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~~R.K. PASCHALL~~

DECONTAMINATION AND DECOMMISSIONING
CRITERIA
FOR USE IN
DESIGN OF NEW PLUTONIUM FACILITIES

ERDA Research and Development Report

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ABSTRACT

Decontamination and decommissioning (D&D) criteria were assembled for use in designing new plutonium facilities. These criteria were gathered from literature searches and visits to many plutonium facilities around the country. The recommendations of reports and experienced personnel were used.

Since total D&D costs can be millions of dollars, improved designs to facilitate D&D will result in considerable savings in cost and time and will help to leave the site for unrestricted future use after D&D. Finally, better design will reduce hazards and improve safety during the D&D effort.

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INTRODUCTION

Several plutonium facilities were decontaminated and decommissioned (D&D) during the past several years. Others are currently undergoing D&D. The costs of D&D are high--several million dollars for some facilities. The time required for D&D is great--up to four years for some facilities. Therefore, the Energy Research and Development Administration (ERDA) now requires that new facilities be designed for ease of D&D. In particular, Appendix 6301 of the AEC Manual has a new Section I (approved September 17, 1974), in Part II containing minimum design criteria for new plutonium facilities.

This report assembles, investigates, and recommends design considerations for new plutonium facilities which will help to minimize the eventual D&D costs and time and will help to leave the site for unrestricted future use after D&D. The investigations included literature searches and visits to many existing plutonium facilities. The purposes of the visits were to: (1) view various types of facilities, (2) have discussions with experienced personnel, and (3) obtain applicable internal reports and letters of information.

DESIGN CRITERIA

These design criteria are meant to be general criteria for consideration during the plutonium facility design phase. Every criterion does not necessarily apply to every facility. Nevertheless, they should be considered and weighed.

A check list of the D&D criteria should be made during the design phase of the new plutonium facility. Then, each item selected in the facility design, which is pertinent to the check list, can be compiled along with possible alternatives. The reasons for selecting one and rejecting others should also be explained. This will make it possible for other designers and reviewers to verify that the design criteria were considered. The completed result should provide sufficient information for independent cost-effective evaluations.

The following questions should be answered for each item being designed:

1. What is being designed (glove box, wall, building zones, etc.)?
2. What is the selected item (construction material, surface coating or covering, construction design, etc.)?
3. How does it meet each applicable D&D design criterion?
4. What are the alternatives? How do they meet the D&D design criteria? (better or worse than that selected? . . . to what extent better or worse?)
5. Why was the selected one chosen over the alternatives?
6. What other criteria, besides those for D&D, influenced the selection? Did the other criteria dominate the selection? If the other criteria were ignored, would one of the alternatives have been selected?
7. What is the expected life of the equipment or facility?

Interior Walls

1. The surface of the walls should be smooth and flat.

Basis

It is desirable to provide a surface which is very easy to decontaminate. At the same time, we want to make sure that it is easy to smear in order to measure how much contamination there is on the wall. Some walls made out of concrete cinder blocks have an epoxy coating over them which is very smooth. However, the walls are not flat and may have many indentations because of the nature of the subsurface. These pits allow contamination to collect in them and make decontamination more difficult. For decontamination, either a liquid has to be sprayed on the wall forcefully or some type of a rubbing device has to be inserted down in the pit to reach that surface and remove the contamination. Then, a smear is taken by rubbing a piece of filter material over the surface to be measured. Obviously, this filter material just touches the top surface of the wall and does not give an indication of how clean the pit is. One must take something like a Q-tip and swab each of the pits to get a true measure of the decontamination that has been achieved on this type of wall. Therefore, even though it is a smooth surface, if it is not flat, it is hard to clean and decontaminate, and it is difficult to get an accurate smear reading when trying to measure how much contamination is present on the wall.

2. The surface should be easy to clean and decontaminate.

Basis

Many types of materials can be put on the surface, such as paints or epoxy, or the surface can be left uncoated, as is usually true with stainless steel. It is obvious that some materials are much easier to

use and much easier to clean than other materials. Higher decontamination factors can be achieved with some materials than in others. The combination of the types of contamination that are going to get on the wall and what their carrier is affects the decontamination factors. For instance, if it is a gas bearing the contamination to the walls, its adhesion might be different than contamination which is carried by liquids. The length of time that the contamination is on the walls before it is cleaned off is also important, and can add to the difficulty of decontamination later. Many laboratories use epoxy coatings. It has been suggested that there are special epoxy coatings available now which may be applied in layers. On a concrete wall, an undercoat which penetrates some distance into the concrete is put on first. This is followed by several layers of topcoating epoxy material, building up a thickness of 30 to 40 mils. It is believed that this type of layered epoxy coating is resistant to scratches and abrasions and is very easy to decontaminate. The contamination does not penetrate too deeply into the material. In the event that the contamination did penetrate to a certain depth, the top layer can be removed and still leave the concrete wall essentially undamaged.

3. Contamination should not penetrate far into the surface.

Basis

As an example of poor practice, walls made of concrete which are not covered with any surface coating at all allow contamination to penetrate to depths of several inches over a long period of time. This would require the entire wall to be disposed of in order to get rid of all the contamination. On the other hand, stainless steel walls would not allow the contamination to penetrate very far at all. They would also provide for ease of decontamination by means of liquids wiped on by hand or sprayed on with a high pressure spray.

4. Contamination which does penetrate the surface should be easily removed. This may require removing part of the surface.

Basis

Rather than paint over a surface which has contamination in it, it is better to remove the contaminated surface. This is especially true when it comes time to decommission the facility. At that time it may be absolutely necessary to remove all of the surface in order to reduce the contamination to levels which allow the facility to be released for unrestricted use. The alternative to removing the surface of the walls is to remove the entire wall.

5. No sandwich materials should be used which may trap contamination between the layers.

Basis

Mound Laboratory used a sandwich type of construction wall material in their SM Building and found, when they decommissioned, that a considerable amount of contamination was trapped between the layers of the sandwich material. This required that the entire wall material be removed, even if the surface could be decontaminated sufficiently. Therefore, they suggest that this type of material be avoided in future facilities.

6. Repeated decontamination should not reduce the effectiveness of the surfaces for future decontamination; or, surfaces should be reprepared to return them to their original effectiveness.

Basis

Over a long period of operation, surfaces tend to be contaminated and decontaminated several times, at least in selected areas. Therefore,

it is desirous to have a surface which retains its ability to be decontaminated even after repeated cleanings. If the method of decontamination is so vigorous, or requires removal of part of the surface, then the surface should be able to be rehabilitated and returned to its originally decontaminable state.

7. The number of wall penetrations should be minimized.

Basis

Wall penetrations are always a possible source of paths for leakage of air from one room into the other. Further, the place where the penetration is made into the wall is a possible collection point for contamination, even though it may be sealed because contamination can collect around the seal.

8. The annular space around penetrations through the walls should be sealed.

Basis

The annular space around penetrations through the walls for service pipes, electrical connections, duct work, etc., should be adequately sealed so that air cannot pass back and forth through the walls. This will prevent contamination from reaching places in the interior of the wall or adjacent rooms.

9. Penetrations into the walls should be sealed around.

Basis

Such items as screws, bolts, threaded stock, and other materials which are driven or screwed into the walls should be adequately sealed

around so that contamination cannot leak into the crevices and cracks and the threaded portions in the wall material. Threaded portions in the wall material itself are virtually impossible to decontaminate adequately. Therefore, at decommissioning time, these portions of the wall would have to be completely chipped out and removed in order to bring decontamination levels down to the appropriate values.

10. Walls with interior spaces should be sealed to prevent contamination from reaching this interior. It is better to seal than to depend on pressure differentials to keep contamination out.

Basis

Rather than having a solid wall, it is possible to have a doubled-wall structure such as plaster board, with an air space in between the two walls. If such a structure is used, it is imperative that the walls be completely sealed so that contamination cannot get into the air space in between the two portions of the wall. If contamination does get into the air portion between the walls, it will be necessary to completely remove the walls at the time of decommissioning, even if the outside surfaces can be decontaminated to sufficiently low levels. Also, contamination on the interior surfaces may be spread around the facility when the walls are removed. The hazards of removal are increased considerably.

A combination of both a pressure differential and adequate sealing would be preferred to keep contamination out of the interior spaces of hollow walls.

11. The surface should be decontaminatable to levels determined by final disposition criteria, or the walls should be easily disposed of.

Basis

The ultimate, final disposition of the facility will be to release it for unrestricted use. Therefore, it will have to be possible to decontaminate the walls to levels sufficient for this purpose.

12. The walls should be easily disposed of if they cannot be decontaminated to levels required for decommissioning. This includes minimizing labor and waste material created during disposal, having convenient size wall sections for handling and shipping, and minimizing wall weight for shipping and storage.

Basis

If the walls cannot be decontaminated to a level such that the facility can be released for unrestricted use, then the walls will have to be dismantled and shipped away for safe disposal. To prepare for this, the walls should be designed so that disposal efforts can be done with a minimum of labor, and the waste material created during the disposal effort can be kept to a minimum. Wall sections will have to be a convenient size for handling, moving through the facility, packaging, and shipping. To keep the cost to a minimum, it will be necessary that the weight and bulk be minimal.

Exterior Walls

Exterior walls will have many of the same requirements that the interior walls have. However, one important difference occurs; that is, the exterior walls will be massive in order to meet minimum earthquake and tornado criteria. Therefore, it is unlikely that they will be disposed of. Instead, it is preferable that wall coatings, surface layers, or liners be used which can be easily disposed of if they cannot be decontaminated to the levels required for decommissioning. This, then, includes minimizing the labor and waste material created during

disposal, using convenient size liner sections for handling and shipping, and using minimal surface layer and bulk for shipping and storage. The major line of defense for the exterior walls is the use of adequate ventilation systems with four levels of pressure differentials to keep contamination from ever reaching the exterior wall surfaces. Nevertheless, there is always the likelihood that some amount of contamination may reach the surfaces; so, it is desirable to have the same decontamination properties on these surfaces that the interior walls have. Being able to remove the wall completely seems unlikely, or otherwise extremely expensive; therefore, having some type of surface or liner which is removable is more appropriate. Basements and attics should also have four zones of ventilation pressure differentials to prevent spreading of contamination to exterior walls there.

Ceilings

Ceilings have the same requirements as interior walls. In addition, light fixtures should be recessed flush to the ceiling surface and the edges around the recessed light fixture should be sealed so that no contamination can get into the light fixture compartment. Again, penetrations should be minimized and be sealed into the ceilings. Threaded penetrations into the ceiling should be minimized or eliminated. If used, the penetrations should be sealed so that no contamination gets into the threaded portion. False ceilings should not be used or, if they must be used, as little as possible should be in the cavity between the false ceiling and the ceiling above it. It should be easy to remove the false ceiling and decontaminate the area above the false ceiling.

Basis

Again, we are trying to make the surfaces as smooth as possible with the lowest possibility for cracks or crevices to gather contamination. As far as false ceilings are concerned, there are facilities which are using them, jamming them full of service piping, duct work,

light fixtures, etc., and trying to prevent contamination in that area by means of pressure differentials to the room below. However, it has been found that pressure differentials are not an ultimate means of preventing contamination above the false ceilings. Contamination can flow against the pressure differentials in small amounts which will build up over a long period of time. Ventilation systems can fail and allow contamination to get up into the area above the false ceiling, and since the area is so small, and so crowded with items, it is very difficult and expensive to decontaminate both the items that are located there and the ceilings themselves. On the other hand, if the false ceilings are meant merely to provide a barrier to contamination so that it does not reach the true ceiling above it; namely, if the false ceilings can easily be removed, disposed of, and replaced by new false ceilings, they can minimize the amount of contamination which reaches the ceilings above them. However, false ceilings generally are hung by means of hangers from the ceiling above; this requires that hangers be screwed or bolted into the ceiling, thus providing small regions where contamination can be lodged.

Floors

1. Again, most of the criteria which apply to the walls and ceilings also apply to the floors. One difference is that the surface must be smooth but not slippery; therefore, it may be necessary that the surface not be flat as was specified for the walls and ceilings. This does not mean that the surface should be rough and pitted, but it can be finished for adequate traction. Modern facilities have slightly bumpy surfaces which are smooth but not slippery.

