experience with uranium concentrate accidents, it would appear that the NRC underestimates the accident potential and the resultant impacts.

3. The NRC has in the past not required its licensees to prepare transportation accident contingency plans and apparently still does not feel inclined to do so. While the carrier does have some legal responsibility under such circumstances, they certainly do not have the expertise, personnel and equipment to adequately respond in a timely manner. The licensee however is in a position to respond and also should protect its interests. Therefore, Colorado will be requiring its uranium mill licensee to plan accordingly.

4. The recommendations for decontamination of the equipment and accident site made by the NRC were based on the nuclear power plant decommissioning criteria of NRC's Regulatory Guide 1.86. The Colorado Department of Health felt the application of such a criteria inappropriate as the situation could be easily decontaminated to levels well below those specified in 1.86. The "as low as reasonably achievable " philosophy as required by Colorado allowed decontamination of the equipment and site to background levels. Apparently the AEC's old philosophy of just requiring what the regulations specifically state still exists in the NRC. The Rocky Flats Plant off-site soil contamination and the old inactive uranium mill tailings pile legacy were a result of this regulatory stance.

As a side issue regarding item 4 above, the ERDA/EPA Phase II, Title I final reports requested by Congress are now being published. The appropriate remedial action will require in excess of a hundred million dollars. Because this situation occurred as a result of the Federal procurement program and inadequate regulation by the Federal Government, the State of Colorado, along with other states and jurisdictions, have taken the position that any remedial measures taken are to be at full Federal expense.

Should you have any questions regarding the Department's Springfield Accident Report or our comments regarding the NRC report, please do not hesitate to contact this office.

Sincerely,

Albert J. Hazle

Albert J. Hazle
Director, Radiation
& Hazardous Wastes
Control Division

AJH:els
Enclosures

POOR ORIGINAL

COLORADO DEPARTMENT OF HEALTH

RADIATION INCIDENT REPORT
URANIUM "YELLOW CAKE" SPILL
SEPTEMBER 27, 1977 - SOUTHEASTERN, COLORADO

9/27/77
4:00 A.M. A Colorado State Patrol dispatcher notified Jim Montgomery of the Colorado Department of Health that a truck carrying uranium "yellow cake" was involved in an accident near Springfield, Colorado. The dispatcher was to notify Jim Montgomery of further details as they became known.

8:30 A.M. Jim Montgomery notified the Colorado Department of Health office staff of the accident near Springfield, Colorado of a truck carrying "yellow cake". Two people were reported injured and an unknown quantity of the yellow cake had been spilled. Darrel McDanial and Chuck Mattson were delegated to respond for the Department.

Chuck Mattson called Bill Dunn, of the Colorado Department of Health Laboratory Division, who said he had been called by the Poison Control Center concerning treatment of the victims. He had no more information on the truck accident.

Chuck Mattson called Poison Control Center and discussed the accident victims. It was suggested that urine and fecal samples, and nasal wipes be taken to indicate any ingestion of uranium. They were informed that there was little radiation hazard, but a potential for a heavy metal poisoning.

Anti-contamination clothing, sampling and counting equipment was gathered together, and Health Physicists Mattson and McDanial departed for Lamar at about 10:00 A.M.

11:40 A.M. William Somers of the Colorado Department of Health received a phone call from Mr. Gerald Ortloff (713-656-4239) of Exxon Corporation concerning the truck accident near Springfield, Colorado. He informed Mr. Somers that Lee Way Motor Freight of Oklahoma City was the carrier and was responsible for the clean-up. Mr. Ortloff stated that he was sending the environmental Engineer from the mill, Mr. Richard T. Hornsby, and one technician, Nancy Dennis, to the site. They are equipped with a complete emergency kit and would check the undamaged drums for contamination before loading them on another truck the carrier was sending. They would also coordinate the clean-up with the Department of Health staff at the scene of the accident. Exxon's intention was to moisten the yellow cake to help prevent the spread of airborne contamination and recover the yellow cake and soil wet. Twenty-55 gallon drums are being sent to the site to be used for picking up the yellow cake and soil.

POOR ORIGINAL

11:40 A.M. (cont.) Mr. Ortloff asked about evacuating nearby residents if the yellow cake was being blown towards them. William Somers stated that this could be done with Department sanction if there was a definite risk. Mr. Ortloff then asked about blocking the highway to traffic and W. Somers stated that would be up to the Colorado State Patrol. The conversation was concluded at approximately 11:45 A.M.

2:30 P.M. Chuck Mattson and Darrel McDaniel arrived at accident site and observe that the truck and spill area had been covered with plastic sheets. It appeared that the majority of the drums had been thrown from the truck and the "shapes" of the covered drums indicated that many had been severely damaged. No one from Exxon had arrived at the scene. C. Mattson and D. McDaniel talked to Baca County Sheriff's Deputies and Mr. Walters from Colorado Highway Department concerning the accident, accident victims, and rescue personnel. D. McDaniel stayed at the site while C. Mattson and Mr. Walters drove into Springfield to inspect the hospital, victims and ambulance.

2:45 P.M. A gamma radiation survey was performed at the accident scene using Colorado Department of Health micro-R meter U.S. AEC L39196. The following readings were recorded: * (see figure 1)

3:30 P.M. Chuck Mattson arrived at hospital, introduced himself to the Administrator, Edna Chensweth, and was introduced to the ambulance crew. The ambulance was posted with a DO NOT ENTER sign and bags containing clothing of ambulance personnel and the truck drivers were observed outside the rear hospital door.

A survey with the Ludlum alpha radiation survey meter of the ambulance indicated the floor, entry ways, and some equipment was contaminated to 400 cpm alpha. The interior of the ambulance was vacuumed and scrubbed, and all the equipment was cleaned, after which there were no readings on the meter.

The hospital shower rooms, emergency room, and the victim's room was free from contamination.

Clothing in plastic bags was observed to be covered with the yellow cake and gave readings to 100 μR/hr. with the gamma radiation scintillator. Hospital personnel were told to leave the clothing in the bags until it was decided how they would be cleaned or disposed of.

Gamma and alpha radiation surveys of the victims' hands, faces, and nasal wipes showed no activity.

* Natural background radiation levels were determined to be 18-20 micro-R/hr.

POOR ORIGINAL

4:00 P.M. Rick Hornsby and Nancy Dennis of Exxon Corporation's Highland Uranium Operations arrived at the scene of the incident. Mr. Hornsby asked Mr. McDaniel how the Colorado Department of Health was going to manage the clean-up operation. Mr. McDaniel told him that the Colorado Department of Health was at the scene to insure that the material was cleaned up properly and that the Department would not do the actual clean-up. Mr. Hornsby asked questions concerning the responsibility for the clean-up. He maintained that it should be Lee Way's responsibility to clean up the spill. He was advised by the Colorado Department of Health that the yellow cake would have to be hand shoveled into new barrels, and moistened when necessary to prevent blowing.

4:10 P.M. Mr. Hornsby began making arrangements for security of the truck and uranium barrels during the night. He also began making arrangements for equipment and manpower for the clean-up operations which were to begin at dawn, September 23, 1977.

4:15 P.M. Alex Ewing, Exxon Security Agent, from Midland, Texas arrived at the scene.

4:20 P.M. Mr. Hornsby and Ms. Dennis conducted an initial inspection of the truck and contents to determine the extent of damage to the drums. Mr. McDaniel was informed of the following:

1. A truck with twenty empty drums was being dispatched from Wyoming so that the uranium oxide could be shipped back to the mill for reclamation,
2. Exxon was going to buy all the contaminated clothing from the rescue personnel, and
3. A planning meeting was to be held that evening to make all logistics plans.

5:15 P.M. Darrel McDaniel and Rick Hornsby, wearing respirators and anti-contamination clothing, entered the trailer to examine the extent of damage to the drums that had not been thrown from it. There were 18 drums in the trailer, all damaged to some extent. At least half of the 18 drums were visibly leaking or had dumped the yellow cake.

5:30 P.M. A visual examination of the surrounding area was made by Ms. Dennis, Mr. Hornsby and Mr. McDaniel to determine the extent of blowing of the yellow cake (wind from southeast). There was no conclusive evidence that significant amounts of yellow cake had blown. Rick Hornsby informed Darrel McDaniel that all drums and yellow cake would have to be shipped back to Wyoming. Mr. Hornsby requested assistance from the Colorado Department of Health for monitoring and release of equipment after decontamination. He also requested that traffic control and decision making be in cooperation with the Colorado Department of Health.

6:00 P.M. Chuck Mattson left the hospital. Mr. McDaniel performed a gamma radiation survey of the area surrounding the accident scene to determine background. The following readings were obtained with micro-R meter - AEC 139196: (see figure 2)

9/28/77 8:00 A.M. Darrel McDaniel and Chuck Mattson arrived at the accident site. No progress had been made toward clean-up. Mr. Hornsby drove to Springfield to telephone his office prior to making any decisions or answering any questions. He was told that the Colorado Department of Health regarded Exxon as the agency responsible for clean-up, and providing enough trained personnel with proper equipment, to get the job done. The remainder of the day was spent waiting for the personnel and equipment. Mr. Mattson and Mr. McDaniel returned to Denver late that evening

4:15 P.M. Chuck Mattson phoned Richard Gamewell at the Colorado Department of Health. Mr. Gamewell requested that bioassays be obtained for a fireman who reportedly had fallen in the yellow cake shortly after the accident.

4:30 P.M. Mr. Gamewell notified John Barry of the U.S. ERDA Radiological Assistanc Team, Idaho Falls. Help was not requested. This was their initial notifi cati

4:35 P.M. Mr. Gamewell notified Frank Rozich, Director of the Colorado Department of Health Water Quality Control Division. Since local farmers use effluent from the Springfield sewer plant, Rozich decided to have it sampled.

9/29/77 9:00 A.M. Mr. Gamewell notified Paul Smith, Region VIII, U.S. EPA and Ace Bischard Colorado Department of Health Air Pollution Control Division.

11:30 A.M. Floyd Nichols, Region VIII, U.S. EPA notified Mr. Gamewell of the Colora Department of Health that a photo flight over the accident was planned that afternoon.

11:35 A.M. Gerald Ortloff, Exxon, called the Colorado Department of Health (Gamewel Mattson, and McDaniel). The Colorado Department of Health advised him of the desirability of getting people to the accident site who were thoroughly trained in the fitting of respirators and the use of sensitive radiation survey meters.

11:40 A.M. Mr. Gamewell updated Jim Montgomery of the Colorado Department of Health who requested that Chuck Mattson return immediately to the site and that a press release be issued.

1:45 P.M. Mr. Ortloff telephoned the Colorado Department of Health and said two individuals, Marvin Smith, a certified Health Physicist, and Ed Foster, a Health Physics Technician, from Exxon Nuclear at Richland, Washington would arrive in Lamar about 7:00 P.M. They will supervise the clean-up job. They are also sending 2 Scott air packs and 10 full face masks with fittings for compressed air bottles. It was recommended that they contact Chuck Mattson at the El Mar Motel, Lamar, Colorado.

3:40 P.M. Mr. Gamewell of the Colorado Department of Health called Ms. Davis, Head Nurse at Southeast Colorado Hospital in Springfield, about bioassays on the drivers. Urines were still being collected and would be sent for analysis to the University of Colorado Medical Center, Denver (Dr. Robert Peterson).

5:30 P.M. Jerry Hensel, U.S. EPA, advised Mr. Gamewell of the Colorado Department of Health of successful photo flight.

6:00 P.M. Chuck Mattson arrived at accident site and talked briefly with Rick Hornsby who was on his way to a dinner meeting with his Exxon crew. Photos were taken of the accident scene. The only work which was being done was improvement of roadside barricades by the two evening guards. Chuck Mattson returned to the motel at 8:15 P.M.

11:50 P.M. Chuck Mattson received a telephone call from Mr. Marv Smith who introduced himself as the Consulting Health Physicist hired by Exxon to assist in the clean-up. He had worked for Exxon before and is on the faculty of the Graduate School of the University of W shington. He discussed his plans to build an enclosure as a "wind shield" to keep the dust down during clean-up. The face masks which he recommended that the clean-up crew wear were the full face, double cannister type, because he had used these before in plutonium work. An appointment was made for breakfast at 7:00 A.M.

9/30/77
7:00 A.M. Chuck Mattson introduced himself to Marv Smith, of Exxon, and went to the breakfast meeting. Ten Exxon employees, who had been sent to assist in clean-up, also attended the meeting. Mr. Mattson talked briefly with Mr. Smith concerning his plan for the clean-up including the building of a portable shelter so that all clean-up work could be done without wind interference. The use of protective clothing and full-face respirators was also discussed.

8:30 A.M. Mr. Gamewell advised Albert J. Hazle, Colorado Department of Health, of the situation.

8:40 A.M. Mr. Gamewell advised Robert D. Siek, Colorado Department of Health, of the situation. Mr. Siek requested an immediate letter to the U.S. Nuclear Regulatory Commission.