Basis

The desire is to have a floor surface which is easy to decontaminate. Most of the spills of liquid and solid material reach the floor to a higher degree than the walls and ceilings. Also, the floor gets much

traffic on it, and heavy equipment may be rolled across it. Therefore, a surface is needed that is very resistant to wear and tear, scratches, scraping, and damage in general. There are considerable differences of opinion as to what the flooring material should be or how the floor should be covered. One type of floor covering might consist of an epoxy undercoating which penetrates into the concrete subfloor, covered by several layers of epoxy topcoating to build up a very thick topcoat layer. This would form a continuous coating with no cracks or crevices in the floor. On the other hand, if something does damage the floor or scrapes it such that contamination gets down beneath the surface level into the actual floor material, it is necessary to remove that portion of the surface and repair it. Therefore, other people feel that the flooring should be in sections that are easy to remove, using some type of linoleum or vinyl covering held onto the concrete subfloor by means of a mastic. Some places have used large sheets of this type covering, thereby minimizing the cracks in between the sections. Contamination does get down in the cracks between the sections even though they are sealed. Then, the contamination gets into the mastic underneath and both the topcoating and the mastic must be removed to remove the contamination. If large sections of linoleum are used, then the large sections have to either be removed in one piece or smaller sections have to be cut and replaced. On the other hand, if small tile squares are used, just a few tile squares need to be removed and replaced if they are damaged and contaminated.

2. The edges of the floors, where they meet the walls, must be easy to clean and decontaminate.

Basis

The edges of the floors at junctions with the walls are one of the most likely spots for liquids, solids, dust, dirt, and contamination to gather during the lifetime of the facility. Therefore, these corners must be kept clean and decontaminated at all times. Having a rounded

surface at the edge facilitates this cleaning and decontamination. If the corners are not rounded, dirt and contamination get into the edges and can go down into the cracks and penetrate below the surface of the floor and the walls. Rounding of the edges between the floors and the walls can be done at the time that the concrete is poured, by having the concrete itself rounded. This is preferable to having square edges with a rounded flooring covering material. If rounded floor covering material is used with square edged concrete, there are always chances that the floor covering can crack or be punctured where the round flooring surface meets the squared edges. Therefore, it is preferable to have the concrete rounded so that the floor linoleum or tiles will conform to the rounded concrete and leave no spaces underneath for dirt and contamination to penetrate. This will also prevent open spaces underneath the floor covering material, if it cracks.

3. The floor should have drains in it, and the floor should slope toward the drains.

Basis

Contamination is often caused by liquid spills, and there are also many times when liquids are used to clean up the floors. It is desirable to have all of these liquids run into drains, for ease of cleaning and decontamination. If there are spots which do not drain easily, these will act as gathering spots for contamination. These spots probably will become more contaminated over long periods of time than they would if they were smooth surfaces sloping down toward the drain. The time required to clean up liquid spills or to clean up washing solutions will also be reduced if the solutions flow smoothly toward the drains and into hold-up tanks.

4. Floor drains should be smooth and easy to decontaminate, and should not contain cracks or crevices around them which will act as gathering spots for contamination during clean-up operations.

Basis

After contaminated liquid has been flushed down the floor drains, one does not wish to have high contamination levels in the drains or in the vicinity of the drains; therefore, they should be designed so that they may be cleaned at the same time that the floors are being cleaned.

5. Rounded curbs should be provided around all the floors. The curbs should be of such a height as to prevent criticality during liquid hold-up.

Basis

Rather than having liquids flow from one room to another or flow outside of the building, it is preferable that the liquids be held up within curbs, and drain into the appropriate drainage pipes and tanks. Curbs will provide for this; however, they must be of a low enough height to prevent criticality. They should be rounded into the floor (just as the walls are) for easy decontamination.

Glove Boxes

1. Glove boxes should be sized for ease of disposal or rearrangement. This includes removal from the facility, packaging, and shipping as well as storage or burial. If necessary, the glove boxes should be sectionable so they meet these size conditions.

Basis

Currently, there are many glove boxes in existence which are too large to move around in the facility, through the hallways, or outside of the facility. They are also too large for packing into standard containers for commercial shipping either by truck or by rail car. Further, there are no means for separating them into smaller sections

or units. They present a definite problem for D&D. For future installations, glove boxes should be designed to be small enough to be packed as a whole unit, or should be designed so that they can be separated easily into smaller units or pieces. Possibly, glove box trains should be connected by smaller tunnels which are flanged for ease of separation and removal; if this is not possible, then the glove box trains themselves should be flanged so that they can be separated into small units.

2. Glove boxes in trains, along with associated conveyer systems, should be designed so that they are easy to separate for rearrangement or decommissioning. It should not be necessary to start at one end and work to the middle in order to remove some middle section. Each and every section should be easy to remove without disturbing the rest of the sections. Portions of the conveyer system should be easy to remove without disturbing other portions of the conveyer or the associated glove box train.

Basis

During operation of the facility, especially in the case of R&D facilities where operations are changed from time to time, it is frequently necessary to modify or rearrange the glove box train. However, it may not be necessary to rearrange the entire train, so it is helpful to be able to work on only a few of the glove boxes in the train without disturbing the other glove boxes or disturbing the attached conveyer system. Design of the glove boxes and their interconnections should be made to facilitate this ease of rearrangement, transfer, removal, insertion, etc. Obviously, when the glove boxes require additional shielding, meeting this criteria becomes a greater problem. Therefore, the design of the glove boxes, including the shielding, should be considered in total when easy glove box removal is being planned.

3. Pipes, ducts, conduits, and other attachments to the glove box should be easy to disconnect from the glove box, to facilitate its removal and/or exchange.

Basis

Not only is it necessary to make it easy to separate glove boxes and conveyer systems from the glove box train, but it is also necessary to make it easy to separate all other attachments from the glove boxes, to facilitate removing and exchanging boxes. Therefore, all items should be connected in such a way that they are easy to disconnect, dismantle, and separate. Even if this is not necessary during operation of the facility, it most likely will become necessary during decommissioning.

Glove Box Materials

1. The box shall be designed for ease of decontamination inside and out. The inside of the box should have a smooth finish which is easy to clean and decontaminate.

Basis

The glove box is the first line of defense in preventing the spread of contamination. Therefore, it is essential to keep it as clean as possible at all times. In the event that a glove box should fail, exposing its contents, the less contamination there is in the glove box the lower the possibility of any escaping into other areas. Having the surface smooth and easy to decontaminate makes it possible to keep the glove box contamination down. In general, a stainless steel box with a smooth finish is preferred. There are cases where a mild steel box covered with an appropriate surface covering of paint or epoxy is acceptable; primarily, this depends on the use the box receives, the type of equipment in the box, and the chance of scraping the surface. If the atmosphere in the glove box is corrosive to stainless steel, then another type of material must be used or an appropriate surface coating, such as teflon, may be put on the surface of the box to stop the corrosion. Fiberglass glove boxes have been used in such circumstances, but generally they become very contaminated. They are also very hard to clean.

2. Glove box windows shall be made of glass wherever possible. The glass will be held in by sealed flanges, and the flanges will be covered with a fire-protective metal.

Basis

Glass is harder than plastic; therefore, fewer scratches will occur in glass, and it should not become as contaminated as plastic. Further, it is easier to decontaminate glass than plastic. Glass also reduces the fire hazard of the box.

3. Materials used in gloves shall be designed for long life, to withstand the environment to which they are exposed, and to withstand penetrations by fingernails, instruments, and rough surfaces.

Basis

The glove box glove is the most vulnerable point for release of contamination outside of the glove box. It is essential that this weak point be as strong as possible. Material should be tailored to the application and the environment to which it is to be exposed. If the glove gets heavier wear than usual, a heavy-duty type should be used. If considerable flexing is required, a lighter weight glove with flexing resistance and wear resistance should be used. In corrosive environments, gloves which are resistant to the damaging environment should be used.

4. Glove ports should be covered when the gloves are not in use.

Basis

Since the gloves are the weakest line of defense in the glove box, it is important to use covers over the glove ports when the gloves are not being used. In the event that a glove does develop a small leak, a

cover will help contain the leak and contamination within the glove itself. These covers should be sealed so that the contamination is indeed contained.

5. Openings in walls between glove boxes should be minimized. The opening should be no larger than necessary to allow passage of materials from one box to the other. Separate sealed penetrations should connect boxes for service pipes, electrical conduits, ducts, etc.

Basis

Minimizing the opening in the wall between glove boxes helps to minimize the spread of contamination from one box to the other. A smaller opening is easier to close. Having separate sealed penetrations for service pipes, electrical conduits, and ducts reduces the size required for the opening. A small opening facilitates D&D since it is easier to cover and seal for packaging and shipping.

6. The size of glove box windows should be as small as practical, and their number should be minimized.

Basis

Windows need to be large enough so that the interior of the glove box can be viewed easily. However, by minimizing the size of each window, the area exposed to the outside room is minimized. Then, with proper ventilation and negative pressure differentials, the amount of contamination which escapes to the outside room should be minimized if the window fails. By minimizing the number of windows, the number which may fail is minimized. If a glove box is going to contain equipment which is large, and which must be moved in and out of the glove box, then removable steel panels should be used to facilitate this access rather than removable glass or plastic panels.

7. Glove box shielding should be designed so that it is easy to clean and decontaminate the surfaces which are exposed. It should also be designed to prevent the gathering of contamination in hard-to-clean areas, such as gaps and crevices.

Basis

Either the glove box shielding should be an integral part of the glove box, or it should be easy to remove for ease of routine cleaning and decontamination. The surface of the shielding material should be such that it is easy to clean. In the case of lead, it is probably preferable to cover the surface with paint or epoxy which is easy to clean. An example of poor design is a glove box with shielding material temporarily taped onto the glove box. The space between the shield and the glove box wall can trap contamination. This space is difficult to reach for routine cleanup.

8. Glove boxes should have lighting fixtures which are flush with the top of the glove box and which are sealed so that contamination is not trapped around the fixture. The sealed surface should be smooth and easy to clean and decontaminate.

Basis

If lighting fixtures are inserted into the glove box rather than being flush with the top of the glove box, the surfaces, conduits, outlets, etc., have crevices which easily gather contamination and which are very hard to clean and decontaminate. Therefore, it is preferable that the lighting fixture itself be outside of the glove box, with its surface flush with the top of the glove box and sealed so that the contamination cannot get out or get into the light fixture. The sealed surface should be smooth and flat, easy to clean and decontaminate.

9. Ventilation in the glove box should be of the down-draft type, the air flowing downward from the top of the box to the bottom.

Basis

Down-draft ventilation seems to be preferred in glove box ventilation systems. This keeps contamination down near the bottom of the box, where the box is easiest to clean. (It is easier to reach the bottom portions of the box with the gloves and cleaning materials and solutions.) The glove box bottom should be designed for ease of decontamination. Minimizing the amount of contamination which gets on the top and sides, around the windows, and into crevices, minimizes the total amount of contamination which is retained in the glove box.

10. The glove box should have rounded edges where the bottom of the box meets the walls of the box, where the walls meet each other, and where the top of the box meets the walls.

Basis

As elsewhere, the elimination of sharp edges and corners in glove boxes eliminates points of contamination accumulation. By rounding all the edges, the amount of contamination which can accumulate is minimized. This also facilitates decontamination and recovery of spilled nuclear materials.

11. The surfaces of glove boxes should be corrosion resistant.

Basis

Corroded surfaces have a higher probability of collecting contamination and holding it. Therefore, corrosion resistant materials or surfaces should be used in glove boxes; or, whenever corrosive materials are used in the glove box, the box should be cleaned as soon as possible after the materials have been removed.

12. The boxes should be designed to minimize the effects of scraping, scratching, gouging, and damaging of the surface while in use.

Basis

Glove box surfaces may be damaged, scraped, or scratched during the insertion or removal of heavy equipment, machinery, tools, and materials. Damage can also occur during normal operations when the use of tools, equipment, and machinery can mar the surface. All spots of damage to the surface result in areas where contamination can adhere more easily or become fixed in the interior of the surface. Therefore, the box should be designed to minimize this type of damage.

13. The use of special, self-contained enclosures within the glove box itself should be considered for all cases where exceptionally hazardous operations or dangerous materials are being used.

Basis

By providing a separate, self-contained enclosure within a glove box for operations or materials which are extremely hazardous, the possibility of contamination being spread outside of the glove box is reduced. If the separate enclosure has its own ventilation and services connected to it, then these can be separately contained and monitored. If anything serious happens inside this self-contained enclosure, it will be contained therein and will not be released to the glove box or into the lab.

Conveyers and Conveyer Enclosures

1. Enclosed conveyers may be used to connect short glove box trains together rather than connecting the glove boxes themselves. These conveyers are used to transfer material from any one glove box to any other glove box in the glove box train.

Basis

In some operations, it is desirable to pass material from one glove box to another without having to go through several glove boxes. The procedure or sequence of operations is different from one time to another, and it is not convenient to have the material pass through several glove boxes to go from one location to the other. The solution is to use a conveyor to transfer the materials. A conveyor can also make it simpler to dismantle glove boxes later on, even if normal operations involve a fixed sequence of events and material always passes through the same chain. It is probably easier to disconnect the glove box from a conveyor outlet than it is to disconnect it from an adjacent tunnel or glove box on each side.

2. Enclosed conveyers should be used to connect long glove box trains to one another.

Basis

The use of enclosed conveyor systems to transport materials from one glove box train to another is of extreme importance in minimizing bag-out/bag-in operations. This, in turn, minimizes the possibility of a contamination leak or spread of contamination during those operations. Thus, the long glove box trains can be compartmentalized inside small laboratories, and the laboratories connected through the use of the conveyor system which penetrates the walls. Sealed penetrations maintain the integrity of each of the individual rooms and the glove box trains. Some laboratories prefer to use overhead conveyor systems, with a drop coming down into the ceiling of each glove box. Others have short glove box trains which dead end into the long conveyor system enclosure, usually at a 90° angle (although some systems are at other angles such as 45°).

3. Conveyer enclosures should be separable into convenient size segments for ease in dismantling, boxing, and shipping at decommissioning time. The same is true of the conveyer system within the enclosure. Most importantly, the lines of separation should be at the same location for both the enclosure and the conveyer inside..

Basis

For ease of handling at decommissioning time, and to make it possible to box and ship the conveyer and the conveyer enclosure, these items should be separable into convenient sized packages or segments. The design should be such that the end of a segment of the enclosure coincides with the end of a segment of the conveyer inside it. Then the two can be removed together as a package and the end sealed without having to cut one or the other to make their ends correspond. This will simplify the decommissioning effort considerably. There are instances now where platform type conveyers inside the enclosure are segmented with the conveyer segments ending in the middle of the enclosure segments. This requires that the conveyer system be sawed at the ends of the enclosure segments before it can be removed. Sawing is time consuming, expensive, and increases the hazard of contamination exposure and spreading.

4. Conveyer systems should be connected to glove boxes in such a way that it will be easy to remove the glove boxes.

Basis

Glove boxes are often rearranged for new work, removed, and replaced for new types of operations, or removed for dismantling and decommissioning. Therefore, removal of the glove box from the attached conveyer enclosure should be as easy and simple and safe as possible. The design should incorporate methods to expedite this.

Ventilation

1. Ventilation should be the primary means by which contamination spreading is minimized and controlled. This includes the glove boxes, the laboratories, the access corridors, the offices, and the building itself.

Basis

The primary means of controlling the spread of contamination is the ventilation systems of the building. With appropriate flowrates of air through the systems, the spread of contamination can be virtually eliminated, or at least minimized in very serious situations. For instance, should a glove start to leak, a sufficient pressure differential and inward flow of air will prevent most contamination from escaping through the leak in the glove. The worst condition would be if a glove comes off or a window breaks. Air rushing into the glove box at a sufficiently fast rate would minimize the spread of contamination through the broken port.

2. Intake filters on glove boxes should include prefilters and HEPA filters.

Basis

It is important to have prefilters and HEPA filters on the glove boxes in order to prevent release of contamination should the glove box accidentally pressurize and reverse the flow of air out through the intake filter system.

3. The exhaust filters on glove boxes should contain prefilters and HEPA filters. Additional exhaust filters should be provided in plenums or other filter boxes.

Basis

The exhaust from the glove boxes must pass through several stages of filtration. As a minimum this requires a prefilter followed by a HEPA filter in the glove box itself. Additional protection would be provided by additional HEPA filters in the glove box. The exhaust gases then must pass into a central filtration system, which is either housed in large plenum rooms or other contained boxes. Some glove box systems have several stages of HEPA filters on the exhaust systems where new sections of filters are inserted to push old sections into the glove box interior for easy removal. By routinely removing the accumulated filter contamination in this manner, very little contamination reaches the large filter plenums during normal operations. This makes the large filter plenums easy to decontaminate and decommission. Care must be used that an accumulation of contamination does not build up in the filter system in the glove box. This would create higher radiation levels.

4. The glove box should be provided with pressure regulation to prevent overpressurization.

Basis

In order to maintain the appropriate pressure differentials between the glove box and adjacent areas, it is necessary to provide a method of pressure regulation in the glove box. This may be accomplished by means of valves or liquid bubblers. Valves, which may have a tendency to malfunction, should be provided in duplicate for redundancy, or possibly both methods of regulation could be used as a means of redundancy. Overpressurization is a great hazard because of the possibility of blowing off gloves, or blowing out windows or filtration ports, thus releasing large amounts of contamination into the adjacent rooms. Explosive release of contamination through overpressurization spreads contamination over considerable distances; much more so than just an

ordinary leak in the glove port, for instance. Injuries to personnel could also occur from an overpressurization explosion.

5. Rooms into which glove boxes open, or in which glove boxes are placed, should have separate prefilters and HEPA filters both on the inlet supply air system and the outlet exhaust system. The exhaust air will then go into the larger filter plenums which also filter the air from the glove boxes.

Basis

The reasons are similar to those for the glove box filter systems, in that air coming into the hot rooms or potentially hot rooms will be filtered and in case of an overpressurization in the room, any air escaping through the supply duct will be filtered. Filters for the exhaust air may be routinely removed and replaced, thus preventing higher levels of contamination reaching the larger filter plenums. Again, this minimizes decontamination and decommissioning work and costs.

6. Cold areas, such as offices, corridors, and cold laboratories, should have prefilters and HEPA filters on the inlet air supply system. The exhaust air should go directly to the large filter plenums.

Basis

Filtration of the inlet air will prevent any escape of contamination to the outside atmosphere in the event of overpressurization within the entire building. In the event that contamination does escape from hot areas into cold areas, the large exhaust air filter plenums will capture the contamination.

7. Down-draft flow should be used for all ventilation systems in the glove boxes, hot room areas, and cold room areas. Inlet supply air should originate near the ceiling and the exhaust outlet should be located near the floors.

Basis

By using a down-draft ventilation air flow, contamination in the glove boxes or rooms will be principally contained near the floor or the lower portions of the walls. Here it will be easier to decontaminate than if it is high up on the walls or on the ceilings.

8. Pressure regulators should be used between the glove boxes and the hot room areas and also between the hot and cold areas of the facility.

Basis

It is desirable to prevent contamination from spreading from the hot areas into the colder areas. Therefore, in the ventilation system, pressure differentials should be used for this. In order to maintain pressure differentials, it will be necessary to use pressure regulators. These regulators can be mechanical valves or liquid bubblers. If mechanical valves are used, a redundancy using more than one valve is necessary. Liquid bubblers are a fail safe type of device for maintaining pressure differentials. A combination of both types of regulators is preferred for redundancy purposes.

9. Special portable local ventilation systems should be used near glove boxes during such operations as glove changes, bag-out or bag-in procedures, glove box entry, etc.

Basis

During such operations as glove changes, bag-out or bag-in steps, glove box entry, etc., the chance of contamination leaking out into the room is increased. Therefore, by using portable local ventilation systems, such as a vacuum system which can be put in the immediate vicinity of the operation, this contamination can be trapped and prevented from escaping into the room in which the operation is being performed. The portable system should have a prefilter and HEPA filter to contain the contamination. This system can be moved about the room, or from room to room, as needed. The use of this type of a device, along with the normal in-flow of air into the glove box from the room, should minimize the spread of contamination into the room.

10. Special plastic enclosures should be used around the port or opening into a glove box when there is a high likelihood that contamination may escape from the box.

Basis

A special plastic enclosure (sometimes called a greenhouse or plastic room) should be used around the glove box opening when there is a high likelihood of contamination escaping from the glove box. Depending on the hazard of the operation, as many as three separate plastic rooms may be used to minimize the spread of contamination and provide separate contamination control areas. The room adjacent to the glove box is used to perform the operation, a second room is used for decontamination of the worker and equipment, and the third room is used as a clean room for checking out the worker and equipment before he enters into the laboratory or maintenance corridor. Use of this plastic containment keeps the contamination out of the room, thereby minimizing decontamination and decommissioning problems later on. The frame for the enclosure should be outside the plastic to prevent it from becoming contaminated.

11. Exhaust ducts which may be hot should either be doubly enclosed by a second duct, or should have a secondary enclosure through which access to the primary duct is possible.

Basis

Because there is a possibility of a leak from the hot duct into the room through which it is passing, some type of secondary enclosure should be provided to contain contamination. One method is to have a second duct around the first duct, with the space between the two ducts monitored for contamination by sampling the air between the spaces. This would allow detection of a leak in the primary duct; however, it does not allow easy access to the primary duct for repair or replacement. A larger enclosure, which is designed to allow access to the primary duct, might be preferable. This must be designed to provide for determining where the leak occurs and for repairing or replacing that portion of the primary duct which is leaking.

12. Air monitoring systems should be provided in each area where radioactive material is handled.

Basis

Early detection of airborne contamination is essential to minimizing the spread of contamination and the amount of contamination which is released. This in turn reduces the decontamination effort required and also facilitates decontamination to the lowest possible values. A central air sampling system should be provided. Sampling heads should be placed at or near breathing zones, with approximately one head for every two glove box stations, and at various other locations in room exhaust systems. Continuous air monitors with recorders and alarms should also be provided at locations to be determined by process equipment layout. All sampling systems should be provided with emergency power. A space for processing the air sampling filter paper should be provided in the Health Physics area.

13. The type of gas used for ventilation in each glove box should be selected for its appropriateness to the type of operation performed in that box.

Basis

Since there are a variety of gases which may be used for ventilation in the glove boxes, an evaluation should be made to determine which type of gas is most appropriate. Typically, the choices are between air, nitrogen, argon, and helium. In some cases an inert atmosphere is definitely required; in other cases there may be a choice between air or an inert atmosphere. Air is the least expensive gas to use but may not necessarily be the most appropriate. High velocity air has many advantages; however, it does not lend itself to detection of small leaks in gloves or ports. On the other hand, when an inert atmosphere is used in a demand-only type glove box, an oxygen sampler may also be used to determine when there are small leaks. By detecting these small leaks as soon as they occur, it is possible to minimize the spread of contamination out of the glove box. Demand-only type systems using air appear to be relatively poor, because oxygen sampling cannot be used to detect leaks. Also, water vapor and/or other corrosive vapors may build up in the glove box over a long period of time, when there is not a constant flow of gas through the glove box.

Service Pipes

1. Service pipes for glove boxes should go through the floors of the glove boxes into the basement through sealed penetrations in the room floor.

Basis

Having the service pipes for gases, water, electrical, liquids, etc., go through the glove box floor directly into the basement eliminates a large number of pipes crowding the laboratories and access

corridors around the glove boxes. This, of course, minimizes decontamination efforts in those areas. In the basement area, the pipes can go directly to other glove boxes, other junctions, or points of inlet or outlet, using minimum lengths of pipe. This isolates the pipes from contamination which might be released from the glove boxes. Also, any leaks from pipes carrying radioactive gases or liquids would not spread contamination into the laboratories or access corridors around the glove boxes.

2. Hot service pipes should be contained in secondary enclosures.

Basis

Service pipes which carry hot gases or liquids should be contained in secondary enclosures in order to prevent contamination from escaping in the event of a leak. The secondary enclosure might be another pipe outside the primary pipe, or it might be an access tunnel through which one can gain access to the pipe for repair or replacement of a damaged section or sections. In either case, the space between the primary and secondary containers should be monitored to determine when radioactivity has been released from the primary enclosure. A method should also be developed to ascertain where the leak occurs.