8:45 A.M. Chuck Mattson arrived at the accident site. It was observed that a farmer and his dog were on guard. A-1 Rental Company employees were setting up a portab e toilet.

9:30 A.M. A gamma radiation survey of the area was conducted with a Model PRM-7C survey meter. (see figure 3)

9:30 A.M. (cont.) Ed Foster was using a Thyac III with a pancake probe for all environmental surveys. Mr. Ed Foster was the Health Physics Technician Specialist for Exxon Nuclear, where he had worked for 6½ years. Prior to this, he had four years experience at Battelle (Hansford). His training consisted of one year as a "trainee", 3 years as a "monitor", and then experience as a "journeyman". Marv Smith talked about "taping" holes in damaged barrels then wrapping in plastic for shipping. He stated this was preferable to emptying the barrels and handling the yellow cake.

11:05 A.M. Chuck Mattson called the Department and related the following:

1. The 2 Health Physicists from Richland, Washington have arrived.
2. They are building a movable structure of 2 x 4's and plastic to act as a wind block around the spill.
3. A shower and changing tent from the National Guard was being set up at the site.
4. Urine samples of 13 persons involved in the rescue were being collected and sent to U.S. Testing Laboratory for analysis. Results should be available on approximately 9/30/77.
5. Exxon wants to tape and tar punctured barrels. It was recommended that they obtain Department of Transportation and Colorado Department of Health approval.
6. Workers would wear full face masks with canisters suitable for plutonium.
7. Mr. Mattson suggested that contingency plans be made to cope with rains and flooding.

11:30 A.M. Chuck Mattson stopped at the Southeast Colorado Hospital. The Administrator, Ms. Chensweth, related how the victims' urine samples had not been forwarded to the Colorado University Medical Center for analyses. She also indicated that the chelating agents had not been received from the supplier. A nurse had been told to collect urine samples for 24 hours after the administration of the drug "cuprimine". She had understood that she was to send in all samples together, so she had held onto them.

Mr. Mattson talked to Dr. Robert Peterson at the Colorado University Medical Center and was asked questions about the victims condition and these questions were forwarded to the physician at the hospital. If there had been a heavy metal problem with either victim, they would have already been symptomatic. The Administrator was asked to send the samples by the fastest means possible for analyses.

12:15 P.M. Mr. Mattson arrived back at the accident site. The OLA3 (USAF Operating Location Alpha 3: Cheyenne Mountain), 947th Medical Company (Army National Guard) and the Lamar Fire Department were completing the installation of a tent for showering. A portable shelter for barrel exchange was being constructed.

12:15 P.M. (cont.) Mr. Smith stated that he had talked to Department of Transportation in Washington, D.C. concerning the shipping of damaged drums. Their reply according to Mr. Smith was to use satisfactory industrial containers, and to ship the yellow cake in a 'sole use vehicle'. There were no specifications on the containers

1:50 P.M. Gerald Ortloff, Regulatory Affairs Manager, for Exxon, arrived at the site. Mr. Ortloff is the Regulatory Affairs Manager for the Minerals Department of Exxon, U.S.A. He has worked in the Minerals Department for 5¼ years. Prior to this he worked in the Exxon Production Department as a chemical engineer.

2:00 P.M. Mr. Al Hazle telephoned Dr. George Voelz, Los Alamos, New Mexico, and requested that he call Southeast Colorado Hospital, Springfield, Colorado to determine whether the bioassay methods being used were appropriate. Mr. Hazle also requested that Dr. Voelz advise the hospital of the proper procedures and methods to be used in an incident of this type.

2:30 P.M. Traffic was detoured around the site via Highway 116, a dirt road about 1 mile east of U.S. 287. It required one way traffic and an escort by the State Patrol through the detour. This detour would remain in effect, during daylight hours, until clean-up was completed.

3:30 P.M. The portable barrel exchange enclosure was set down on black tarp over one barrel, and the outside sealed around the bottom. One man with protective clothing and full face respirator went inside the enclosure and cut the plastic cover. The barrel, dented on the side, but not broken, was washed, lifted by front loader, surveyed and then transferred to a decontaminated barrel area.

Two additional barrels were filled with yellow cake, dirt, and weeds from the area inside the enclosure. These were then washed, surveyed by wiping the outside and moved to the decontaminated barrel area.

Work continued until dusk.

4:00 P.M. The Colorado Department of Health mailed out first press release.

5:30 P.M. Mr. Mattson called and updated Mr. Gamewell. Mr. Mattson was requested to return to Denver on October 1st if the situation appeared under control.

10/1/77 8:00 A.M. Chuck Mattson arrived at the accident site. A gamma radiation survey was done with a Micro-R meter (U.S. AEC 139196): (see figure 4)

Work was progressing slowly; the Health Physicist was being very conservative in the handling of the clean-up. The Health Physics Technician appeared knowledgeable and conscientious with his surveys.

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12:30 P.M. Chuck Mattson talked to Gerald Ortloff and Rick Hornsby and requested that they call at 9:00 A.M. and 4:00 P.M. daily with a report of progress, monitoring results, bioassays and any problems encountered during clean-up. Mr. Mattson then returned to Denver.

10/2/77
8:30 A.M. Chuck Mattson received a telephone call from Nancy Dennis, who provided results of urine analyses for the people involved in the rescue. She stated that the minimum detectable amount was 10 μgms uranium per liter of urine.

Two persons exceeded this minimum detectable amount:

- 16.4 μgms/l

- 10.2 μgms/l

These levels are considerably below Safety and Health Standards.

A National Guard tent had been used at the site as additional cover for the truck to prevent blowing of the yellow cake.

A number of plastic bag drum liners had been purchased.

Five drums of dirt and yellow cake had been barreled.

10/3/77
8:30 A.M. A staff review of the incident and clean-up attempts to date was conducted at the Colorado Department of Health. Questions were raised concerning responsibility for clean-up, adequacy of personnel and equipment, and the technique to be used for the final survey to assure complete clean-up.

9:30 A.M. Call received at the Colorado Department of Health from the Lamar newspaper. The reporter was referred to the Colorado Department of Health Public Relations office.

10:30 A.M. Chuck Mattson stopped at the Denver Federal Center, Building 53, Room B2217, and talked to Jerry Hensel concerning the aerial photographs of the accident site. All photos were viewed and 15 were selected to be sent to the Colorado Department of Health.

2:30 P.M. Darrel McDaniel received a telephone call from Mr. Coleman Smith of the Oklahoma Department of Health, Occupational and Radiological Health Service, (405) 271-5221. Mr. Smith indicated he had talked to a Lee Way truck driver named Harold E. Shea. Mr. Shea had stopped his truck at the accident scene and was involved in the rescue operations. A urine bioassay had been taken from Mr. Shea and Mr. Smith wanted to know where it should be assayed. Mr. McDaniel told Mr. Smith that he should talk to Mr. Gamewell of the Colorado Department of Health Laboratory.

10/4/77
7:45 A.M. Chuck Mattson arrived at the accident site. Mr. Blount and two Exxon employees were at the site. They were working on the electrical wiring.

A pickup truck from A-1 rental delivered a compressor. Four more Exxon employees arrived with twelve rolls of plastic tarp.

A Southeast Colorado Power Association truck arrived and the men began to install a three-phase transformer and two street lights on the power poles.

Two Colorado Highway Department trucks delivered eight rolls of snow-fence. This was used to encircle the accident site. The fence was then covered with plastic tarps which served as a wind break.

Vacuum cleaners, filters, and miscellaneous boxes of equipment were delivered during the day by taxi service from Pueblo.

10/5/77
3:00 P.M. Chuck Mattson returned to Denver.

4:00 P.M. Darrel McDaniel received a telephone call at the Colorado Department of Health from Mr. Gerald Ortloff, Exxon Corporation, to report the progress of clean-up operations. Mr. Ortloff informed him that the contents of 27 drums had been recovered and placed with 50 drums previously filled for shipment back to Wyoming. He hoped that clean-up would be completed by the weekend and that final grading and scraping would be finished by the first of the following week.

Mr. Ortloff also reported the following information:

Total activity on air filters in the clean-up area (continuous sampling 7:30 A.M. to 11:30 A.M.) = 2.2×10^{-10} µCi/ml

Activity on air filters sampled 50 feet downwind from work area (continuous sampling 7:30 A.M. to 11:30 A.M.) = 1.3×10^{-10} µCi/ml

Urine sample results from U.S. Testing Service:

All samples for men doing clean-up were less than the limits of detection (i.e. <10 µg/ml).

Ten results had been received for the men involved in rescue work. Two of these were above the limits of detection, one 10.2 µg/ml and the other 16 µg/ml.

POOR ORIGINAL

10/6/77
11:00 A.M. Darrel McDaniel listened in on a phone conversation between Don Hendricks, EPA, Las Vegas and Chuck Mattson. Mr. Hendricks was interested in knowing about the accident and specific questions about the makeup of the yellow cake, its solubility, and final calcining temperature. He mentioned that ammonium diuranate was more soluble than uranium oxide.

Mr. Hendricks offered the use of some Geiger-Muller instruments that had been calibrated for counting yellow cake on air filters. However, we declined at that time, but Mr. Mattson called back later and had two instruments sent to the Colorado Department of Health.

The attached handwritten note from Mr. Albert Hazle contains calibration information for the EPA Geiger-Muller instruments and also decontamination levels.

2:00 P.M. Margo Hornblower, of Washington Post, called Chuck Mattson with request for an interview with Al Hazle. Mr. Hazle was not in the office at that time.

2:10 P.M. Mark Weaver, of KDEN radio, called Chuck Mattson for an interview with Al Hazle, who was out of the office.

2:45 P.M. Wayne Kerr, U.S. NRC, telephoned and talked with Al Hazle concerning Representative Tim Wirth's questions about the accident. Congressman Wirth had reportedly requested a meeting with the NRC Commissioners for 10:00 A.M. the following morning.

Mr. H. Hattori of the Mitsubishi Company requested by telephone a copy of the Department's final news release concerning the spill. He read about the incident in a Tokyo Japan newspaper.

3:00 P.M. Mr. David Range of Exxon in Richland, Washington telephoned Chuck Mattson concerning the makeup and relative solubility of their yellow cake product. He stated that their yellow ammonium diuranate is calcined at 1000° F which converts part of the material to the black U_3O_8. The product in the accident was an olive green, and was estimated by Mr. Range to be about 60% oxide and 40% diuranate. A probable chemical makeup of the product was stated to be:

$$U_3O_8 \mp 95\%$$

$$\left.\begin{matrix} NH_3 \\ H_2O \\ SO_4 \end{matrix}\right\} = \mp 2\%$$

less than 1/2% total of Si, P, Cl, and Mo.

POOR ORIGINAL 651 016

4:15 P.M. Mr. Gerald Ortloff called Darrel McDaniel and informed him that of the 18 drums on the trailer, 7 had been placed in plastic bags and moved to the storage area. The other 11 drums had been turned right side up in the trailer. All the loose yellow cake had been picked up and secured.

He did not feel that there would be a problem with yellow cake under the trailer because the side of the trailer lying on the ground appeared to be intact.

Mr. Ortloff also stated that all of the damaged drums would be shipped by a "super tiger" container truck while the new repackaged drums would be shipped back to Wyoming via conventional trucks.

He stated that eighteen drums had been filled with yellow cake and dirt. The vacuum cleaners were reported working well for pickup of the dry powder. Work had begun in the truck, with seven drums having been removed. The walls of the truck were sound, damage to the top was extensive. There was little dust problem, according to Mr. Ortloff.

The micro-R meter had not yet been received. Twenty-six persons were involved in the rescue after the accident and twenty-one of these had already been contacted and urine samples taken. These samples had been sent to U.S. Testing Corporation for uranium analyses.

Jerry Everett, of Region IV, U.S. NRC, was at the site. Air samples had been taken and given preliminary analysis before shipment to Highland, Wyoming for lab analyses.

Preliminary analysis results were as follows:

2 Hr. 15 min. - 1.3×10^{-10} µCi/ml
2 Hr. 15 min. - 1×10^{-10} µCi/ml - (downwind - 50 ft.)
5 min. 1.9×10^{-10} µCi/ml - in immediate work area

10/7/77
9:00 A.M. Jerry Combs from the Emergency Preparedness Branch, Department of Energy, called Chuck Mattson and requested a report and photos of the incident.

9:10 A.M. Jerry Everett, called Chuck Mattson and Richard Gamewell from Lamar. He said he had talked to Marv Smith and Jerry Ortloff concerning his position on decontaminating the truck and soil. He quoted from the U.S. AEC Regulatory Guide 1.86.

His recommendation for soil was based on an exposure of 0.5 Rem/yr. to the general public. This translates to 0.06 mR/hr. at 3 ft. (gonadal region), or 60 µR/hr.

9:10 A.M. (cont.) Richard Gamewell and Chuck Mattson quoted the NRC "Branch Position Uranium Mill Tailings Management" from Wayne Kerr on 5/19/77, requiring decontamination to "essentially background". Mr. Everett was told that the Division would discuss this matter and state the Department's position at the 4:00 P.M. call.