Building Arrangements

1. The building should be compartmentalized.

Basis

By dividing the building into small but useful compartments, contamination released to any one compartment can be contained within that compartment. Cleanup and decontamination of the compartment will then be minor compared to having to clean up a large room. Also, during the decommissioning of the facility, small rooms are much easier to handle

as far as dismantling of equipment, removal of the equipment, and final decontamination of the compartment is concerned.

2. The building should be divided into different floors.

Basis

By having at least two floors, one being the operations floor with the glove boxes and the other being the basement, gross compartmentalization is already established. The glove boxes and labs are separated from the filter plenums, process pipes, ventilation ducts, etc. More floors can be added depending on the complexity of the facility and the operations performed there. Several operations floors may be required; several basements may be required; even an attic may be required.

3. The floor containing the glove box and operating labs should be compartmentalized.

Basis

First of all, the floor containing the glove boxes should be divided into pressure differential zones. The different zones will be the glove boxes, maintenance corridors, laboratories, access corridors, and offices. By means of adequate pressure differentials between these various zones, the spread of contamination is minimized and the contamination is contained within the hot areas of the building. Then the amount of decontamination effort required during decommissioning is minimized. Also, this keeps the exterior offices and walls clean so that no decontamination is required during the decommissioning phase. This is important, since it should not be necessary to remove any or all of the exterior walls for complete decommissioning.

4. Areas within pressure zones should be compartmentalized.

Basis

Areas which are designated as hot areas, or areas which may possibly become contaminated, should be divided into small working compartments in order to minimize the spread of contamination. This then minimizes the decontamination effort which is required in the event of a spill, gas leak, or accident. All decommissioning will be expedited by minimizing the number of small compartments which have to be decontaminated during the decommissioning effort.

5. Airlocks should be provided between the hot and cold areas, and between different pressure zones within the hot areas.

Basis

By providing airlocks between the hot and cold areas, and between the different pressure zones in the hot areas, spread of contamination from one area to another is minimized. Also, the passage of personnel between various areas is expedited. Airlocks provide a contamination control room. In the event of serious contamination within a small compartment, personnel can use the airlock for decontamination procedures when leaving a contaminated compartment before passing into a clean area. The airlock can then be decontaminated at the appropriate time.

6. Basements should have hot and cold areas and possibly maintenance corridors and access corridors.

Basis

By dividing the basement into hot and cold areas, and providing pressure differentials and compartmentalization, the spread of contamination is minimized just as it is above on the operations floor.

Hot ventilation plenums, hot ventilation ducts, and hot service pipes are contained in the hot basement areas. Thus any leaks or spills of contamination do not reach the large number of cold pipes and equipment. Cleanup in the hot areas is reduced to a minimum. Again, airlocks should be used between hot and cold areas and between different hot pressure-differential zones.

7. Sufficient room should be provided in the building arrangement for easy movement of glove boxes and equipment.

Basis

The labs often require rearranging of glove boxes, introducing new equipment, and removing old equipment. This is made easier, faster, and less hazardous to personnel if adequate working space is provided for such operations. Decontamination and decommissioning efforts are greatly expedited by having sufficient room. This includes having doorways which are adequately sized and access corridors which are large enough for easy movement of equipment. Decommissioning expenses are obviously increased when doorways have to be enlarged and walls removed in order to move equipment in and out of rooms.

Compartment Arrangements

1. Compartments which are hot, or may possibly become hot, should be arranged such that they are as open and empty as possible. This means that all service pipes, duct work, outlets on the walls, equipment in the rooms, tools, etc., should be kept to a minimum.

Basis

The idea is to minimize the amount of effort required to clean up contamination. The simpler the room is, and the less cluttered it is, the easier it is to decontaminate and decommission. By eliminating as

many pipes and ducts as possible from the room, the process of clean-up is simplified and the manpower, time, and costs are reduced. The hazards of clean-up are also reduced, since it is easier to clean up a few items and keep them clean than it is to clean up many pipes and ducts and pieces of equipment. When a room is cluttered with items, it is possible that contamination from an item that has not been cleaned may spread to an item or items which have already been cleaned, thereby requiring the clean-up crew to go back over those items which they have already cleaned at least once and possibly several times before the entire room is clean. If a room is cluttered with pipes and ducts which are usually located overhead, the hazards of clean-up are increased when personnel have to work near the ceiling on ladders and scaffolding.

2. Room ventilation ducts should be minimized and easy to clean and clean around.

Basis

In conjunction with having the room as empty as possible, the room ventilation duct work should be minimized. Obviously, this simplifies the clean-up effort in the event of contamination on the duct work. Having the ducts away from the walls and other objects also simplifies the clean-up operation. Also, it makes it easier to clean the walls or adjacent items when there is adequate room between the ducts and these items for personnel to get in and perform the clean-up operation. An alternative to having the ducts sufficiently far from other items is to have the ducts sealed to the walls so that contamination cannot reach the spaces between the walls and ducts. The ducts then become a sealed part of the wall or ceiling. One problem with this alternate method of sealing the ducts to the walls or ceiling is that the ducts may possibly be contaminated on the inside. Should this be the case, the problem of decontamination or removal of the ducts is compounded. One solution to this problem is to have the primary duct work, which may become contaminated, isolated inside of a secondary duct enclosure. Advantages to a

dual duct system are that the space between the primary and secondary ducts may be monitored for contamination and the leak points may be detected. Then the primary duct system may be repaired or replaced as required. However, if the primary duct does leak and contamination does spread to the secondary enclosure, then it will be necessary to decontaminate or remove the secondary enclosure at decommissioning time. Whatever design is incorporated in the room ventilation system, its primary consideration should be to minimize the overall effort for leak detection, contamination spread, decontamination effort and decommissioning effort.

3. There should be minimal protuberances from the walls, floors and ceilings.

Basis

The compartments should have minimal protuberances from the walls, floors, and ceilings in order to minimize decontamination and decommissioning efforts. Such items as light fixtures, electrical outlet boxes, and gas and liquid supply fixtures should be minimized. It would also help to have these protuberances covered during times when they are not in use. Fixtures which can be recessed, with their surfaces flush with the wall or ceiling surfaces, are desirable.

4. There should be sufficient room in each compartment for moving gloveboxes and equipment.

Basis

Sufficient room should be provided in each compartment so that gloveboxes can be rearranged, equipment can be moved around easily, new equipment can be brought in, and old equipment removed. By having adequate room for such movement and operations, the chance of contamination release or the spreading of contamination is reduced. In cases

where there is not sufficient room, often other equipment or gloveboxes must be moved prior to performing the primary operation. The more equipment that must be moved, the greater the chance of contamination release or contamination spreading. The hazards to personnel are increased by not having adequate room for moving material and equipment around, and the effort at time of decommissioning is also greatly increased.

Effluents and Wastes

Gaseous Effluents

1. The exhaust stack leading from the ventilation system should be designed so that it can be separated into segments small enough for packaging and shipping at decommissioning time. Also, the duct work leading from the final HEPA filter bank to the exhaust stack should be separable into segments small enough for packaging and shipping.

Basis

Although the absolute filter system in the facility is designed to remove nearly all of the radioactive material from the building air and gaseous effluents before they are exhausted, over a long period of time contamination may build up on the inside surfaces of each exhaust stack and the duct work leading to the exhaust stack. At decommissioning time, it will probably be necessary to dismantle the exhaust stack and duct work and package it for shipping and storage or burial. By constructing the stack and ducts originally in segments, the decommissioning effort will be minimized. Otherwise at decommissioning time, a greater effort will be required to cut the stack and ducts into the required-sized segments for shipping. This will increase labor costs, hazards of the operation, and time to complete the operation. Also a cutting operation rather than a simple dismantling operation will increase

problems which are involved with contaminated material, such as prevention of contamination spreading. Personnel would have to wear more cumbersome protective clothing and equipment, thereby reducing productivity and further slowing down the operation.

Liquid Wastes

2. Pipes containing radioactive liquid wastes should be as short as possible. If the liquid goes to a hold-up tank, the tank should be located as close to the source as practicable.

Basis

By having pipes carrying radioactive liquid wastes as short as possible, both the time required to remove these pipes during the decommissioning effort and the quantity and volume of pipes which must be packaged and shipped for storage or burial are reduced. It may even be desirable to place the hold-up tanks inside the facility in order to minimize the pipe lengths. By having the pipes and hold-up tanks inside the facility with easy access, the decommissioning effort is simplified. When pipes and tanks are buried, the effort required to locate and dig them up may be great, and the possibility of releasing contamination to the soil is increased. Also, the hazards associated with the removal of pipes and tanks from the soil are increased.

3. The pipes and hold-up tanks should be doubly encased. The space between the primary and secondary enclosures should be monitored to detect leaks from the primary enclosures.

Basis

Whether the pipes and hold-up tanks are located within the facility or are buried underground, they should be doubly contained to prevent contamination from spreading to the facility or into the ground in the

event of a leak. By monitoring the space between the primary and secondary enclosures, leaks can be detected. The design should afford capability for repairing the leaks or replacing those sections of pipes which are leaking. It should be possible to decontaminate the secondary enclosure where it becomes contaminated. In decommissioning, the secondary enclosures will probably have to be removed and shipped as well as the primary enclosures, however, this should not spread contamination to the facility or soil during the decommissioning phase.

4. Liquid hold-up tanks should be designed for ease of decontamination and decommissioning.

Basis

Many current hold-up tanks are poorly designed in that they allow contamination to accumulate in spots which are hard to clean out even though the tank may have been drained. These spots provide high radiation zones which are obviously hazardous to personnel working on the tanks. Hot spots create problem areas when trying to decontaminate the tanks for decommissioning, packaging, and shipping. Therefore, the design of hold-up tanks should provide a minimum of crevices where contamination may accumulate and should provide for remote means of decontaminating the inside of the tanks, with high pressure sprays or solutions.

5. Pipes carrying radioactive liquid waste to waste disposal facilities outside of the plutonium facility should be easily accessible and doubly contained.

Basis

Here again there are current examples of long pipe lengths going from a plutonium facility to radioactive waste disposal facilities which are buried deep underground. There is no way of knowing if the pipes

are leaking, how much material has leaked out, or how far it has seeped into the ground beyond the pipe. When it comes time to decommission that pipe and remove it from the ground, many problems will be incurred. First, it has to be found. Then, it has to be dug up and cut into segments small enough for packaging and shipping. An attempt will have to be made to minimize the amount of contamination that gets into the ground during the decontamination process. After the pipe is removed and disposed of, the soil along where the pipe was buried will have to be surveyed for any contamination, and if it is present, this contamination will have to be removed from the soil. This could indeed be a very extensive and expensive operation. If, on the other hand, such pipes are designed so that they are doubly contained, easily accessible, and monitored for leaks in the primary pipe system, the time, hazards, and costs of decommissioning can be greatly reduced. Rather than running such a pipe from one facility to another, it may even be preferable to transport the material by some other means just to eliminate this problem.

Special Rooms

Special rooms in the plutonium facility may create unique problems at the time of decontamination and decommissioning. On the other hand, other special rooms in the facility may help to make the D&D effort considerably easier, faster and cheaper. They may also make the effort very much safer, especially if these rooms contain remote handling and operating apparatus. Remote operations reduce radiation and contamination hazards to personnel.

1. Plutonium facilities should have one or more decontamination rooms.

Basis

If a decontamination room is used normally during the lifetime of the facility to clean up equipment and material, it could be especially helpful at the time of decontamination and decommissioning of the facility.

It is possible that gloveboxes containing equipment could be properly sealed up, transported to the decontamination room, and unsealed for a decontamination effort. Then the glovebox and its equipment could be decontaminated, preferably remotely, using appropriate solutions, chemicals, high pressure sprays, steam cleaning, sand blasting, or ultrasonic cleaning methods. In some cases, the items may be cleaned to a level where they could be released for general public use. In other cases, they may still have a contamination level which allows only restricted use. Even if the items are not to be reused at all, this decontamination effort may be required to reduce radiation levels sufficiently to allow handling. Radiation and contamination levels may also have to be reduced to meet Department of Transportation requirements for packaging and shipping of the material offsite. By performing all of these decontamination efforts in the special room or rooms, it is much easier and safer than trying to do the work throughout the facility where the items are located.