Mr. Ortloff related that the truck was to be cleaned out this day, decontaminated possibly tomorrow, then released to Lee Way Trucking.

He had talked to the Lamar Daily News, reporting the yellow cake was 99 +% cleaned up.

The plywood on the left side of the truck was to be torn out and barreled, then the truck vacuumed, decontaminated and turned upright.

The tent used to cover the truck was purchased by Exxon from the Colorado National Guard. The radiation surveys of the interior of face masks and nasal wipes continue to be negative.

Weather is cloudy and cool, with no wind.

4:15 P.M. Call received at the Colorado Department of Health from Gerald Ortloff. He stated that a "super tiger" container had been loaded with 21 drums and had departed for Wyoming. The truck was to return to Springfield at about 3:00 P.M. the following day for another 21 barrels.

The plywood lining of the truck had been removed and the walls were being scrubbed with water and sponges. Plans were to upright the truck the next day. All sides of the truck were reported to be in good condition, with the exception of the roof. The area immediately around the trailer had also been cleaned up. It was anticipated that the trailer would be released to Lee Way no later than Sunday. Field calculations of the air samples indicated concentrations of 20-45 x 10^{-11} $\mu Ci/ml$ in the immediate work area, 0.7 x 10^{-11} $\mu Ci/ml$ at the controlled area perimeter, and 13 x 10^{-11} $\mu Ci/ml$ downwind (50 ft.) from the controlled areas.

10/8/77 3:30 P.M. Richard Gamewell arrived at the accident site. He met with Rick Hornsby, Marvin Smith, Gerald Ortloff, an Exxon lawyer, and an Exxon Public Relations man. The truck had been uprighted. Three Exxon men, after vacuuming the inside of the trailer, were scrubbing it down with brushes, sponges and 2 gallon portable tree sprayers filled with water. There was plastic sheeting under the truck. Some of the water in the truck was being vacuumed up. The plywood liner on the left side of the trailer had been completely removed, cut up and barreled. The opening in the roof that had been torn by the yellow cake barrels on impact had been enlarged to facilitate decontamination. Alpha readings in the truck were less than 200 cpm which Mr. Smith calculated was equivalent to 2500 dpm/100 cm^2. The rear end of the truck was pulled about 6 feet west and then the truck was towed forward about 75 feet. The rear wheels showed slight contamination so they were hosed off. The truck was towed

3:30 P.M. (cont.) to Springfield at 7:00 P.M. for transfer to a low boy truck and hauled to Lee Way's main repair shop in Oklahoma. Mr. Smith said they found no contamination in the cab. Sgt. Benson of the State Patrol said that the northern edge of the spill was about 6 feet in front (south) of the cab. Some people might have contaminated themselves while standing in the area but he personally advised everyone to shower, and leave their clothes outdoors in plastic bags until they could be checked for contamination. He further said that the driver's leg was pinned under the cab and could not be moved until a drilling rig lifted the whole cab off the ground. The driver was then pulled out through the top of the cab. The left front of the cab was completely mangled from impact with the culvert. The right front and radiator of the cab were damaged from impact with the three horses. Sgt. Benson believed that on the basis of the skid marks, the truck had not been speeding.

Mr. Gammell took color slides of the truck and accident site. Damaged barrels were encased in plastic bags and shipped to the Highland Uranium Mill in Wyoming via the "super tiger" truck. The barrels containing the clean-up material were loaded on another Lee Way truck which left for Highland about 7:45 P.M. The load was over the front and rear axles. Empty barrels and 2 x 4's were used as a spacer between the axle loads. Barrels were loaded with a fork lift with a barrel loading attachment. Ed Foster (Exxon) thoroughly wiped the top, bottom and sides of each barrel and checked the wipes with their Thyac II. Sgt. Benson said that both he and the Baca Sheriff had benefited from the Colorado Hazardous Materials Safety Course which they attended in Lamar two years ago. Sgt. Benson said that the Exxon shipping papers were handed to him as soon as he arrived on the scene. Copy attached. They briefly described the nature of the cargo, its potential hazard, and a list of protective actions in case of accident. Mr. Hornsby said the yellow cake had been barreled between 8-4 and 9-18-77.

5:10 P.M. Gerald Ortloff called Chuck Mattson at home in Denver to report the clean-up progress. He said that the truck had been turned upright and final decontamination was being done prior to removal.

The "super tiger" had been loaded with twenty-one drums of yellow cake and had left for Casper, Wyoming. It was scheduled to return on Sunday morning for the remaining damaged barrels.

A Lee Way truck was at the accident site and was being loaded with approximately fifty drums.

Air sample results were reported and were stated to be less than 10^{-10} $\mu Ci/ml$ in the immediate work area and no different from background at the restricted area boundary.

The bioassay (urine analyses) results were reported as:

- <10 µCi/l (the detection lim
- 14 µCi/l
- <10 µCi/l

A large vacuum cleaner, a "Cyclovac" with self cleaning bag, had arrived at the site and would be used in final clean-up, if necessary.

"Newsweek" had called Mr. Ortloff and questioned him, in general terms, concerning the accident.

10/9/77 10:20 A.M. — Rick Hornsby called Chuck Mattson at home and stated that all the drums had been removed from the truck, which had undergone final decontamination and been towed away.

No new information was received concerning bioassays or air monitoring. Rick Hornsby stated that all the yellow cake should be cleaned up this day and they would be ready for their final survey early the next morning. Chuck Mattson told him he would be available the following morning to assist and to check their survey and to perform a final survey.

10/10/77 6:50 A.M. — Chuck Mattson arrived at accident site. Four people were observed shoveling dirt into barrels, one man driving the barrel loader, and Nancy Dennis talking to a man from the highway department. Mr. Lempke stated that there was a lot more clean-up to be done, probably more than could be completed in one day.

7:15 A.M. — A survey of the area surrounding the accident site was completed. All ground readings were between 14 and 20 µR/hr. The filled barrels gave readings of 170 to 800 µR/hr.

9:30 A.M. — Chuck Mattson was introduced to Paul Plummer, Attorney of the Exxon Legal Department, Houston, and Wiley Bragg, Exxon Public Affairs Manage Houston; both were suited and shoveling dirt.

9:15 A.M. — Chuck Mattson picked up a Springfield sewage sample with the assistance of Mr. Tommy Licka, City of Springfield.

10:00 A.M. — Chuck Mattson picked up a sample of water from the well at the house approximately one half mile south of the accident site.

It was stated by the home owner that the well located 1/4 mile southeas of the accident was not operable due to a broken push rod, and was not going to be used.

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11:00 A.M. Chuck Mattson assisted Marv Smith with a survey of the accident site. There were two patches of ground which showed "green" which read to 100 uR/hr. One of these was a patch of asphalt which the crew attempted to clean, but it was decided it would be easier to break the asphalt and barrel it. Approval to remove the asphalt (approximately 3 feet by 5 feet) was granted by Mr. Walters of the Highway Department.

Two areas of approximately 2 feet by 4 feet and one area measuring 2 feet by 15 feet gave readings of about 45 μR/hr. These areas were staked to be further decontaminated. All other readings were less than 20 μR/hr, as measured with a Ludlum micro-R meter. Clean-up continued on the remaining contamination.

A Lee Way truck was filled with barrels, each barrel having been checked for external contamination at loading. When filled the truck was posted as "radioactive", and was driven to Springfield for weighing

11:45 A.M. A highway worker driving a U.S. Army road grader broke up the contaminated asphalt, and the pieces were barreled for shipment back to Wyoming.

12:10 P.M. The grader was used to scrape the top of the ground to a depth of one to two inches.

12:30 P.M. The "wind rows" built up by the road grader were surveyed and the loose material which read greater than 30 μR/hr. was shoveled into drums. The only fixed areas which read greater than background were areas on which water had been used. These fixed areas were shoveled into drums.

2:15 P.M. Another survey indicated some small patches which read 30 μR/hr. These were picked up and barreled as discovered.

3:00 P.M. No areas remained which read greater than 30 μR/hr. A complete survey showed the average exposure in the area to be less than 20 uR/hr, a few local areas of exposure to 30 μR/hr. but none greater.

A comparison of the Department's Ludlum micro-R meter with the Exxon Ludlum micro-R meter gave identical readings.

A comparison of the EPA Ludlum/Thyac meter and that which had been used by Exxon was made. The readings differed slightly. The Exxon meter had an additional wire screen added over the mylar for protection. Readings with the EPA Ludlum/Thyac meter over the area gave readings varying from 0.05 mR/hr. to 0.15 mR/hr. at the soil surface, over twenty-five different locations. The background measured from 0.03 to 0.06 mR/hr.

Messrs. Ortloff and Hornsby were told by Chuck Mattson that the area appeared to have been adequately decontaminated and the clean-up was acceptable to this Department.

Removal of the area decontamination equipment and the leveling and replanting of the highway right-of-way was begun. Mr. Walters, of the Colorado Department of Highways appeared to be in charge of this portion of the operation.

Chuck Mattson left for Denver just after 4:00 P.M.

The complete list of Exxon employees involved in the clean-up:

Richard T. Hornsby	Tony S.ntiestevens
Nancy Dennis	Larry Evans
Carl Lampke	Mary Smith
John Osterman	Ed Foster
Marv Harmsen	Don Crawford
Leroy Moore	Bill Meyer - Exxon
Bill Tibbs	Alex Ewing - Security, Midland, Texas
Don Kaiter	John Hunt - Security, Denver
Emmet Bourquin	Paul Plummer
	Wiley Bragg

10/12/77 2:15 P.M. The Colorado Department of Health received a telephone call from Tom Tasseigne, hazardous materials specialist with the National Transportation Safety Board. He asked general questions concerning the accident and requested a copy of our final report. His number was (202) 426-3872. Mailing address: TE 40, Washington, D.C. 20094.

10/13/77 4:00 P.M. Bob Luna of Sandia Labs called and requested copies of our final report and also of some slides showing the smashed barrels and spilled yellow cake. His address is: Robert Luna, Division 5432, Sandia Labs, Albuquerque, New Mexico 87115.

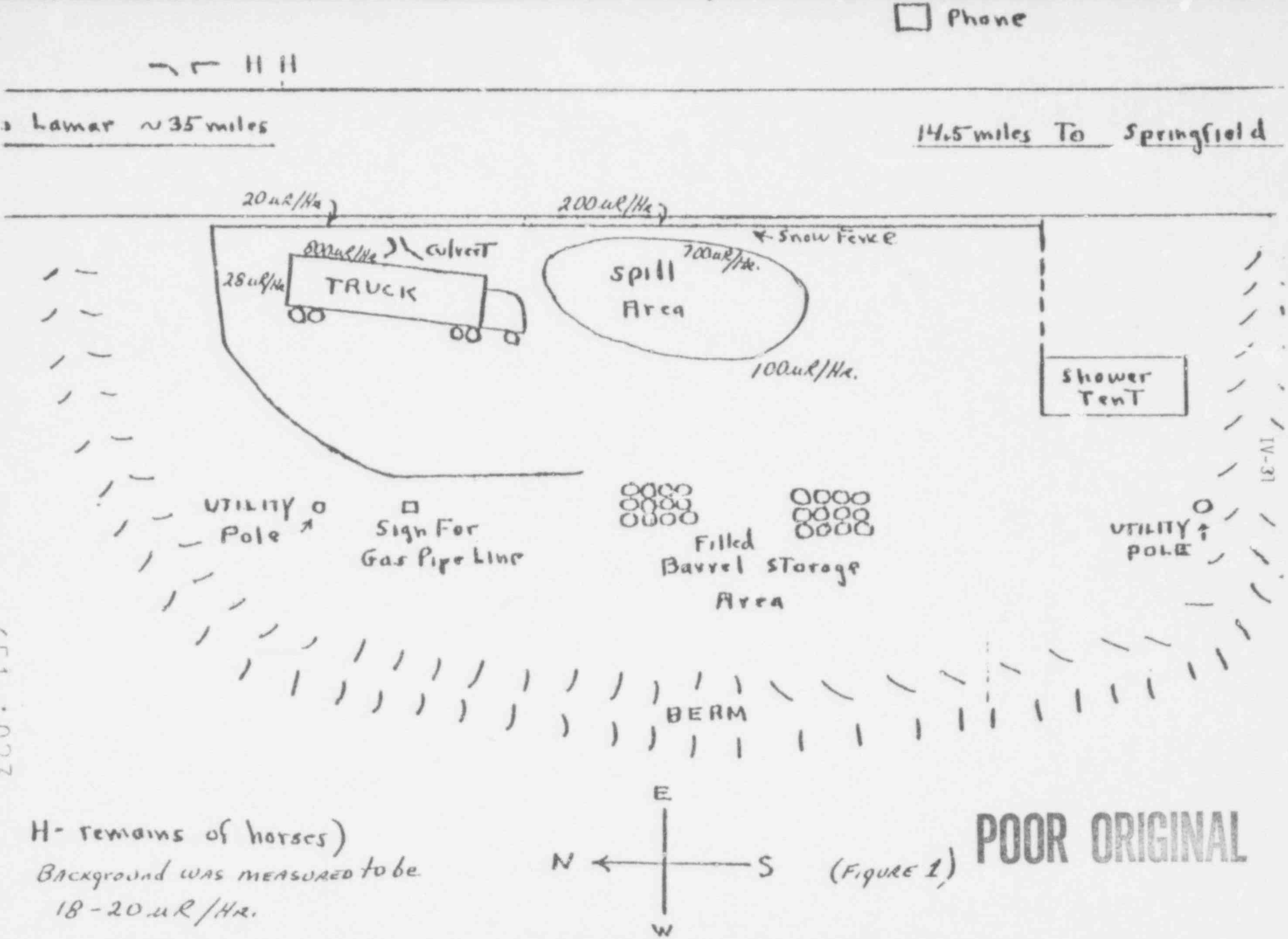
1:15 P.M. Chuck Mattson received a call from Harry Calley of EPA who requested a copy of the Colorado Department of Health news release.

Steps that should be taken to preclude future uranium transportation accidents:

1. All uranium mill licensees be made aware of their responsibility for immediate response to control and clean-up of their materials in transit.

2. Item 2, bottom of page 2, A thru F of 10/3/77 letter from Robert D. Siek to S. Myers. (see attachment)

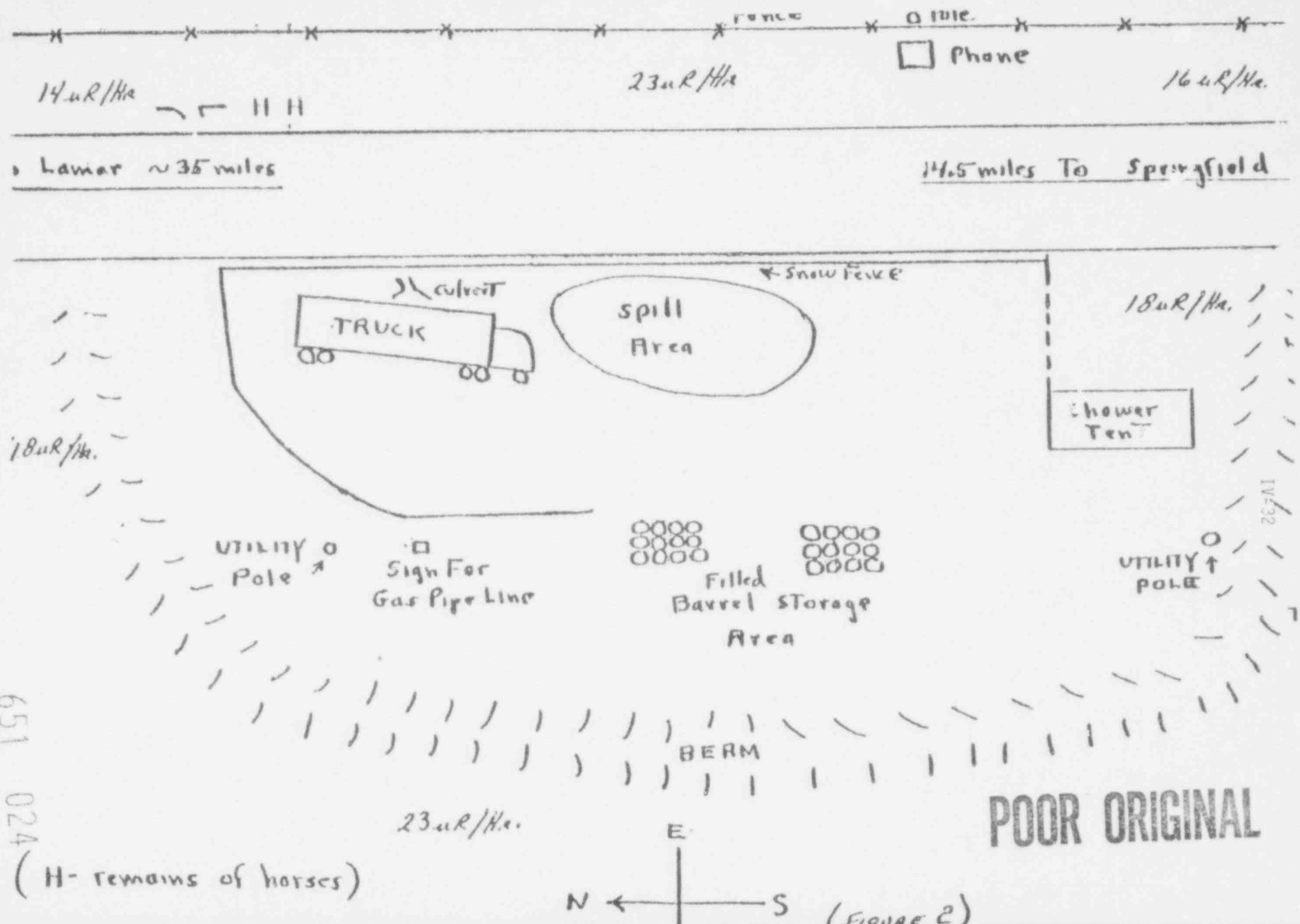
3. Alternate routes for uranium trucks to take which avoid populated areas.



H- remains of horses)

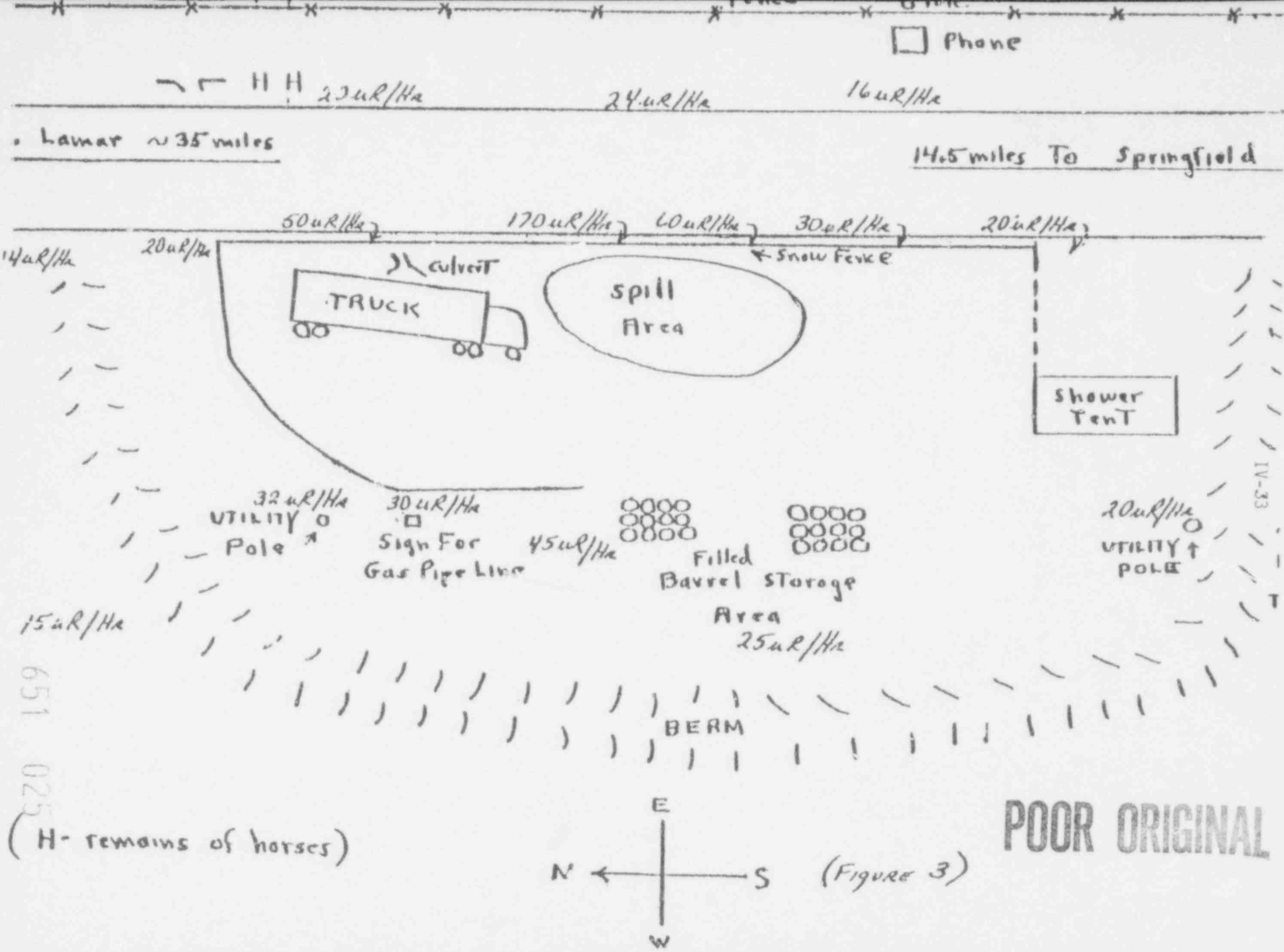
Background was measured to be 18-20 uR/Hr.

(Figure 1)

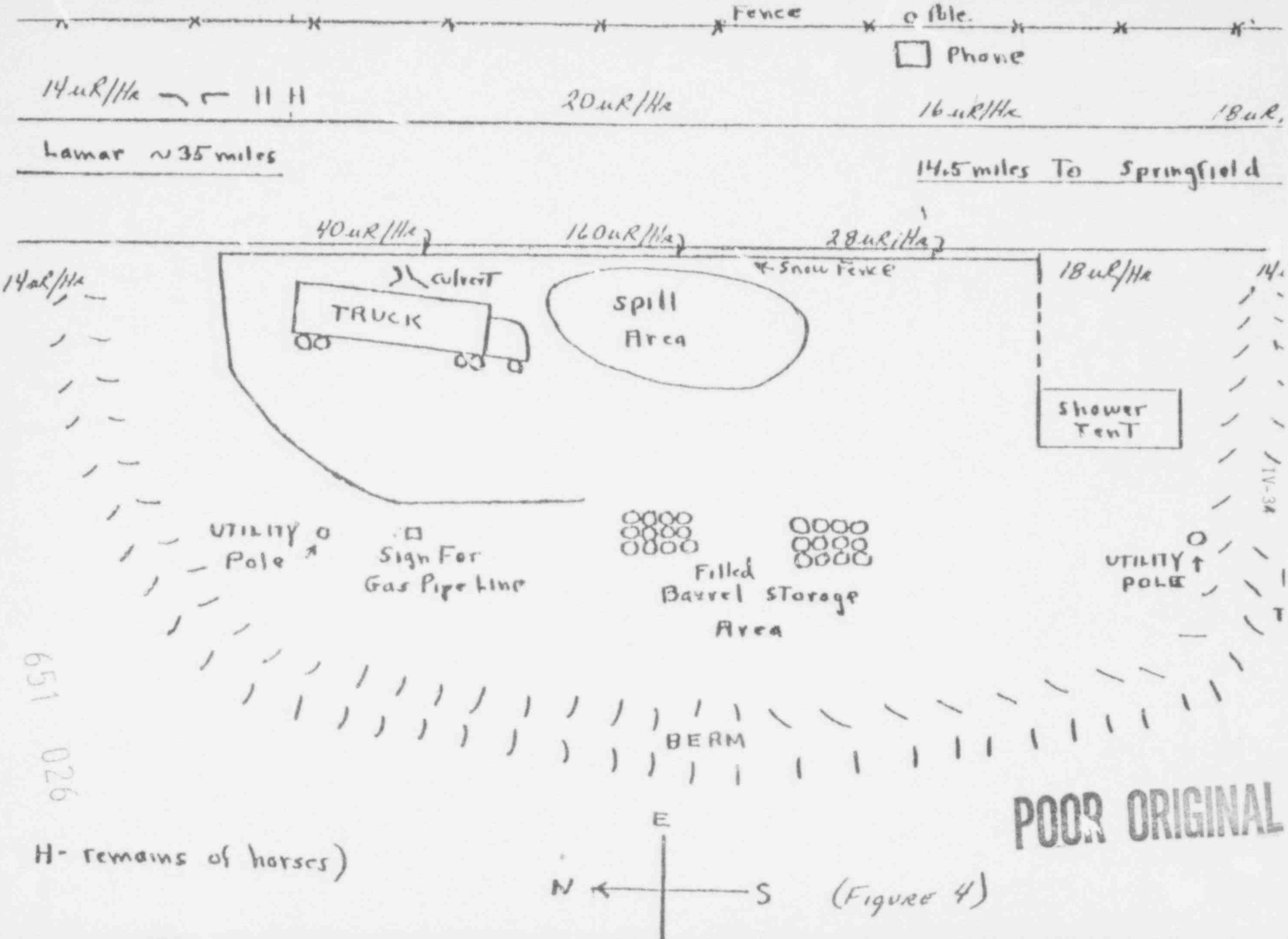


(H- remains of horses)

(Figure 2)


Phone
H H
23uR/Hr
24uR/Hr
16uR/Hr
Lamar ~35 miles
14.5 miles To Springfield
50uR/Hr
170uR/Hr
60uR/Hr
30uR/Hr
20uR/Hr
14uR/Hr
20uR/Hr
culvert
Snow Fence
TRUCK
Spill Area
Shower TenT
32uR/Hr
UTILITY Pole
30uR/Hr
Sign For Gas Pipe Line
45uR/Hr
Filled Barrel Storage Area
25uR/Hr
20uR/Hr
UTILITY POLE
15uR/Hr
BERM
E
N
S
W
(H- remains of horses)

(Figure 3)



(Figure 4)

IV-34

POOR ORIGINAL

651 026

Fact Sheet - Transportation of Radioactive Material - Natural Uranium Oxide (Yellowcake)

OCTOBER 1977

Regulations - The transportation of radioactive materials is regulated principally by the Department of Transportation (DOT) and by the Nuclear Regulatory Commission (NRC). Safety regulations for transporting radioactive material in the United States are based on standards developed internationally by the International Atomic Energy Agency (IAEA). The international standards were developed through the active participation of IAEA member states. The United States participated through representatives from both NRC and DOT.