2. The plutonium facility should have one or more rooms provided for size reduction.

Basis

Considerable amounts of material, equipment, and solid and liquid wastes are generated during the operation of the facility. As a routine matter, it is desirable to minimize the volume of these wastes which leave the facility. Size reduction capabilities may be necessary for this reason. In addition, at the time of decontamination and decommissioning of the facility, these size reduction capabilities will be of much help, since a large volume of contaminated material will be generated during the decommissioning process. Because the costs of packaging, shipping, storage and burial are so large, size reduction will greatly help reduce these costs. In some cases, size reduction may be desirable before a decontamination effort in order to facilitate the decontamination effort. For instance, if a glovebox is moved into a size reduction

room and its windows, flanges, and gaskets removed, it will possible to decontaminate the resulting skeleton to a lower contamination level. Another example might be having the capability to cut the glovebox up into segments which are small to be immersed in a decontamination tank to dissolve the contamination off the surface. Size reduction also includes compaction equipment for compacting material into drums, or crushing large objects. Size reduction could also include melting of metals into smaller volumes. Ideally, one would like to melt a glovebox into a small ingot for final disposal. One would also like to melt complex machinery and equipment into small ingots.

3. Combustible wastes should be reduced to a minimum by controlled incineration or other methods.

Basis

Combustible wastes should be burned during the normal operation of the facility. Since there will be a large amount of combustible waste to be disposed of during the D&D effort, this incineration capability will help to reduce the volume and costs of disposing of this material. These combustible wastes are both those which are normally in the building and those which are generated during the D&D effort.

4. The facility should have the capability to reduce the volume of disposable liquid wastes.

Basis

Since liquid wastes are generated both from normal operations of the facility and during the D&D effort, provisions should be made for volume reduction of these liquids using evaporators, centrifuges, etc. By reducing the volume of liquid wastes, which must finally be packaged, shipped, and stored or buried, the costs will be minimized. Also the size and costs of liquid waste hold-up tanks and storage tanks at the facility site will be reduced. If liquid wastes can be converted into

solid wastes, problems associated with packaging, transportation, storage, and burial are further reduced or eliminated. This also reduces costs of D&D.

CONTROVERSIAL SUBJECTS

One of the controversial subjects is whether to use sand filters, or HEPA filters, or both. There is, first of all, some disagreement about the relative efficiencies of each. Also, the huge bulk of the sand filter causes questions regarding final disposal. On the other hand, during severe fires, sand filters are claimed to survive, remain operative, and continue to filter, while HEPA filters clog up rapidly with carbon and also may burn or melt. Some of these arguments may have been more valid in the past, and created the current prejudices. However, many of the negative traits have now been corrected or eliminated. Therefore, the designer of a new facility should investigate objectively all aspects of both filter types on the basis of the most current tested capabilities and specifications.

A second controversial subject is the filling of glove boxes with polyurethane foam when preparing them for disposal. The reason for the practice is to hold contamination in place during sealing, handling, shipment, and burial or storage. Also, if other equipment is contained inside the glove box for disposal, that too is held in place. The objection to this practice is that it drastically hampers or prevents size reduction of the glove box and its contents, should that be required at some future date. Foaming causes different problems depending on which method of size reduction is employed (cutting, crushing, melting, dissolving, etc.).

A third controversial subject is size reduction before disposal. The question involves added health and safety hazards, the potential for contamination spreading, extra waste materials generated, and extra costs for all aspects of size reduction. The question is: Is size reduction cost effective when all the aspects are considered? Proponents of size reduction claim that it is cost effective, especially with increased complexities and restrictions on packaging, shipping, burial or storage, and all the associated cost increases. Also, there are political and environmental pressures to minimize radioactive and contaminated waste volumes which must be considered along with the costs.

ILLUSTRATIVE D&D EFFORTS

Battelle Pacific Northwest Laboratories (BNW) is estimating that the cost for the proposed D&D of the 233-S (Redox Plutonium Concentration) Building at Hanford will be \$3,500,000 (\$600,000 of this is for project tests).⁽¹⁾ Approximately three years will be required, including planning and preparation. The facility is housed in a high-bay structure with overall dimensions approximately 85 X 37 ft (3100 sq ft). The control, loadout, storage, and change rooms are one-story reinforced concrete. The high-bay area is 32 ft high.

The Atlantic Richfield Hanford Company (ARHCO) completed the D&D of P-11 Facility at Hanford in 1974.⁽²⁾ Cost of this effort was approximately \$265,000. It took approximately eight months to complete. The 120 Building, which was a single story metal building about 32 X 42 ft (2300 sq ft), contained the critical assembly room, a small chemistry laboratory, storage and tank room, and a change room. Everything was completely removed and the site returned to a condition which allowed it to be released for unrestricted access as defined by AEC security regulations for the Hanford site.

Mound Laboratory decontaminated and partially decommissioned the Special Metallurgical (SM) Building from August 1968 to September 1972.⁽³⁾ Several million dollars⁽⁴⁾ have been spent on the D&D effort to date. The building had one portion 115 X 115 ft (13,000 sq ft), constructed of a steel superstructure with exterior walls of two aluminum panels sandwiching a fiberboard insulating core. The other portion (SM addition) was 46 X 115 ft (5,300 sq ft), constructed of a steel superstructure with exterior walls of concrete block. The outside of the building still remains, and cannot be released for unrestricted access since the walls have wipeable contamination of 8,000 d/m/100 cm² and the floor has 20,000 d/m/100 cm². Also, there is approximately 11.2 curies (0.925g) underground (floor slab, underground, sewers, drains, etc.).

The Savannah River Plant (SRP) converted a used ^{239}Pu recovery room in a separations building to another use.⁽⁵⁾ The operation took seven months (1972-1973). The room was 20 X 85 ft (1,700 sq ft) by 18 ft high. It was cleaned until transferable contamination was less than 100 d/m/100 cm².

The Savannah River Plant also decontaminated five modules of a highly radioactively contaminated "hot canyon" in one of the chemical processing plants for installation of a new process.⁽⁶⁾ Decontamination was completed in about one year (1970-1971) at a cost of about \$150,000. The final radiation level averaged about 20 mR per hr, with no smearable or airborne contamination.

Los Alamos Scientific Laboratory (LASL) decontaminated and decommissioned Building 12, an old plutonium filter facility, from June 1972 to February 1973.⁽⁷⁾ The building was mostly one story with a sheet metal exterior, covering approximately 9,600 sq ft. Everything was completely removed and the site was returned to a condition for unrestricted use on the LASL site. The D&D cost was approximately \$153,000.⁽⁸⁾

Battelle Columbus Laboratory decontaminated the large (main) laboratory in the Plutonium Facility in 1970 after an accidental release of plutonium.⁽⁹⁾ The decontamination costs and equipment loss were approximately \$100,000. It took approximately six weeks to complete the effort. The laboratory size was 40 X 40 ft (1,600 sq ft). The laboratory was returned to normal use.

Atlantic Richfield Hanford Company is decontaminating and decommissioning its Division of Military Applications (DMA) Facility in the 234-5Z Building at Hanford.^(10,11) This facility occupies only a small portion (probably 10,000-15,000 sq ft) of the building. The D&D effort was estimated to be 27 percent complete as of December 31, 1974. The estimated total cost is \$2,000,000, with an 18-month completion schedule. The scope of the decommissioning work provides for: (1) the removal of all DMA fabrication and inspection equipment held in standby status in

the 234-5Z Building, (2) disposition of all equipment and materials removed by packaging for 20-year retrievable storage, (3) reclamation of salvagable materials and equipment for use on-site by other ERDA contractors, and (4) restoration of cleared-out areas for other future Richland Operations Office programs.

A paper presented at the International Symposium on Surface Contamination in 1964 described the decontamination of two facilities contaminated with plutonium.⁽¹²⁾

- 1) -- Plutonium Research Facility--an 8,000 sq ft section of a plutonium development laboratory was contaminated as the result of an accident discharge from a glove box. The decontamination effort (including 8-man days direct labor) cost \$860!!! Little description is given of the laboratory and its contents except that it was cinderblock, one level, with epoxy floor, and it had easily cleanable surfaces. Final average contamination was less than 20 d/m/100 cm² transferable.
- 2) -- Plutonium Contaminated Truck Terminal--an 8,300 sq ft truck terminal (brick frame, one level, with a concrete shipping platform and a tiled office area) was contaminated by leakage from a shipment of a plutonium solution. The cost of decontamination was \$21,000, including 265-man days of direct labor. Final average contamination was less than 500 c/m/100 cm² total.

There have been other plutonium facilities which have been decontaminated and decommissioned. One purpose of the above illustrations is to show that the costs of D&D can be very large and the effort required may continue for a long time. The variations depend on such parameters as:

- 1) facility size
- 2) construction materials
- 3) surface coatings or coverings
- 4) facility design
- 5) contents of facility
- 6) methods of decontamination
- 7) final contamination levels
- 8) final disposition of facility (what, how, where)
- 9) final disposition of contents (what, how, where)
- 10) health physics efforts during D&D
- 11) types and initial levels of contamination and radiation
- 12) waste disposal effort

This demonstrates that the application to new plutonium facilities of design criteria for ease of D&D can result in a large savings in time and money.

Naturally, cost-effect evaluations must be made of the D&D design criteria while considering all the other design criteria and related costs. This applies to original building costs as well as operational costs.

Often, an improvement for one criterion results in improvements for other criteria. For instance, design of equipment to reduce the MUF (Material Unaccounted For) may reduce radiation and contamination levels during the entire facility lifetime. This in turn probably reduces the D&D effort considerably. The reverse may also be true. In this example, glove boxes which are easy to decontaminate may reduce the MUF considerably. Also, radiation and contamination problems as well as fire hazards can be reduced.

Therefore, a great interdependency exists between the various design criteria. Even though they often seem to be more and more restrictive as the number increases, they often complement each other and simplify the overall objectives, i.e., to minimize total fixed and operating costs and to reduce hazards to facility personnel and the public.

RECOMMENDATIONS

In contrast to all the work that has been done on decontamination, very little information about that work has been recorded, and considerably less reported in the open literature. While gathering information for this report, we discovered that many experienced people had different ideas on how to decontaminate similar items.

Consider, for instance, a concrete wall. A great variety of answers resulted from such differences as:

poured concrete vs block wall,
smooth surface vs rough,
flat surface vs pitted,
uncoated vs coated, and
epoxy coating vs latex paint.

Other conditions which influenced the wide range of answers were:

- 1) the exact type of contamination (elements or compounds, isotopes, liquid, gas, or solid, etc.),
- 2) the original level of contamination and the final level achieved,
- 3) the amount of fixed and the amount transferable,
- 4) the mode of contamination spreading (liquid spill, solid spill, explosion, gas diffusion, gradual accumulation, etc.),
- 5) the time the contamination remained before it was cleared up, and,
- 6) the methods and materials that were used for decontamination.

Unless all this information is provided in a written report for comparison with other written reports, any conclusions drawn or evaluations made based on comparing memories should be suspect.

One attempt at standardization in evaluation is ANSI Standard N512-1973, Revision N5.9-1967, "Protective Coatings (Paints) for the Nuclear Industry." However, this standard is limited in the variety of test conditions, methods, and materials specified.

Since mixed fission products are the only contaminants specified, results are not obtained for transuranic contaminants. Also, test results are very limited. A private communication from the Carboline Research and Development Laboratory (a manufacturer of protective coatings) stated:

Interpretation of Decontamination Test Results - In general, high decontamination factors are not normally obtained for coatings with the gentle treatments used in this standard test. Certain generic types of coatings may contaminate more readily than others, and the responses to decontamination treatments also vary generically. In some cases, the desired level of decontamination may only be achieved by removal of a thin film of the coating surface leaving the coating thinned but serviceable; in other cases, decontamination may be achieved only by complete removal of the coating.

This decontamination test provides a method of ranking the relative ease of decontamination of the coating systems. The higher the overall DF, the easier the coating will be to decontaminate. Coating systems tested under the test methods given in this Report and normally used for nuclear facilities subject to frequent decontamination typically yield DF ratings in the range of 5 to 20.