The enclosed Memorandum of Understanding delineates the respective responsibilities of NRC and DOT for regulating safety in transportation of radioactive materials. Generally, the DOT is responsible for regulating safety in transportation of all hazardous materials, including radioactive materials, and the NRC is responsible for regulating safety in receipt, possession, use and transfer of byproduct, source, and special nuclear materials. The NRC reviews and approves or denies approval of package designs for fissile materials or for other radioactive materials in quantities exceeding Type A limits, as defined in 10 CFR Part 71 (copy enclosed), i.e., the more hazardous types and quantities of radioactive materials.

DOT regulations pertaining to shipment of radioactive material are contained in Title 49, Code of Federal Regulations, Parts 171-189.

NRC regulations pertaining to shipmemt of radioactive materials are contained in Title 10, Code of Federal Regulations, Part 71.

From its inception in January 1975, the NRC has been reviewing the existing regulations and procedures it inherited from the AEC. As part of this review, the NRC initiated in June 1975 a public rulemaking proceeding regarding the air transport of all nuclear materials, including plutonium and enriched uranium. With the technical assistance of Sandia Laboratories, a draft generic environmental impact statement was prepared to assess the impacts associated with the transportation of radioactive materials by air and other modes, including relative costs and benefits of alternative modes of transportation. Information derived from research into the accident-resistant properties of plutonium shipping packages and data collected from the NRC's Radioactive Materials Shipments Survey were used in preparing the statement. The draft statement (NUREG-0034, copy enclosed) was completed in March 1976 and made available for comment to the general public and other Federal and State agencies. About 30 letters of comment were received and analyzed, and changes to the statement are being made, as appropriate. The final environmental impact statement is expected to be issued this year.

As a follow-on, the NRC has undertaken a study of the special features of radioactive material transport -- under both normal and accident conditions -- in large, densely populated areas, that will result in a generic environmental impact statement on the transport of radionuclides in urban environs. The study will evaluate the effects, including radiological safety, of characteristics peculiar to large cities, such as high population density, local meteorology, and numerous tall buildings.

Sandia Laboratories, the NRC contractor for this study, has begun model formulation and preliminary data gathering. A draft statement is expected to be issued in the spring of 1978.

All indications from the present studies are that the risk associated with the transportation is very low, is within established national guidelines, and is very small in comparison to other risks accepted by the general public, such as accidents involving motor vehicles and death associated with electrical shocks.

Uranium Concentrate Characteristics - Uranium concentrate (yellowcake) typically is produced from uranium ore by a process in which the ore is crushed and ground, leached with sulfuric acid or sodium carbonate-bicarbonate, separated by filtration, decantation or centrifugation, further separated by a solvent extraction or ion exchange process and finally precipitated by neutralization with ammonia, magnesia or caustic soda. The resultant product is a solid usually canary-yellow in color (though it may be dark brown or even black) and ranges in consistency from granular to powder. This material, commonly called "yellowcake," is what is shipped from uranium milling plants in the Western United States to two sites in the United States for conversion to uranium hexafluoride (UF_6), the feed for the enrichment process.

Shipping Requirements - Uranium concentrate is classified as low specific activity materials (LSA) according to the Department of Transportation

Hazardous Material Regulations (49 CFR 173.389(c)) and, due to its low concentration of radioactivity, is not required to be shipped in special packaging. The typical packaging, which has been used for many years, is a 55-gallc steel drum. A 55-gallon drum has a capacity of about 850 pounds, though this may vary from shipment to shipment depending upon the moisture content of the concentrate. Where larger capacity drums are used, the number shipped per vehicle is less and where smaller capacity drums are used, the number shipped per vehicle is more.

When packaged and shipped in transport vehicles which are for the sole use of the consignor, the following requirements (49 CFR 173.392(c)) must be met:

1. Materials must be packaged in strong, tight packages so that there will be no leakage of material under conditions normally incident to transportation.
2. Packages must not have any significant removable surface contamination. This means the average amount of radioactive contamination which can be removed by wiping the external surface of the package with an absorbent material, as measured on the wiping material, does not exceed 10^{-10} curie per square centimeter beta-gamma and 10^{-11} curie per square centimeter alpha.
3. External radiation levels must not exceed the following:
    a. 1,000 millirem per hour at three feet from the external surface of the package (applies to closed transport vehicles only);

651 030

b. 200 millirem per hour at any point on the external surface of the vehicle (applies to closed transport vehicles only);

c. 10 millirem per hour at six feet from the external surface of the vehicle;

d. 2 millirem per hour in any normally occupied position in the car or vehicle (does not apply to private motor carriers).

4. Shipments must be loaded by the consignor and unloaded by the consignee from the transport vehicle in which originally loaded.
5. There must be no loose material in the vehicle.
6. Shipment must be braced so as to prevent leakage or shift of lading under conditions normally incident to transportation.
7. The outside of each exterior package must be stenciled or otherwise marked "Radioactive-LSA."
8. Specific instructions for maintenance of exclusive use (sole use) shipment controls must be provided by the shipper to the carrier. Such instructions must be included with the shipping paper information.

Packaging requirements for LSA materials are less restrictive than for other radioactive materials because safety factors reside in the low concentration of radioactivity uniformly distributed in the material. The basic premise behind this concept is the high improbability of the intake of 10 mg or more by any one person as a consequence of a transportation accident. Although such material (LSA) may be assoc[illegible] with a maximum permissible body burden, meaning a dose to organs of 15 rem per year, equivalent to a small radioactivity (5×10^{-9} Ci for U-238 in soluble form), the corresponding mass of material (17 mg for U-238) would be so large that the intake of such a mass of material as a result of a transportation accident is highly unlikely. The validity of the LSA classification depends on the high improbability of the intake of 10 mg or more by any one person as a consequence of a transportation accident.

In addition, each shipment of nuclear fuel material is classified according to a transport group. Uranium concentrate is in transport group III which means that the quantity of curies allowable in one package (strong, tight package) cannot exceed three (approximately 10 tons) to be subject only to the regulations of the DOT. Depending on the purity of the concentrate and the size package used, the typical package of uranium concentrate has approximately .053 to .096 curies and is well below the limit where NRC would be involved.

Estimated Quantities Shipped - Based on a Radioactive Materials Shipments Survey made by NRC in 1975, it is estimated that 45,000 MT of uranium concentrate is shipped each year by truck and rail. There are no specific federal regulatory requirements with regard to routing of hazardous materials other than truckers carrying hazardous goods are required by DOT regulations to avoid congested places insofar as is practicable. The transport of yellowcake is in the Central-Western States.

Accident Probabilities - The probability of occurrence of a transportation accident, such as the recent spill of yellowcake near Springfield, Colorado, is small, about one accident per million vehicle miles, and decreases with increasing severity of the accident to about one severe accident per 100 million vehicle miles. Assuming 2000 shipments per year at an average distance of 1000 miles each, two accidents could be expected per year with a severe accident occurring approximately once every 50 years at the assumed shipping rate. When both the probability of occurrence and the extent of the consequences are taken into account, the risk to people and the environment due to the radiological effect from transportation accidents is negligibly small.

Transportation Incidents - The enclosed "A Review of Five Years Accident Experience in the U.S.A. Involving Nuclear Transportation," discusses the recorded accident experience during 1971-1975. In that period, there were 32,000 Hazardous Material Accident Reports submitted to the DOT of which 144 were related to radioactive material. In 36 cases, there was an indication of release of contents or excess radiation levels. Also enclosed is a copy of NUREG-0179 which discusses functional responsibilities of the different parties involved in dealing with transportation accidents.

A summary of the accident involving uranium concentrate near Springfield, Colorado is enclosed.

SUBJECT: SUMMARY REPORT, SPILL OF URANIUM CONCENTRATE NEAR SPRINGFIELD, COLORADO

At 0130 hours, September 27, 1977, a commercial carrier, carrying 50 steel drums of uranium concentrate (42,000 pounds) overturned near Springfield, Colorado. Twenty-nine drums lost their lids and lost various amounts of concentrate. Concentrate spillage was estimated to have been 10,000 pounds on the ground and 5,000 pounds in the truck trailer.

Police and Fire Department personnel covered the truck and contaminated areas with canvas and heavy plastic sheets. The carrier (Leeway Lines), the licensee (Exxon) and State of Colorado Health authorities were notified by the Sheriff's Department. Region IV (Dallas) and DOT were notified by the licensee on September 27, 1977.

Exxon personnel arrived on September 27 and working with the State of Colorado and local authorities devised a decontamination plan. The operation is now essentially complete with only minor cleanup of equipment and soil remaining. For the decontamination of soil, Colorado has insisted upon background levels.

Wind conditions at the time of the accident were calm. Other than at the time of initial spillage, airborne uranium concentration at the perimeter of the restricted area has been minimal.

The persons involved in the accident have been monitored for contamination. Once the restricted area around the spill was established by Exxon on September 27, 1977, exposures were limited to Exxon personnel performing recovery of the yellowcake and decontamination of the area. Exxon employees wore full .ticontamination gear with respirators. Entrances and exits to the restricted area were monitored. Traffic on the highway was detoured around the site to preclude resuspending any uranium.

The licensee is not required by his license to have a plan for responding to transportation accidents or incidents. The use of DOT approved containers and acceptance by an interstate carrier places the responsibility on the carrier for safe delivery and response to accidents.

Colorado has access to RAT* for such incidents, with the closest location being at the Department of Energy Rocky Flats facility. Region IV (Dallas) contacted the Agreement State of Colorado on September 27, 1977; Colorado advised that the situation was being handled and no help was needed. On September 28, 1977, the EPA representative in Denver contacted Region IV requesting information concerning acceptable levels following cleanup and acceptable measuring techniques. On October 6, a Region IV inspector observed and reviewed the licensees recovery operations.

The uranium concentrate (commonly referred to as yellowcake) is a concentration of the uranium isotopes which occur naturally in the environment. This material is classified as a low specific activity material since the radioactivith per unit weight is low. The hazard to personnel is therefore relatively low since significant quantities must be taken into the body before damage to tissue occurs. For this reason, the DOT packaging requirements are less stringent for yellowcake than for many of the other radioactive isotopes.

* RAT Radiological Assistance Team - These special Department of Energy teams may be called by licensees and States to provide early advice and assistance for radiological incidents.

ON MINERALS COMPANY, U.S.A.
OFFICE BOX 2180 · HOUSTON TEXAS 77001

GERALD D. ORTLOFF
OPERATIONS ANALYSIS MANAGER

December 12, 1977

Mr. Sheldon Meyers, Director
Division of Fuel Cycle and Material Safety
S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Meyers:

Mr. Robert D. Siek of the Colorado Department of Health wrote to you on October 3 regarding a transportation accident which occurred near Springfield, Colorado on September 27, 1977. The accident resulted in spillage of natural uranium concentrate which was in transit by common carrier from Exxon's Highland uranium mill. Unfortunately, the copy of Mr. Siek's letter which he sent to me was improperly addressed and was delayed by some two weeks in reaching me.

We do not believe that Mr. Siek's account of the accident and the ensuing clean-up operation properly describes either Exxon's response to the situation or the role which the Colorado Department of Health chose to play. The enclosed report provides a concise and accurate account of the entire occurrence. Please feel free to contact me if you have any questions concerning the accident or the clean-up.

Sincerely,

Gerald D. Ortloff

GDO:mr
Enclosure

c: Mr. Robert D. Siek
Colorado Department of Health
Mr. A. J. Hazle
Colorado Department of Health
Mr. A. W. Grella
Office of Hazardous Materials Operations
U. S. Department of Transportation
(all w/enclosure)

bc: Mr. D. B.
Mr. J. W.
Mr. R. T.
Mr. J. D.
Mr. J. B.
Mr. R. B.