Thus, we see that much more information is needed for a complete evaluation of products, especially for plutonium facilities.

Often, the costs associated with each decontamination effort are not reported. Thus, even if the decontamination work can be evaluated, no cost comparisons can be made with other work.

This is just the sort of problem a designer faces when trying to design a new facility. About all he can resort to is reviewing other facilities which are most similar to his. He can copy those items which seem to work satisfactorily in those facilities. Other items which are new or different for his facility must be designed using ideas which may or may not represent scientific facts (which are lacking).

Recommendation 1 - Detailed records should be kept of all decontamination and decommissioning efforts, including costs. This data should be reported so that it may be compared with other efforts. Very probably, a standardized form should be established for recording and reporting the data. This would ensure that all the necessary information is gathered. It would also simplify comparison of data from several reports.

Recommendation 2 - Further studies, investigations, and experiments should be made to obtain correlated quantitative information on decontamination. Data must be recorded on all the initial conditions, as well as the results and costs. This would provide designers with the necessary information to help them make cost effective decisions on trade-off designs.

SUMMARY AND CONCLUSION

Decontamination and decommissioning (D&D) criteria were assembled for use in designing new plutonium facilities. These criteria were gathered from literature searches and visits to many plutonium facilities around the country. The recommendations of reports and experienced personnel were used. Some of the criteria are those which helped D&D previous facilities. Other criteria are corrections for previous designs which were poor or failed. Many criteria are merely the results of gradual improvements or basically sound design practices. These improvements include better design ideas as well as technological improvements in materials and processes.

By designing for ease of D&D, considerable cost and time can be saved, even if it is a small fraction of the overall D&D effort. Also, an interdependency exists between the D&D criteria and other criteria such as fire, criticality, radiation, layout, ventilation, contamination confinement, maintenance, effluents, wastes, accountability, and safety. The criteria often complement each other and simplify the overall objectives, i.e., to minimize total fixed and operating costs and to reduce hazards to facility personnel and the public.

REFERENCES

1. Letter, K. M. Harmon to R. B. Goranson, "Disposition of 233-S Building at Hanford," (January 28, 1975)
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9. Letter, D. L. Keller to K. A. Dunbar, "Report on September 20, 1970, Spill Incident in the Plutonium Facility," (September 21, 1971)
10. H. E. Johnson, "Work Plan for Removal of Division of Military Application Equipment 234-5 Z Building," ARH-3079, (April 26, 1974)
11. Atlantic Richfield Hanford Company, "Decommissioning of Division of Military Application Equipment at Richland Operations Office for Period Ending December 31, 1974," (January 16, 1975)
12. P. Loysen, "Economics of Building Decontamination," CONF 555-14, (June 12, 1964)

APPENDIX A
FACILITY VISITS

The following facilities were visited during March and April 1975.

The majority of contacts at each facility are also listed.

1. Rocky Flats National Laboratory (Golden, Colorado)
Joe Watt (ERDA)
R. O. Williams, Jr. (V.P. and General Manager)
Don Mason (Facilities, Engineer and Construction Mgr.)
Ken Freiberg (Project Manager-Plutonium Recovery)
2. Kerr - McGee Nuclear Corporation (Oklahoma City, Oklahoma)
W. J. Shelley (Mgr. - License and Control)
Don Rhodes (Mgr. - Pu Plant)
Bill Buntz (Mgr. - Eng. and Technical Services)
Wayne Norwood (Health Physics and Ind. Safety)
Ray Wagner (Project Engineer)
Jim Carr (Technical Supervisor)
Morgan Moore (Mgr. - Pu and U Facilities)
Marty Binstock (Project Mgr. - FFTF Fuel)
3. Los Alamos Scientific Laboratory (Los Alamos, N.M.)
W. J. Maraman (Mgr. - CMB-11 Division)
E. L. Christenson (Mgr. - CMB-11 Division)
4. Battelle Pacific Northwest Laboratories (Richland, Washington)
R. D. Fogerson (ERDA)
K. M. Harmon (Manger - Hanford Waste Management Programs)
C. E. Jenkins (Project Manager - Commercial Nuclear Facilities Study, D & D Safety)
H. T. Fullam (Eng. Associate - Chem. Tech. Dept.)
J. R. Carrell (Manager - Nuclear Waste Projects)
B. W. Mercer (Research Associate - D & D Characterization)
C. H. Allen (Sr. Research Eng. - Equipment Development)
M. R. Kreitzer (Technical Leader - Nuclear Waste Management)
5. Atlantic Richfield Hanford Company (Richland, Washington)
H. H. Hopkins (Mgr. - Strategic Planning Dept.)
W. Van Slyke (Mgr. - Waste Processes and Storage Technology)
George BEitel (Sr. Physicist - Hanford Waste Eng.)
Dave Crawley (Process Engineer - Pu Production)
Ned Raile (Project Engineer - Facilities D & D)
Melvin Swett (Engineer - T Plant)

6. Lawrence Livermore Laboratory (Livermore, California)
 - Jim Olsen (Mgr. - Hazards Control and Plant Engineering)
 - Wade Patterson (Mgr. - Radiation Safety Div. in Hazards Control Div.)
 - John Balanda (Mgr. - Waste Disposal and Decontamination)
 - Virgil McIntosh (Bldg. Coordinator for Pu Metallurgy Bldg.)
 - Ron Hill (Mgr. - Technicians for Pu Metallurgy Bldg.)
 - James Loftis (Pu Metallurgy Bldg.)
7. Savannah River Plant (Aiken, S.C.)
 - T. B. Hindman (ERDA)
 - W. D. Conners (ERDA)
 - P. R. Moore (Mgr. - Canyons)
 - Art Messick (Liason - Facility Design)
8. Numec Div. of Babcock and Wilcox (Apollo, Pa.)
 - Dr. C. S. Caldwell (Mgr. - Engineer Dept.)
 - Dale Smay (FFTF Fuel Mfg. - Engr.)
 - Bill Ross (FFTF Fuel Mfg. - Engr.)
 - Ted Brewer (Health Physics - Engr.)
 - Chuck Woods (Project Mgr. - Pu Fuel Facility)
 - Bob Williams (Mgr. - Health and Safety)
9. Battelle Columbus (Columbus, Ohio)
 - Harley Toy (Staff)
 - Don McKown (Mgr. - Radiation Safety)
 - Don Kaiser (Mgr. - Pu Facility)
 - Dave Freas (Mgr. - Pu Laboratory)
 - Roger Ballard (Mgr. - Electronics, Physics, and Nuclear Tech. Dept.)
 - Mike Poberskin (Staff - Pu Laboratory)
 - George Kirsch (Health Physics)
 - Tom Emswiler (Adm. Ass't., Hot Laboratory)
10. Mound Laboratory (Miamisburg, Ohio)
 - Jack Stevens (ERDA)
 - Joe Garner (Staff-Health Physics)
 - Bernie Kokenge (Mgr.-Pu Processing)
 - Bill Harris (Mgr.-Facility Technology)
 - Bill Davis (Mgr.-Health Physics, SM&PP Areas)
 - Clayton Marsh (Mgr.-SM Building)
 - Sam Freeman (Chief Engineer-Design of PP Facility)
11. Argonne National Laboratory (Argonne, Illinois)
 - Bobby Davis (ERDA)
 - Hayden A. Flanger (Project Mgr.-ATSO)
 - W. H. Klein (Mgr.-Central Maintenance, Plant Operations)
 - Dr. M. J. Steindler (Staff-Chem. Eng. Div.)
 - B. Koprowski (Mechanical Engineer)
 - W. H. Livermash (Engineer Specialist)
 - L. R. Kelman (Sr. Metallurgist-Material Science Div.)
 - A. G. Hins (Metallurgist Eng.)
 - Sid Parker (Mgr.-Glove Box Removal, Decon. and Temp. Storage)
 - Norm Levitz (Chemical Engineer)
 - Tom Gerding (Engineering)

APPENDIX B

BRIEF SUMMARY OF CRITERIA

Interior Walls (May also apply to Exterior Walls, Ceilings, and Floors)

1. The surface of the walls should be smooth and flat.
2. The surface is easy to clean and decontaminate.
3. Contamination does not penetrate far into the surface.
4. Contamination which does penetrate the surface can be easily removed. This may require removing part of the surface.
5. No sandwich materials are used.
6. Repeated decontamination does not reduce the effectiveness of the surfaces for future decontamination; or, surfaces can be re-prepared to return them to original effectiveness.
7. The number of wall penetrations is minimized.
8. Penetrations through the walls are sealed around.
9. Penetrations into the walls are sealed around.
10. Walls with interior spaces are sealed.
11. The surface can be decontaminated to levels determined by final disposition criteria, or the walls can be easily disposed of.
12. The walls can be easily disposed of if they cannot be decontaminated to levels required for decommissioning.

Exterior Walls

Surfaces are easy to decontaminate or have removable liners.

Ceilings

Surfaces are easy to decontaminate, light fixtures are flush, and avoid false ceilings.

Floors

1. The surface is smooth but not slippery.
2. The edges of the floors where they meet the walls are easy to clean and decontaminate.
3. The floor should have drains in them and the floor should slope toward the drains.
4. Floor drains should be smooth and easy to decontaminate.
5. Curbs should be provided around all the floors.

Glove Boxes

1. Glove boxes should be sized for ease of disposal or rearrangement.
2. Glove boxes should be designed so that they are easy to separate.
3. Pipes, ducts, conduits, other attachments to the glove box should be easy to disconnect from the glove box.

Glove Box Materials

1. The box shall be designed for ease of decontamination inside and out.
2. Glove box windows shall be made of glass wherever possible.
3. Materials used in gloves shall be designed for long life.
4. Glove ports should be covered when the gloves are not in use.
5. Connecting areas between glove boxes should be minimized.
6. The size of glove box windows should be small as practical.
7. Glove box shielding should be designed so that it is easy to clean and decontaminate the surface which are exposed.
8. Glove boxes should have lighting fixtures which are flush with the top of the glove box and sealed.
9. Ventilation in the glove box should be of the down-draft type.
10. The glove box should have rounded edges.

11. The surface of glove boxes should be such that corrosion does not affect them.
12. The boxes shall be designed to minimize the effects of scraping, scratching, gouging, and damaging of the surface while in use.
13. Use of special self-contained enclosures within the glove box enclosures should be considered.

Conveyers and Conveyer Enclosures

1. Enclosed conveyers may be used to connect short glove box trains together.
2. Enclosed conveyers should be used to connect long glove-box trains to one another.
3. Conveyer enclosures should be separable into convenient size segments.
4. Conveyer systems should be connected to glove boxes in a manner for easy removal.

Ventilation

1. Ventilation shall be the primary means by which contamination spreading is minimized and controlled.
2. Intake filters on glove boxes shall include prefilters and HEPA filters.
3. The exhaust filters on glove boxes shall contain prefilters and HEPA filters.
4. The glove box will be provided with pressure regulation to prevent overpressurization inside.
5. Hot rooms or corridors shall have separate prefilters and HEPA filters both on the inlet supply air system and the outlet exhaust system.
6. Cold areas, such as offices, corridors, and cold laboratories, shall have prefilters and HEPA filters on the inlet air supply system. The exhaust air shall go directly to the large filter plenums.
7. Down-draft flow shall be used for all ventilation systems in the glove boxes, hot room areas, and cold room areas.

8. Pressure regulators shall be used between the glove boxes and the hot room areas and also between the hot and cold areas of the facility.
9. Special portable local ventilation systems shall be used near glove boxes during such operations as glove changes, bag-out or bag-in procedures, glove box entry, etc.
10. Special plastic enclosures will be used around the port or opening into a glove box when there is a high likelihood that contamination may escape from the box.
11. Exhaust ducts which may be hot should either be doubly enclosed by a second duct, or should have a secondary enclosure through which access to the primary duct is possible.
12. Air monitoring systems shall be provided in each area where radioactive material is handled.
13. The type of gas used for ventilation in each glove box shall be evaluated to determine its appropriateness for the type of operation used in that box.

Service Pipes

1. Service pipes for glove boxes shall go through the floor of glove boxes into the basement through sealed penetrations in the room floor.
2. Hot service pipes shall be contained in secondary enclosures.