651 036

UR IUM CONCENTRATE SPILL - BACA COUNTY, COLORADO

At about 1:00 A.M. MDT on September 27, 1977, a tractor-trailer operated Lee Way Motor Freight, Inc., a common carrier, overturned after colliding th three horses on U.S. Highway 287 in a sparsely populated farming and nching area about 14 miles north of the town of Springfield in southeastern lorado. The trailer was loaded with 40,329 pounds of Exxon's natural anium concentrate (yellowcake) contained in fifty 55-gallon steel drums and s en route from the Highland uranium mill to the Kerr-McGee conversion cility at Gore, Oklahoma. The concentrate had been packaged, loaded, and ipped in full compliance with applicable regulations of the Nuclear Regulatory mmission and the Department of Transportation.

As a result of the truck's overturning and subsequent sudden stop when it id into an excavated sump for a drainage culvert, 32 of the 50 drums were rown through the top of the trailer near the front. These drums came to rest the shoulder of the highway. Drum lids, which were secured to the drums by lted steel ring closures, came off 17 of the 32 drums which left the trailer. ids also came off 12 of the 18 drums which remained in the trailer.

A total or about 12,000 pounds of concentrate spilled from the opened drums. out 5,000 pounds of this spilled material was contained in the overturned ailer. The remaining 7,000 pounds was spilled on the ground within an area of ,000 to 4,000 square feet.

The Highland Mine Manager was notified of the accident by a telephone call om the Baca County Sheriff's Office at about 2:00 A.M. MDT. The written etailed emergency instructions prepared by Exxon which accompany each bill of ading for our concentrate shipments had been found, and the mine had been called accordance with those instructions. At that time, efforts of law enforcement ersonnel and others were being directed primarily at extricating the driver, who as pinned in the tractor cab. Because of the concentration on the rescue of e driver and the difficulty of assessment of the magnitude of the spill in the ar..ness, the initial estimate relayed from the scene was not accurate. The stimate was that 6 to 12 of the drums had lost lids and part of their contents.

Highland responded quickly and appropriately to the notification. The heriff's office was requested to see that the truck and spilled concentrate ere covered by tarpaulins or heavy plastic sheeting as soon as possible to prevent preading of the concentrate by wind. Highland's Environmental Coordinator nd one technician left Casper by commercial airline at 7:50 A.M. MDT, taking ith them several large boxes of emergency equipment which included protective lothing, respirators, radiation monitoring and air sampling equipment. This quipment was appropriate and adequate for handling and monitoring the situation as eported. Prior to leaving, the Environmental Coordinator had been advised by the aca County Sheriff's Department that the spill had been completely covered by heavy lastic sheeting, and that there was no near-term risk of airborne migration of the oncentrate. Shortly after the departure of the Environmental Coordinator by plane, n experienced mill shift supervisor and an experienced operating technician left he mill in a truck carrying 20 drums and additional equipment for use in recovering nd repackaging spilled concentrate.

Mine 'als Headqu^*^ was advised of the accident by the Highland Mine Manager at about 8:30 ... A security agent was dispatched to the scene from Midland, Texas. Headquarters Medical was notified and an Industrial Hygienist was sent to assist the Highland personnel.

Because the accident occurred while the concentrate was in interstate transport, notification of the Office of Hazardous Materials Operations, Department of Transportation, by the carrier was required. Exxon notified the carrie of its reporting obligation, then followed up with direct telephoned notificati to the DOT. Exxon also telephoned the Office of Inspection and Enforcement, Region IV, U.S. Nuclear Regulatory Commission, and the Colorado Department of Health to notify those agencies of the accident and to advise them of the steps being taken by Exxon to mitigate the effects of the spill. The Nuclear Regulat Commission advised that since Colorado is an "Agreement State", it has the resp sibility for regulating source material within its borders, and that Exxon shou work with the Colorado Department of Health in cleaning up the spill. They requested that they be kept advised of developments, and advised that they woul communicate also with the Colorado Health Department.

Soon after notification by Exxon, the Colorado Department of Health sent t health physicists to the scene by automobile from Denver.

The Highland Environmental Coordinator arrived at the scene at about 3:30 MDT. He quickly determined that the spill was considerably more extensive than had been reported initially by the Baca County authorities. He also determined that an excellent job of covering the truck and the spilled material had been d by the Sheriff's Department. Because there was no significant remaining risk o spreading, there was time for proper planning for the clean-up and recovery.

It was our expectation that Exxon would work closely with the Colorado Dep ment of Health in the clean-up operations. However, the two health physicists the Health Department at the scene declined to participate in detailed planning the clean-up. Instead, they indicated that the clean-up was Exxon's responsibi and that the Health Department would observe the operation, set standards for f decontamination, and determine the adequacy of the clean up.

Exxon personnel then proceeded to make detailed plans with full cooperatio and assistance from the other state and county agencies - the State Patrol, the State Highway Department, and the Sheriff's Department. The willing assistance of those agencies was greatly appreciated by our people.

The plan which was developed included the use of a front-end loader to pic up the spilled material along with a thin layer of topsoil, transferring it to new drums. Water sprays were to be used to control dust, and an air sampling program was designed to evaluate airborne concentrations. All personnel were t be equipped with appropriate respiratory protective equipment and clothing whic was already on site.

On the morning of September 28 the representatives of the Colorado Departm of Health returned to the scene and set out detailed requirements they had dec upon independently. They insisted that the clean-up be accomplished by hand shoveling with only a limited area uncovered at any one time to minimize the potential for airborne contamination of the surrounding area. They further required Exxon to conduct a thorough radiation survey outside the immediate sp area to establish background radiation levels, which would then be set as the limit for acceptable clean-up in the spill area. They laid out other requirements for air sampling, contamination surveys, respiratory protection, and bioassays. They reiterated that the Colorado Department of Health would not assist in the clean-up, and that their function was to set standards for Exxon to meet.

After conferring by telephone with Minerals Headquarters, the Environmental Coordinator agreed to conduct the clean-up operation in accordance with the directives of the Colorado Health Department representatives. Those representatives then departed on September 28 for their headquarters in Denver. Four additional mill operating technicians were then sent by Highland via commercial airline to assist in the clean-up.

On the following morning, September 29, Minerals Headquarters discussed the situation by telephone with several Colorado Health Department officials in Denver.

Later in the day, Minerals Headquarters requested assistance from Exxon Nuclear Company. Exxon Nuclear sent their Consulting Health Physicist and a Health Physics Technician from Richland, Washington to assist at the scene. Both arrived via chartered aircraft at Exxon's clean-up headquarters in Lamar late on September 29, bringing with them additional respiratory protection equipment and additional radiation survey equipment.

The Regulatory Affairs Manager, Minerals Department, departed from Houston on the afternoon of September 29 to coordinate the clean-up operation and act as liaison with the Colorado Health Department and other interested government agencies.

Clean-up operations began on September 30. In order to meet Health Department requirements, ground decontamination was accomplished on about 100 square feet at a time under a specially constructed "greenhouse" while the remainder of the spill area remained covered by plastic sheeting. Progress was very slow for several days. Vacuum cleaning devices and greenhouse ventilation equipment recommended by Exxon Nuclear arrived on October 4; employment of these devices increased the rate of progress materially.

On October 5, however, the Colorado Health Department ordered Exxon to abandon the greenhouse, uncover larger areas of ground and work in the open to accelerate the operation. The Health Department had come around to ordering Exxon to conduct the operation in a fashion similar to that planned originally by Exxon. Clean-up then proceeded in an orderly and rapid fashion. The truck was cleaned, righted and decontaminated on October 8, and the entire area was released by the Health Department on October 10 after their final survey.

Damaged drums were double-bagged in heavy plastic bags prior to shipment to Highland in a special container designed for transport of high-level waste which was rented from Nuclear Engineering Company. Material which was repackaged in new drums was shipped to Highland in conventional common carrier tractor-trailer rigs assigned to Exxon for exclusive use.

All equipment used in the operation was surveyed and decontaminated to meet all applicable standards before shipment to Highland or release for unrestricted use.

Final topsoil replacement and any necessary replanting of grass in the decontaminated area will be completed by the Colorado Highway Department.

It should be noted that while natural uranium concentrate is classified by the Department of Transportation as a hazardous material, it is unlikely that the health of any members of the public - even those most intimately involved - would be adversely affected by exposure to yellowcake spilled in a transportation accident.

Radiation doses to the body from external exposure to yellowcake for hours or days are insignificant. If yellowcake is ingested, the principal concern is chemical toxicity rather than radiotoxicity; yet the chemical toxicity of uranium is lower than that of lead, cadmium or mercury. Ingested yellowcake is rapidly eliminated from the body. While chronic yellowcake inhalation can cause uranium to build up to toxic levels in kidney tissue, there is no recorded occurrence of detectable adverse health effects resulting from a single acute ingestion.

Urine specimens for uranium bioassay were obtained by Exxon from some 25 persons who were known to have been in the vicinity of the spill before it was covered. Results of the bioassays show that physically damaging uranium ingestion did not occur. Results of his bioassay are being reported by letter to each individual.

In retrospect, the following conclusions can be drawn:

1. Initial securing of the spilled concentrate was prompt and effective.

2. Exxon responded in a timely and appropriate manner to the accident, even though Exxon did not have the primary obligation for response.

3. Effective clean-up was delayed by the initial clean-up and recovery techniques insisted upon by the Colorado Department of Health. Despite the delay, physical security of the yellowcake was maintained and public health was not endangered.

4. Other state and local agencies involved were most cooperative and fully supportive of Exxon's efforts.

GDO:mr
12-6-77

EXXON MINERALS COMPANY, U.S.A.
POST OFFICE BOX 2180 · HOUSTON, TEXAS 77001

RECEIVED
MAR 17 1978
W. S. NECHODOM

GERALD D. ORTLOFF
REGULATORY AFFAIRS MANAGER

March 15, 1978

Mr. Albert J. Hazle, Director
Radiation and Hazardous Wastes Control
Colorado Department of Health
4210 East 11th Avenue
Denver, Colorado 80220

Dear Mr. Hazle:

As agreed with Mr. Charles Mattson last October, we have prepared the enclosed technical report on the clean-up of the uranium concentrate spill which resulted from the truck accident near Springfield, Colorado on September 27, 1977. The report presents the results of the environmental and personnel monitoring programs which were conducted at the accident site. It also contains the results of the bioassays which were performed to assess the intake of uranium by individuals who were involved in the rescue of the injured truck driver and in the subsequent yellowcake containment and clean-up operations.

We believe that this report provides useful documentation of the conditions which prevailed during the clean-up, the low levels of exposure of personnel involved, and the completeness of the removal of the spilled concentrate from the environment.

Sincerely,

Gerald D. Ortloff

GDO:mr
Enclosure

c: Mr. Charles Mattson (Colorado Department of Health)
Mr. L. C. Rouse (Nuclear Regulatory Commission-Washington)
Mr. E. Morris Howard (Nuclear Regulatory Commission-Arlington)
Mr. R. Jerrel Everett (Nuclear Regulatory Commission-Arlington)
Mr. A. W. Grella (Office of Hazardous Materials Operations, U. S. Department of Transportation)
(all w/enclosure)

bc: 3 Mr. Warren Nechodom - Exxon Nuclear Company
Mr. Marvin L. Smith - Exxon Nuclear Company
Mr. D. B. Achttien
Mr. R. B. Spivey
Mr. J. B. Shannon

EXXON MINERALS COMPANY, U.S.A.

TECHNICAL REPORT

CLEAN-UP OF NATURAL URANIUM CONCENTRATE SPILLED IN A TRANSPORTATION ACCIDENT NEAR SPRINGFIELD, COLORADO ON SEPTEMBER 27, 1977

MARCH, 1978

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INTRODUCTION

IV-52

At about 1:00 A.M. MDT on September 27, 1977, a tractor-trailer operated by Lee Way Motor Freight, Inc., a common carrier, overturned after colliding with three horses on U.S. Highway 287 in a sparsely populated farming and ranching area about 14 miles north of the town of Springfield in southeastern Colorado. The trailer was loaded with 40,329 pounds of Exxon's natural uranium concentrate (yellowcake) contained in fifty 55-gallon steel drums and was en route from the Highland uranium mill to the Kerr-McGee conversion facility at Gore, Oklahoma. The concentrate had been packaged, loaded, and shipped in full compliance with applicable regulations of the Nuclear Regulatory Commission and the Department of Transportation.

As a result of the truck's overturning and subsequent sudden stop when it slid into an excavated sump for a drainage culvert, 32 of the 50 drums were thrown through the top of the trailer near the front. These drums came to rest on the shoulder of the highway. Drum lids, which were secured to the drums by bolted steel ring closures, came off 17 of the 32 drums which left the trailer. Lids also came off 12 of the 18 drums which remained in the trailer.