Building Arrangements

1. The building shall be compartmentalized.
2. The building shall be divided into different floors.
3. The floor containing the glove box and operating labs shall be compartmentalized.
4. Areas within pressure zones shall be compartmentalized.
5. Airlocks shall be provided between the hot and cold areas, and between different pressure zones within the hot areas.
6. Basements shall have hot and cold areas and possibly maintenance corridors and access corridors.
7. Sufficient room shall be provided in the building arrangement for easy movement of glove boxes and equipment.

Compartment Arrangements

1. Compartments which are hot, or may possibly become hot, should be arranged such that they are as void as possible.
2. Room ventilation ducts should be minimized and easy to clean and clean around.
3. There shall be minimal protuberances from the walls, floors and ceilings.
4. There should be sufficient room in each compartment for moving gloveboxes and equipment.

Effluents and Wastes

1. The exhaust stack leading from the ventilation system shall be separable into small segments.
2. Pipes containing radioactive liquid wastes shall be as short as possible.
3. The liquid waste pipes and hold-up tanks shall be doubly encased.
4. Liquid waste hold-up tanks shall be designed for ease of decontamination and decommissioning.
5. Pipes carrying radioactive liquid waste to waste disposal facilities outside of the plutonium facility shall be easily accessible and doubly contained.

Special Rooms

1. Plutonium facilities shall have one or more decontamination rooms.
2. The plutonium facility shall have one or more rooms provided for size reduction.
3. Combustible wastes shall be reduced to a minimum by incineration or other methods.
4. The facility shall have the capability of size reduction of liquid disposable wastes.

APPENDIX C

D&D

REFERENCE DATA COLLECTION

- C1. References Applicable to Each Criterion
- C2. D&D Reference List
- C3. Summary Extractions from the References

C1. REFERENCES APPLICABLE TO EACH CRITERION

Interior Walls 1,7,27,42,47,50,53,59,61,66,69,71,78,85

1. Surface Finish 2,3,27,37,71,77
2. Decontamination 10,11,12,18,19,23,27,37,50,51,61,66,71,78
3. Contamination Penetration 3,11,18,27,71,78
4. Contaminated Section Removal 10,27,37,71,78,88
5. No Contamination Traps (Sandwich Structure, etc.) 27,50,66
6. Some Contaminated Surfaces Must be Repairable 3,28
7. Minimum Through Wall Penetrations 2,27
8. Sealable Through Wall Penetrations 2,27
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10. Sealed Interior Wall Spaces 27,66
11. Decontaminate Surfaces to Specified Levels 3,9,19,23,37,50,51,66
12. Minimum Size and Weight for Contaminated Sections 27,28

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2. Easy to Clean and Decontaminate 3,4,7,10,12,18,19,22,27,23,37,49,66,71,77,78
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2. Glass Windows with Sealed Flanges, Fireproof 45,27,61,68,71
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5. Minimum Interconnecting Boxes Properly Sealed 27,89
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8. Flush-top Lighting Fixtures can be Cleaned and Decontaminated 3,4,10,18,47
9. Down-draft Ventilation 47,71
10. Rounded Corner Box Design 47,71
11. Non-corrosion Materials 3,9,10,11,18,22,29,30,32,47
12. "Non-mar" Surfaces 18,32,37,
13. Self-contained Enclosures 27,28,47,50,61,66

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1. Short Glove Box Train Connectors for Material Transfer 47,51,71
2. Enclosed Long Conveyor Train Connectors 47,51,61,71,85
3. Separable Segment Size for Convenient Decommissioning 27,47,51,61,65,71,85
4. Removal and Rearrangement Parameters 6,27,47,51,61,71,78

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1. Contamination Control 7,19,23,27,38,51,55,59,62,71,77,83
2. Glove Box Pre- and HEPA Filters 38,59,62,71,72,83
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4. Glove Box Pressure Regulation 38,47,51,71,85
5. Separate Glove Box Room Filters 38,47,51,55,59,71,85
6. Filter Arrangement for Cold Areas (Plenums, etc.) 38,47,62,63,66,72,76,82,83,85
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9. Special Portable Systems 21,38,47,51,66,71
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11. Double Enclosures for Exhaust Ducts 38,47,49,51
12. Air Monitoring Systems 2,8,38,47,50,55,85
13. Glove Box Gas Ventilation 27,38,47,50,51,71,85

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3. Compartmentalized Glove Box Labs 27,71
4. Pressure Zone Area Compartmentalization 27,71,85
5. Air Lock Locations 38,59,71
6. Basement Arrangement 58,71
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2. Double Encased Pipes and Holdup Tanks 5,18
3. Design for D&D Ease 1,2,9,18,28,46,57,71
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2. Waste Transportation 57,71,73
3. Disposable Waste Containers 57,70,71,73
4. Cargo Containers 57,79,71
5. Treatment 58,71,73
6. Decontamination 58,71,73

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2. Size Reduction - Solid Wastes 1,2,25,30,39,42,46,48,50,52,65,68,69,71,73,77
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4. Size Reduction - Liquid Wastes 1,2,39,46,48,52,56,65,68,69,77
5. Scrap Recovery 71,73

C2. D&D REFERENCE LIST

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C3. SUMMARY EXTRACTIONS FROM THE REFERENCES

REFERENCE 1 - WASH-1209 - Potential Radiation Implications of Nuclear Facilities in the Upper Mississippi River Basin in the Year 2000 (1973)

Division of Reactor Development and Technology (AEC)

The increasing commitment by the utility industry to the use of nuclear reactors for the generation of electrical power in the United States clearly indicates that nuclear power has become a principal option for helping to satisfy the national need for a clean, safe, and reliable energy supply. There are many factors that may be associated with the selection of any of the clean energy options for widespread use. These factors can best be assessed through the cooperative efforts of those involved in planning for the use of energy in this country. To this end, the Atomic Energy Commission (AEC) has had underway a number of inter-related and interdependent studies that consider the environmental effects and implications of the use of civilian nuclear power plants and the associated manufacturing, shipping, reprocessing, and waste disposal activities. These studies also include examination of alternatives to nuclear power, the economics of introducing nuclear power in various combinations with other proven types of power plants, and provide an assessment of the environmental implications of these mixed economies.

Among its many objectives, this study is intended to provide information that may be used to:

Inform involved organizations and the public of the potential radiological impact of widespread application of nuclear energy for the generation of electricity;

Guide the AEC and the nuclear power industry in planning research and development programs to reduce further the already low levels of radioactive waste emissions;

Assist in the further development of design criteria and regulatory standards related to radioactive waste and emissions;

Aid in evaluating the effects of potential improvements in waste treatment and engineering technology;

Guide the nuclear industry and other agencies and organizations, such as the Environmental Protection Agency (EPA), the Office of Science and Technology (OST), the Federal Power Commission (FPC), and state agencies concerned with the environmental aspects of the electric power industry in planning for new nuclear facilities; and

Provide improved understanding of the contributions of specific radionuclides to radiation potentially received by the population.

REFERENCE 2 LA-5645 Guidelines for Interim Storage of AEC-Generated Solid Transuranic Wastes (1974)

ABSTRACT

Guidelines have been developed to provide a basis against which to judge the adequacy of techniques and methods for the retrievable storage of AEC-generated transuranic-contaminated solid wastes. These guidelines apply to operations for packaging, handling, and storage of such wastes. Each guideline has been fully discussed with emphasis on the reasoning behind the guideline statement, problems that should be considered in developing a storage facility, and methods currently in use at AEC installations.

The Directive acknowledged the need for instrumentation development to improve the lower limits of detection for plutonium compatible with the Directive requirements. The AEC Manual, Chapter 0511 (AECM 0511), dated September 19, 1973, uses a lower limit for retrievable storage of ten nanocuries per gram (10 nCi/g) (see Appendix B).

While IAD 0511-21 refers to earth burial of the wastes, implying the package should be designed to meet the conditions encountered in earth burial, AECM 0511 refers to storage of the wastes. The word "storage" is defined as "retention of radioactive waste in some type of man-made device, such as a tank or vault, in a manner permitting retrieval."

In implementation of the IAD, it became apparent that burial of wastes in the commonly used mild-steel drums would not meet the objective of recovery in 20 years due to accelerated corrosion of the drum. As a result, various storage methods have been developed or proposed to keep the packages out of contact with the soil. These include the asphalt pad at the Atlantic Richfield Hanford Company (ARHCO), the Ideal Transuranic Storage Area (ITSA) pad at the National Reactor Testing Station (NRTS), the asphalt-lined pit at the Los Alamos Scientific Laboratory (LASL), and the culverts at Savannah River. In each of these designs, the packages are isolated from direct contact with the soil and are surrounded by air, although the design in each case requires covering the facility with a layer of soil. In essence, this type of facility is a storage warehouse.

REFERENCE 3.

CORROSION

Official Publication

NATIONAL ASSOCIATION

OF

CORROSION ENGINEERS

VOLUME 18

January through December

1962

Editorial and Business Offices

1061 M&M Building, Houston 2, Texas

REFERENCE 4 - LADC-5775 - Recirculating Wet Vacuum Clean and Scrub for
Decontamination - Los Alamos Scientific Lab

A recirculating vacuum cleaning and scrubbing system was devised for decontamination of the interior of alpha sealed boxes. The specific application is to reduce the beta-gamma activity in the shielded glove boxes within the DP West Plutonium Hot Cells in Los Alamos to a tolerable level for direct maintenance of experimental apparatus. This imposes a further requirement of remote operation of the system.

Main advantages of the system are: (1) recirculation of the decontamination solution, keeping total volumes small, (2) ability to use hot solutions and keep them hot, (3) a vacuum cleaning action which removes small particulate matter, (4) impingement action of the solution and scrubbing action of the brush which helps to loosen and float particulate contaminants into the vacuum pickup, and (5) the system can be remotely introduced and removed without disturbing the alpha containment box.

REFERENCE 5 - WAPD-299 - Decontamination of the Shippingport Atomic Power
Station, Edited by C. S. Abrams and E. A. Salterelli
(January 1966)

The Shippingport Atomic Power Station was decontaminated in conjunction with a modification program on the plant. The primary objective of the decontamination was to reduce radiation levels which had built up during the 67 months of operation. Decontamination was initiated on February 29, 1964, and completed on March 14, 1964. No major problems were encountered. Surveys taken before and after decontamination indicate that the decontamination was a success. The reduction of radiation levels permitted the modification program to be completed without any delays due to radiation exposure.

REFERENCE 6 - ORNL-TM-3253 - MSRE Procedures for the Period Between
Examination and Ultimate Disposal (Phase III of Decom-
missioning Program) by R. H. Guymon (February 10, 1971)

ABSTRACT

This document describes the condition of the MSRE and specifies procedures to be followed after the post-operation examinations and before the ultimate disposal of the fissile and radioactive material in the reactor. The fuel salt will be kept frozen in the sealed drain tanks, within secondary containment whose only opening is through filters to a stack. Surveillance will consist of remote monitoring and daily visits by X-10 plant personnel. Personnel access will be controlled by the security fence around the reactor building. The MSRE Procedures specify remedial actions for abnormal conditions. Also specified are procedures and responsibilities for maintenance, modifications, and removal of surplus equipment.

Keywords: molten-salt reactors, MSRE, procedures, storage, surveillance, administration, containment, flowsheets, maintenance, operations, ORNL, plans, testing.

REFERENCE 7 - BNL-7665 - Decontamination Methods Equipment and Materials - Appendix - Summary (1964)

Decontamination Procedures and Methods

If one is faced with the problem of decontamination, it is well to consider all factors before attempting the operation. He must answer the following questions:

- 1) What is the probability of success? If the surfaces are wood, concrete, or other rough porous materials, it is usually very difficult to clean them completely. It may be wise to dispose of it rather than clean it.
- 2) What are the economics involved? In some cases, it may be more expensive to clean it rather than to replace it and pay for the disposal of the contaminated equipment.
- 3) What are the risks involved? The radiation levels and airborne problems may be such that conventional means are not adequate. If the first part of the work requires remote handling equipment and such equipment is not available, the material will have to be stored safely or disposed of.