A total of about 12,000 pounds of concentrate spilled from the opened drums. About 5,000 pounds of this spilled material was contained in the overturned trailer. The remaining 7,000 pounds was spilled on the ground within an area of 3,000 to 4,000 square feet.

The Highland Mine Manager was notified of the accident by a telephone call from the Baca County Sheriff's Office at about 2:00 A.M. MDT. The written detailed emergency instructions prepared by Exxon which accompany each bill of lading for our concentrate shipments had been found, and the mine had been called in accordance with those instructions. At that time, efforts of law enforcement personnel and others were being directed primarily at extricating the driver, who was pinned in the tractor cab. Because of the concentration on the rescue of the driver and the difficulty of assessment of the magnitude of the spill in the darkness, the initial estimate relayed from the scene was not accurate. The estimate was that 6 to 12 of the drums had lost lids and part of their contents.

Highland responded quickly and appropriately to the notification. The Sheriff's Office was requested to see that the truck and spilled concentrate were covered by tarpaulins or heavy plastic sheeting as soon as possible to prevent spreading of the concentrate by wind. Highland's Environmental Coordinator and one technician left Casper by commercial airline at 7:50 A.M. MDT, taking with them several large boxes of emergency equipment which included protective clothing, respirators, radiation monitoring and air sampling equipment. This equipment was appropriate and adequate for handling and monitoring the situation as reported. Prior to leaving, the Environmental Coordinator had been advised by the Baca County Sheriff's Department that the spill had been completely covered by heavy plastic sheeting, and that there was no near-term risk of airborne migration of the concentrate. Shortly after the departure of the Environmental Coordinator by plane, an experienced mill shift supervisor and an experienced operating technician left the mill in a truck carrying 20 drums and additional equipment for use in recovering and repackaging spilled concentrate.

Minerals Headquarters was advised of the accident by the Highland Mine Manager at about 8:30 A.M. MDT. A security agent was dispatched to the scene from Midland, Texas. Headquarters Medical was notified and an Industrial Hygienist was sent to assist the Highland personnel.

Because the accident occurred while the concentrate was in interstate transport, notification of the Office of Hazardous Materials Operations, Department of Transportation, by the carrier was required. Exxon notified the carrier of its reporting obligation, then followed up with direct telephoned notification to the DOT. Exxon also telephoned the Office of Inspection and Enforcement, Region IV, U.S. Nuclear Regulatory Commission, and the Colorado Department of Health to notify those agencies of the accident and to advise them of the steps being taken by Exxon to mitigate the effects of the spill. The Nuclear Regulatory Commission advised that since Colorado is an "Agreement State", it has the responsibility for regulating source material within its borders, and that Exxon should work with the Colorado Department of Health in cleaning up the spill. They requested that they be kept advised of developments, and advised that they would communicate also with the Colorado Health Department.

Soon after notification by Exxon, the Colorado Department of Health sent two health physicists to the scene by automobile from Denver.

The Highland Environmental Coordinator arrived at the scene at about 3:30 P.M. MDT. He quickly determined that the spill was considerably more extensive than had been reported initially by the Baca County Authorities. He also determined that an excellent job of covering the truck and the spilled material had been done by the Sheriff's Department. Because there was no significant remaining risk of spreading, there was time for proper planning for the cleanup and recovery.

Detailed planning of the clean-up operation began on the evening of the accident, September 27. The planning session was held in the Baca County Sheriff's office in Springfield. Full cooperation and assistance of the State Patrol, State Highway Department, Sheriff's Department, Springfield Police Department, and local merchants during the planning session made it possible for clean-up operations to start the next morning, September 28. On that morning, however, Colorado Department of Health representatives informed Exxon of their clean-up requirements. The nature of the requirements was such that Exxon could not immediately proceed with the clean-up and comply with Health Department stipulations. Exxon's plans had included the use of a front-end loader to pick up the spilled material along with a thin layer of topsoil, transferring it to new drums. If windy conditions were encountered, clean-up would have proceeded with hand shovels instead of the loader. Water sprays were to be used to control dust, and an air sampling program had been designed to evaluate airborne concentrations. All personnel were to be equipped with appropriate respiratory protective equipment and clothing which was already on site.

Following the discussions with the Colorado Department of Health representatives on September 28, four additional mill operating technicians were flown to Lamar, arriving on September 29. They joined two other mill employees (one mill operating technician and one mill shift supervisor) who had arrived late on September 27 with a truckload of clean-up materials. Also on September 29 a health physicist and a health physics technician from Exxon Nuclear Company arrived in Lamar, bringing with them additional respiratory protection equipment and additional radiation survey equipment. On September 30, Exxon's Regulatory Affairs Manager arrived to serve as liaison with the Colorado Health Department and other interested government agencies.

Clean-up operations started on September 30. Prior to starting the clean-up a portable toilet was brought to the site, and a 16' x 32' tent was erected to serve as a changehouse, shower facility, and storage area. A "greenhouse" was constructed of lumber, plywood and plastic sheeting. The purpose of the greenhouse was to minimize the potential for airborne dispersion of the concentrate as required by the Department of Health. Clean-up was to be conducted by hand-shoveling within the greenhouse which covered an area of about 100 square feet. A radiation survey of the surrounding area was conducted to establish background radiation levels, which would then be set as the limit for acceptable clean-up in the spill area. Air sampling, contamination surveys, respiratory protection, and bioassay programs were set up to comply with Health Department stipulations.

Work progress from September 30 through October 2 was very slow due to the difficulty of cutting through grass and weeds with shovels to pick up the concentrate, the confining nature of the greenhouse work area, heat in the greenhouse causing rapid fatiguing of clean-up personnel, and muddy conditions created by the use of water to reduce airborne dust inside the greenhouse. Two trailers were rented to serve as wind breaks for the work area. Due to the location of the spill in a low area next to the highway, two earthen dikes and a diversion ditch were constructed to prevent possible spreading of the concentrate by rainfall and run-off. Also, a road block and detour was set up to eliminate traffic during work hours. During these three days a total of 11 out of 50 drums on the shipment were recovered.

In order to accelerate the clean-up, vacuum cleaning devices and greenhouse ventilation equipment were ordered October 3 and arrived October 4. October 3 was spent in detailed planning of future operations and as a day off for the fatigued clean-up crew. October 4 a snow fence lined with plastic sheeting was constructed around the spill site to reduce wind velocity in the work area. Use of the vacuum cleaners and ventilation equipment was initiated late on October 4 with positive results.

On October 5 the air was calm and a light mist was fallin These conditions permitted work in the open. Clean-up then proceeded in an orderly and rapid fasion using both hand-shoveling and the vacuum cleaners. By the end of the day the remainder of the 32 drums outside the trailer had been recovered. Damaged drums were double-bagged in heavy plastic bags prior to shipment to Highland in a special container designed for transport of high-level waste which was carried on a flat-bed tractor-trailer. Shipments in this container were classified as bulk shipments under DOT regulations. Material which was repackaged in new drums was shipped to Highland in conventional common carrier tractor-trailer rigs assigned to Exxon for exclusive use.

Work on October 6 and 7 was concentrated on cleaning up the damaged trailer and removing the 18 drums contained inside. The vacuum cleaners worked especially well for this purpose. By the end of the day October 7 all of the 50 drums on the shipment had been recovered and moved to the storage area.

On October 8 final decontamination of the trailer was begun, using scrub brushes, water with detergent and a water rinse. By mid-afternoon the truck was righted. Decontamination of the tractor and trailer was completed late in the afternoon and it was hauled from the site.

Final clean up of the ground in the spill area continued on October 9 and 10. The spill area was bladed on October 10 and radiation surveys located a few remaining concentrations which were promptly cleaned up with shovels. All equipment used in the operation was surveyed and decontaminated to meet previously agreed upon standards before shipment to Exxon's Highland Uranium Operation or release for unrestricted use.

By mid-afternoon on October 10 the Health Department cond·cted a final radiation survey and the entire area was released for unrestricted use. Final topsoil replacement and reseeding in the cleaned area was completed by the Colorado Department of Highways.

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Assessment of Accidental Radiation Exposures

The truck upset and resultant spill probably caused suspension of uranium concentrate in the air for a short period of time in the immediate area of the apill. The truck driver, his relief driver, and anyone who rendered assistance immediately after the accident until the suspended material settled would have been exposed to this airborne uranium. An upper limit to the airborne yellowcake concentration that could have existed during this period is the concentration of the dust that could be suspended in air. When vigorously agitated, dust burdens of up to about five grams per cubic meter are obtained. Due to settling, however, within five minutes most of the dust would no longer be airborne. Breathing air containing five grams of uranium per cubic meter for five minutes would probably result in a deposition in the lungs of about 0.045 μCi. Since the material is eliminated from the body with a half-life of 30 days or less, the body burden averaged over a year's time would be about 0.005 μCi. The International Committee on Radiation Protection has recommended that the continuous, steady-state body burden of uranium be limited to less than 0.009 μCi. This value, of course, was established to provide at least an order of magnitude margin to perceivable health effects. Hence, it is unlikely that anyone at the accident scene would be found to be injured by inhalation of yellowcake. This conclusion is borne out by the bioassay results, where the rescue workers are found not to have inhaled significant quantities of yellowcake. Those arriving more than one-half hour after the initial impact, the ambulance crew and the hospital emergency staff, were exposed to much lower concentrations of airborne uranium. The Sheriff's Department personnel and the State Police who were involved in covering the yellowcake were exposed to low levels of airborne uranium.

Bioassay Program

Urine specimens for uranium bioassay were obtained from 27 persons who were known to have been in the near vicinity of the spill, including the law enforcement and rescue personnel present during the time period following the accident. Additionally, specimens were obtained from 17 Exxon personnel who were present during the clean-up operations. Results of the bioassays are tabulated in Exhibit 1 and show that physically damaging uranium ingestion did not occur. Exhibit 2 summarizes the bioassay results and indicates that only 7% of all specimens submitted were above the detection level of 10 µg/l. It should be noted that bioassays for the two truck drivers were arranged by the Colorado Department of Health and the medical personnel at the Southeastern Colorado Hospital in Springfield, where the drivers were taken for treatment of their injuries and

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for observation. We have been advised by the Colorado Department of Health that uranium was not detected in urine specimens from the drivers.

The highest uranium concentration observed, 18.1 µg/l, was found in the urine from one of the rescue personnel. This level is below the typical nuclear industry action level as shown in Exhibit 2. Uranium concentrations in urine of up to 50 µg/liter are considered to be tolerated by the body with no effects. If 50 µg/liter is exceeded, then resampling is done; if the concentration exceeds 200 µg/liter, the person is restricted from working with uranium until the concentration in the urine drops below 50 µg/liter. The chemical toxicity is the limiting consideration with natural uranium. This toxicity is compared to other heavy metals in Table 1.

TABLE 1

Element	Threshhold Limit
Uranium	0.2 mg/meter^3 of air
Lead	0.15 mg/meter^3 of air
Mercury	0.05 mg/meter^3 of air
Cadmium	0.05 mg/meter^3 of air

If the concentrations do not exceed these threshhold limits in a work location, personnel are permitted to work in the location without restriction for a 40-hour work week. This would result in an equilibrium concentration of

3 millionths of a gram of uranium per gram of kidney. The health effect of uranium is the result of a gradual buildup of toxic levels of uranium in tissue of the kidney. There is no recorded occurrence where a single acute exposure of a human to uranium has caused a detectable health effect resulting from its chemical toxicity. The members of the public involved in the rescue operation will not experience any physical effect as a result of their exposure to uranium.

In the letter notifying each person of the result of his urinalysis, Exxon offered to provide in-vivo chest counting for any persons who wanted this additional evaluation. As a result of this offer, eighteen chest counts were performed on December 20, 1977 in Lamar, Colorado by Helgeson Nuclear Services, Inc. Springfield firemen, State Patrol officers, and Highway Department personnel who participated in the rescue of the truck driver or who were present during the clean-up operation were included in the group. No detectable uranium lung burden was found in any person.

Radiological Safety Program

The Certified Health Physicist and Senior Health Physicis Technician from Exxon Nuclear Company conducted the radiologic safety programs. They set up a restricted or controlled area which included all of the area in which yellowcake could be detected by surveys. This controlled area was marked off using yellow and magenta rope, and appropriate signs indicatin rope. The health physics personnel then conducted a training session for all Exxon employees to be involved in the clean-up operation.

Exhibit 3 summarizes the items covered in the training session.

Throughout the clean-up operation frequent radiation surveys were made to insure that containment was maintained. In making the contamination surveys the following guidelines were used:

- o A "less than" value was used whenever contamination above background was not detected.
- o A value of 25 c/m was used as a minimum detection level when the unshielded probe was used. This requires a very slow, methodical survey.
- o A value of 100 c/m was used as a minimum detection level when a shielded probe was used. This probe generally was used for large survey areas.

Radiation surveys made during the clean-up operation are documented in the Appendix.

Radiation doses to the skin and whole body from external exposure to yellowcake were measured by thermoluminescent dosimeter badges (TLD's) worn by the personnel who were directly involved in the clean-up. The maximum dose to any individual was less than 2% of the quarterly limit[1] for the skin and less than 4% of the quarterly limit[1] for the whole body.

Environmental Sampling

An air sampling program was established to evaluate personnel exposures to airborne yellowcake dust and to assess

[1]10CFR20.101(a)

potential dispersion of the concentrate. Three types of air samples were collected: 1) enclosed area samples taken in the greenhouse and the trailer; 2) open area samples taken in the work area; and 3) perimeter samples taken close to the boundary of the controlled area. The first two types of samples were used to evaluate personnel exposures, while the perimeter samples were used to evaluate dispersion beyond the controlled area. Samples used to evaluate personnel exposures were taken with the air sampler at breathing elevation. Exhibit 4 summarizes the results of the air sampling program. High concentrations of airborne yellowcake dust were occasionally present in the enclosed areas. Open area concentrations were relatively low, while perimeter concentrations were usually below maximum permissible concentrations (annual average) for unrestricted areas as set forth in Appendix B of 10CFR20.

Air sample data were used to evaluate exposures to clean-up personnel. In the calculation of the exposures, conservative protection factors were assumed for the respirators. A factor of 10 was used for the half-face mask, while a factor of 50 was used for the full-face mask. Individual cumulative exposures during the clean-up operation were less than 20% of the weekly maximum permissible occupational exposures to soluble uranium compounds, as set forth in 10 CFR 20.103 and in Appendix B of 10 CFR 20.

In addition to environmental air sampling, soil and vegetation samples were taken in the spill area. Results, which are shown in the Appendix, show that the clean-up effectively removed the spilled concentrate from the environment. The very effective job of covering the spill by the Baca County Sheriff's Department allowed time for effective clean-up measures to be established without airborne dispersion of the material.

Decontamination Program

The decontamination program employed radiation surveys of ground, personnel, and all equipment or supplies that could have been contaminated. Each person leaving the controlled area was surveyed. This included counting of nasal smears, facial areas, and the inside of the face mask. Showers were required as necessary at the site to insure decontamination of personnel. All personnel were surveyed to insure that they were carrying no detectable uranium offsite. All equipment used in the operation was surveyed and decontaminated to meet the standards set out below before shipment to Highland or release for unrestricted use. All automobiles and motel rooms used by the clean-up personnel were also surveyed and found to be uncontaminated.

Prior to release of the tractor-trailer from the restricted area, a complete contamination survey was conducted. Before the tractor-trailer was hauled from the site, the

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release limits below were achieved:

Fixed Alpha	5000 d/m/100 cm^2
Smearable Alpha	1000 d/m/100 cm^2
Beta-Gamma	0.2 mR/hour at 1 cm

These limits were also applicable to all other surveyed equipment.

The final site release survey was conducted by a health physicist from the Colorado Department of Health, using a sensitive gamma survey meter. The baseline survey conducted prior to the start of clean-up showed background gamma levels to be in the 14-21 μR/hour range. The final survey showed that all ground within the restricted area had been cleaned up to less than 30 μR/hour gamma. On the afternoon of October 10 the entire spill area was released by the Health Department representative for unrestricted use.

EXHIBIT 1

BIOASSAY (URINALYSIS) RESULTS

Individual	Date	µgU/l	Date	µgU/l	Date	µgU/l	Date	µg!
Member of Public #1	9/29/77	<10						
Member of Public #2	9/29/77	10.2						
Member of Public #3	9/29/77	<10						
Member of Public #4	9/29/77	16.4						
Member of Public #5	10/4/77	<10	10/11/77	<10				
Member of Public #6	9/29/77	<10						
Member of Public #7	10/4/77	<10						
Member of Public #8	9/29/77	<10						
Member of Public #9	10/4/77	<10						
Member of Public #10	10/4/77	<10						
Member of Public #11	10/4/77	<10						
Member of Public #12	10/4/77	18.1						
Member of Public #13	10/4/77	<10						
Member of Public #14	10/4/77	<10						
Member of Public #15	9/29/77	<10						
Member of Public #16	10/4/77	<10						
Member of Public #17	9/29/77	<10						
Member of Public #18	9/29/77	<10						
Member of Public #19	10/4/77	<10						
Member of Public #20	10/4/77	<10						
Member of Public #21	9/29/77	<10						
Member of Public #22	9/29/77	<10						
Member of Public #23	9/29/77	<10						
Member of Public #24	9/29/77	<10						
Member of Public #25	10/11/77	<10						
Member of Public #26	10/10/77	<10						
Member of Public #27	10/4/77	<10						
Exxon Employee #1	10/6/77	<10	10/7/77	<10	10/8/77	<10	10/9/77	<1
	10/11/77	<10						
Exxon Employee #2	10/10/77	<10						
Exxon Employee #3	10/5/77	<10	10/7/77	<10	10/9/77	<10		
Exxon Employee #4	10/1/77	<10	10/2/77	<10	10/4/77	<10	10/5/77	<1
	10/6/77	<10	10/8/77	<10	[illegible]			

EXHIBIT 1 CONTINUED

Individual	Date	µgU/l	Date	µgU/l	Date	µgU/l	Date	µg
Exxon Employee #5	9/30/77	<10	10/1/77	<10	10/2/77	<10	10/3/77	<
	10/4/77	<10	10/6/77	<10	10/7/77	<10		
Exxon Employee #6	9/30/77	<10	10/1/77	<10	10/2/77	<10	10/3/77	<
	10/5/77	<10	10/6/77	<10	10/7/77	<10	10/8/77	<14
	10/9/77	<10	10/10/77	<10				
Exxon Employee #7	9/30/77	<10	10/1/77	<10	10/2/77	<10	10/5/77	<
	10/6/77	<10	10/7/77	<10	10/8/77	<10	10/9/77	<
	10/11/77	<10						
Exxon Employee #8	10/6/77	<10	10/7/77	<10				
Exxon Employee #9	9/30/77	<10	10/1/77	<10	10/2/77	<10	10/3/77	<
	10/4/77	<10	10/5/77	<10	10/6/77	<10	10/7/77	<
	10/9/77	<10	10/10/77	<10				
Exxon Employee #10	9/30/77	<10	10/1/77	14.3	10/2/77	14.9	10/3/77	<
	10/4/77	<10	10/6/77	<10	10/7/77	<10	10/8/77	10
	10/9/77	<10	10/10/77	<10				
Exxon Employee #11	9/30/77	<10						
Exxon Employee #12	10/1/77	<10	10/2/77	<10	10/3/77	<10	10/4/77	<
	10/5/77	<10	10/6/77	<10				
Exxon Employee #13	10/1/77	<10	10/2/77	<10	10/4/77	<10	10/5/77	<
	10/6/77	<10	10/10/77	<10	10/11/77	<10		
Exxon Employee #14	9/30/77	<10	10/1/77	<10	10/2/77	<10	10/5/77	<
	10/6/77	<10	10/8/77	<10				
Exxon Employee #15	10/10/77	<10						
Exxon Employee #16	10/6/77	<10	10/7/77	<10	10/9/77	<10	10/10/77	<1
Exxon Employee #17	9/30/77	<10	10/1/77	12.4	10/2/77	13.6	10/3/77	<1
	10/4/77	<10	10/5/77	<10	10/7/77	<10		

EXHIBIT 2

SUMMARY OF BIOASSAY SAMPLE RESULTS

Total number of samples submitted:	126
Total number of sample results above detection level of 10 μgU/l	9
Maximum concentration found:	18.1 μgU/l

TYPICAL NUCLEAR INDUSTRY ACTION LEVELS

For soluble uranium compounds:	Results > 50 μg/l requires resampling until < 25 μg/l. If two resamples show ≥ 25 μg/l an internal dose evaluation shall be performed.
For insoluble uranium compounds:	Result > 25 μg/l requires resampling. If resample shows ≥ 10 μg/l an internal dose evaluation shall be performed.

EXHIBIT 3

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RADIOLOGICAL SAFETY TRAINING RECORD

(Subjects Covered ☒)

Date 9-30-77

☐ Radiation Protection

- ☒ Relative hazards of the various uranium and/or plutonium compounds that may be encountered.
- ☒ Definitions and Boundaries of Radioactive Materials, Radiation, Intermediate and Clean Areas.
- ☐ Radiation Work Procedures: ______
- ☒ Protective clothing requirements.
- ☒ Change Room Step-Off-Pad procedure.
- ☒ Personnel survey instruments and requirements.
- ☐ Installed radiation and radioactive material monitoring instruments and alarms.
- ☒ Air sampling and monitoring programs.
- ☒ Radioactive material containment and contamination control programs.
- ☐ Glovebox operations.
- ☐ Glovebox glove change procedure.
- ☐ Glovebox bag-in and bag-out procedure.
- ☒ Requirements and procedures for removal of equipment or materials from Radiation Areas.
- ☒ Personnel and equipment decontamination requirements and procedures.
- ☒ Radioactive materials packaging and unpackaging procedures.
- ☐ Requirements and procedures for performing non-routine jobs: ______
- ☒ Treatment of injuries incurred in Radiation Areas; protection for cuts and abrasions.
- ☒ Personnel external radiation exposure controls.
- ☒ Personnel external radiation exposure dosimetry programs and requirements.
- ☒ Bioassay and in-vivo measurement programs and requirements.
- ☒ Radioactive waste disposal procedures.
- ☐ Others: ______

☐ Emergency Procedures

- ☐ UF_6 gas release.
- ☐ Airborne UO_2.
- ☐ Airborne plutonium.
- ☐ Plutonium contamination spread.
- ☐ Fire involving radioactive material.
- ☐ Criticality.
- ☐ Others: ______

☒ Respiratory Protection

- ☒ Requirements and procedures for the use of r[espiratory] protection equipment and devices.
- ☒ Availability of respiratory equipment and dev[ices].
- ☒ Proper selection of equipment and devices.
- ☒ Care and use of equipment and devices.
- ☒ Mask fitting and testing.
- ☒ Mask maintenance, repair, decontamination, [...] and storage.
- ☒ Personnel and mask surveys required followin[g] respiratory protection equipment and/or devi[ces].
- ☒ Bioassay and in-vivo measurement requiremen[ts].
- ☒ Special air sampling requirements.
- ☒ Protection factors.
- ☐ Others: ______

☐ Radiation Exposure to Female Employees (Reg. 8.[...]

☒ Training Aids Used

Full Face Mask

Half Mask

Protective Clothing

Portable Survey Instrument

Air Samplers

Donald Keiter

William Tibbs

Marvin Harmson

John Osterman

Carl Lembke

Nancy Dennis

Richard Hornsby

Leroy Moore

Instructor(s) Edward L. Foster

Edward L. F[oster] (signature)

Date: September 30, 1977

POOR ORIGINAL

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EXHIBIT 4
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AIR SAMPLING RESULTS

	Date	Uranium Concentration (uCi/ml x 10^{-11})
Enclosed Area Samples	9/30	60.7
	10/1	6.2
	10/1	3737.6
	10/1	6.3
	10/1	136.7
	10/1	370.7
	10/2	21.0
	10/2	167.2
	10/4	16.7
	10/5	23.7
	10/5	4.0
	10/5	3.7
	10/6	2.4
	10/6	41.1
	10/7	2.2
Open Area Samples	9/30	1.3
	10/1	0.3
	10/2	1.3
	10/4	1.3
	10/5	0.2
	10/5	14.2
	10/5	1.9
	10/6	2.7
	10/6	1.2
	10/6	30.8
	10/7	0.6
	10/7	0.2
	10/7	0.2
	10/8	0.3
	10/8	1.5
	10/8	0.1
	10/8	0.3
	10/9	4.0
	10/9	29.2
	10/9	4.2
	10/10	0.8
Perimeter Samples	9/30	0.56
	10/1	0.04
	10/1	0.03
	10/1	0.06
	10/2	0.03
	10/2	0.02
	10/2	0.09
	10/4	0.13
	10/5	10.7
	10/5	1.91
	10/5	0.58
	10/5	1.81
	10/5	0.08
	10/6	2.80
	10/6	0.03
	10/6	0.08

	Date	Uranium Concentration (uCi/ml x 10^{-11})
Perimeter Samples Continued	10/7	0.02
	10/7	0.10
	10/7	0.02
	10/8	0.29
	10/8	0.03
	10/8	0.05
	10/9	1.12
	10/9	0.05
	10/10	0.23
	10/10	0.03

CONCLUSIONS

1) Initial securing of the spilled yellowcake by local law enforcement officers was prompt and effective.

2) The clean-up operation effectively removed the spilled uranium concentrate from the environment.

3) Intake of uranium by members of the public and by clean-up personnel was far less than the intake required to cause adverse health effects.

APPENDIX

RADIATION SURVEYS

RADIATION SURVEY DETAILS OMITTED

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. NUCLEAR REGULATORY
COMMISSION

U.S. MAIL

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