REFERENCE 8 - ORNL-TM-1309 - Fire Protection System in Cell A, Building 3026D, Test and Operation, by A. A. Walls (1965)

1. ABSTRACT

A CO₂ fire protection system was installed in Cell A of the Dismantling Cells, Building 3026D, in preparation for the disassembly of irradiated Sodium Reactor Experiment (SRE) fuel elements. The tests and modifications of the system which were necessary before it was acceptable for operation are described. The SRE elements contained NaK, and several steps of the disassembly were performed under flammable oil. One major fire did occur but the protection system performed without fault and quickly extinguished the fire. The system has been relatively free of maintenance and appears practical from an operating standpoint. Its use continues in work involving flammables.

REFERENCE 9 - BNW-SA-636 - Plutonium Recycle Test Reactor Decontamination
Following a MgO-PuO₂ Fuel Element Failure (1966)

INTRODUCTION

The Plutonium Recycle Test Reactor (PRTR) is a pressure tube, heavy water-cooled research reactor located at Hanford. It is rated at 70 Mwt. The PRTR is used to evaluate the plutonium recycle concept. During this evaluation, an experimental MgO-PuO₂ fuel element ruptured on August 21, 1962, resulting in very high radiation fields and gross contamination of the primary system. This necessitated the decontamination of the PRTR.

The decontamination of the PRTR presented unusual problems. The primary system used 3,500 gallons of heavy water as a coolant. Economics dictated that it be salvaged if possible. Although the PRTR is generally considered as being a stainless steel reactor, several different materials are actually a part of the primary system. The in-reactor tubes are composed of Zircaloy-2, the main loop piping is of AISI 304 stainless steel, and the helium pressurization system is of carbon steel. Several other alloys such as Stellite Alloy No. 6 and 400 Series stainless steels are used as valve facing materials, valve stems, etc. The use of these many different materials made the process more involved. This meant that there was a fine balance between corrosion protection of the system and effective removal of rupture debris and absorbed fission products. This paper describes the procedures and results of the PRTR decontamination.

SUMMARY AND CONCLUSIONS

The rupture of an experimental MgO-PuO₂ fuel element in the PRTR resulted in high radiation fields, necessitating chemical decontamination. In a 3½ month period of time, the PRTR fuel elements were discharged and cleaned in an ultrasonic bath, the heavy water primary coolant was cleaned, drained, and stored, a chemical addition system was installed, and the reactor was decontaminated, inspected, tested, filled with D₂O, and recharged with cleaned fuel elements. The chemical decontamination was successfully completed in 10 days. Decontamination factors ranged from 2.2 to 15.0. This reduction in activity has permitted ready access and maintenance of equipment. The levels following decontamination were, in fact, significantly lower than those encountered prior to the rupture. The reactor has operated since the decontamination for over 34 months without any adverse effects from this cleaning operation.

REFERENCE 10 - BNWL-7111 - Decontamination of the Plutonium Recycle Test Reactor (PRTR) Primary System, by Ronald D. Reed, Battelle Northwest Laboratory, Richland, Washington (1968)

ABSTRACT

The Plutonium Recycle Test Reactor primary system was successfully decontaminated in late December 1965. An improved decontamination process

consisting of alkaline permanganate followed by an inhibited oxalic-citrate mixture was used. The decontaminating solutions effectively removed more than 31 Ci of radioactivity with an effective primary system decontamination factor of 24. Corrosion of carbon steel and stainless steels during the decontamination process and development data for the decontamination process are discussed.

CONCLUSIONS

The following conclusions about the decontamination and the procedure were drawn:

More than 31 Ci of beta-gamma activity were removed from the system.

The 304 SS system was corroded less than 0.01 mil; the 440-C alloy (injection pump plungers) was corroded about 0.4 mil during the decontamination.

RDW-3 solution in contact with the primary system piping approached an equilibrium state in solution activity and would not have increased the decontamination effectiveness appreciably if circulated longer.

A second treatment with RDW-3 solution probably would have reduced activity levels in the primary system to a range of from 5 to 10 mR/hr vs 20 to 30 mR/hr.

The decontamination process and procedure used at PRTR can be recommended for stainless steel reactor systems.

REFERENCE 11 - HW-71259 - An Intensive Decontamination Program at Hanford Atomic Products Operation (1961)

To determine the effectiveness of prospective processes for decontamination, two distinct types of contamination are encountered in nuclear reactors: fission and rupture products from ruptured fuel elements, and activated corrosion product films on the piping surfaces.

The general decontamination procedure involves an oxidizing solution for fission and rupture product dissolution, an alkaline-permanganate solution for film conditioning, and an acidic solution for film removal. Several variations of this general procedure are being evaluated for application in specific situations.

REFERENCE 12 - HW-64154 - 100N Decontamination Facility Design Guide (1960)

The concepts of the decontamination processes are under active development by research groups at Hanford. Presently, there are several workable processes known; each one has one or more fairly serious drawbacks.

It is believed, however, that the general outline of the processes are similar enough that a chemical handling facility may now be designed which will be capable of applying whatever process is ultimately chosen to decontaminate the NPR primary loop. This document presents the concepts and data to make design of the facility possible.

Kinds of Decontamination

- 1) Minor personnel decontamination, laboratory spills, etc. Routine established procedures available.
- 2) Decontamination of external surfaces of piping and equipment walls, floors, walkways, etc. Semi-routine nature and will be taken care of by Standard Operating Procedures and/or special procedures developed as required. A small storage space may be required for special chemicals and equipment.
- 3) Small parts contamination. Two facilities are being provided in the building for the purpose of decontaminating tools, valves, dummy fuel elements, tube caps, etc. These facilities will not affect the 122N Facility except for requiring small storage space for chemicals.
- 4) Single pass reactor decontamination. This type of decontamination will require facilities at 122N.
 - During normal reactor operation, a high temperature corrosion film will be deposited on the walls of the system. This film will contain radioactive corrosion products in sufficient quantities to cause significant radiation levels (on the order of 10 to 100 mr/hr) near the primary piping.

REFERENCE 13 - TID-3311 (Supplement 4) - Radioactive Waste Processing and Disposal, Prepared for Division of Waste Management and Transportation (January 1973)

INTRODUCTION

The 464 references cited in this bibliography supplement reports TID-3311, TID-3311 (Supplement 1), TID-3311 (Supplement 2), and TID-3311 (Supplement 3). The references were selected from NUCLEAR SCIENCE ABSTRACTS (NSA), Vol. 26 (1972) by the RESPONSA computerized search technique.

REFERENCE 14 - TID-3312 - Chemistry - Separation Processes for Plutonium and Uranium

Reprocessing of Irradiated Fission Reactor Fuel and Breeding Materials - An Annotated Bibliography of Selected Report Literature, by James M. Jacobs (November 1958)

ABSTRACT

A total of 713 annotated references to the unclassified report literature is presented. Subject, author, and report number and availability indexes are included.

This bibliography was prepared primarily as a guide to those interested in developing commercial processes for the reprocessing of irradiated fission reactor and fuel blanket materials. The scope of this bibliography has been limited to those reports concerned with the problems encountered in reprocessing plants. Corrosion, heat transfer, fluid flow, instrumentation, etc., are dealt with only in relation to this field. Waste disposal problems which are the direct concern of the reprocessing plant, such as stack gas disposal, immediate concentration of effluent waste streams, and short-term storage of waste are covered here. Waste disposal as a whole is considered to be outside the scope of this compilation.

This bibliography contains 713 selected annotated references to UNCLASSIFIED reports in the files of the Technical Information Service Extension (TISE) on November 20, 1958.

REFERENCE 15 - TID-3340 - Radioactive Waste Management - A Bibliography of Publicly Available Literature Pertaining to the USAEC's Hanford, Washington Production Site - USAEC Technical Information Center, Oak Ridge, Tennessee (August 1973)

FOREWORD

This bibliography contains abstracts of 1098 technical reports and journal articles which have appeared in NUCLEAR SCIENCE ABSTRACTS from January 1951 through July 1973, pertaining to radioactive waste management at the Hanford site.

REFERENCE 16 - TID-3344 - Decommissioning of Nuclear Facilities - A Bibliography - USAEC (1974)

Volume 29 (1974)

1984 (CONF-731105-2) Remotely Operated Plasma Torch: A Tool for Nuclear Reactor Dismantling.

Beckers, R. M.; Blumberg, R.; Wodtke, C. H. (Oak Ridge National Lab., Tenn. (USA)). 1973. 28 p. Dept. NTIS \$3.50.

From winter meeting of American Society of Mechanical Engineers; Detroit, Michigan, USA (11 November 1973).

The Elk River Reactor facility is being dismantled in order to return the site to unrestricted use. The highly radioactive components - the reactor internals, the pressure vessel, and the outer thermal shield - have been cut up and shipped to a burial ground. Approximately 10,000 Ci of radioactive metal was removed without significant release of activity and without any overexposure to personnel. The dismantling was accomplished with a remotely operated plasma torch system. The design of the system, the results obtained, and evaluation of this technology are given. (6 references) (auth)

6844 Dismantling of the Elk River Boiling Water Reactor. Manion, W. J. (Gulf United Nuclear Fuels Corp., Elmsford, N.Y.); Jones, J. W.; Pulliam, R. W. Conf. Remote Syst. Technol., Proc.; No. 21, 91-103 (1973).

From 21st conference on remote systems technology; San Francisco, California, USA (11 November 1973). See CONF-731111-.

Dismantling of the Elk River requires the extensive use of remotely operated tooling. This tooling includes mechanical and flame cutting equipment. The flame cutting method selected for the work is the plasma arc technique which permits single-pass cutting of metal up to three inches thick. Because of high radiation levels, positioning and translation of the torch over the work is done automatically. Plasma cutting will be performed underwater and in-air. In-air cutting of radioactive components will require contamination control by means of an enclosure or envelope which is exhausted through high efficiency filters by a high capacity blower. (auth)

REFERENCE 17 - TID-19108 - Material Decontamination at Nevada Test Site (1960)

Introduction: A decontamination evaluation program was conducted to determine the most practical and economical methods for removing radioactive contaminants from skin, clothing, masks, metals, and miscellaneous equipment at the Nevada Test Site (NTS). Due to the lapse in time since a general operation at NTS, most of the test material was artificially contaminated with weapon test debris to simulate actual field conditions.

Equipment used:

- A. Steam Cleaner
- B. Ultrasonic Generator
- C. Industrial Vacuum Cleaner
- D. Industrial Vacuum Cleaner
- E. Portable Sandblaster
- F. Two Dip-Soak Tanks

Conclusions and Recommendations:

- 3) The painting of tools and equipment which are to be used in contaminated areas would facilitate decontamination. If the

contamination were "fixed" to the extent where harsh methods of decontamination would be necessary, the use of Krylon paint or a similar type spray paint would facilitate decontamination by being easily removed with either Strypeeze paint remover or concentrated solution of METSO-99. In most cases, the contamination would be removed with the paint in this manner. Immediate repainting would not only cover and contain the remaining contamination, but it would also protect the equipment for future reuse in any contaminated area.

REFERENCE 18 - ORNL-3589 - Gamma Radiation Damage and Decontamination Evaluation of Protective Coatings and Other Materials for Hot Laboratory and Fuel Processing Facilities, by G. A. West and C. D. Watson (1965)

ABSTRACT

Protective coatings and other plastic materials were evaluated by irradiation in a gamma source and by decontamination tests as an extension of previous tests and for possible use in hot laboratories and fuel processing facilities and other process environs at Oak Ridge National Laboratory. Materials used may be subjected to gamma exposures of 10^4 to 10^5 r/hr and neutron exposures of 4.2×10^4 to 2.1×10^5 neutrons/cm²/sec.

Epoxy, modified phenolic, and inorganic zinc protective coatings were superior to the other generic types tested in radiation environments. Exposure to radiation in the presence of water decreases the serviceable life of organic coatings about 50%. For example, the best coating, epoxy, was found to be serviceable in water exposure up to about 5×10^4 r and in air, surprisingly, up to 1×10^5 r. Vinyls and glossy epoxies were superior to the other coatings in decontaminability.

Among a group of miscellaneous material tested, a nonmetallic plastic heat transfer compound was unaffected at 1×10^5 r exposure in air.

REFERENCE 19 - LA-1530 - Routine Decontamination Procedures for Formulas for Plutonium Contamination, by Earl J. Cox and Robert F. Barker, H&S (1953)

Report consists of a list of methods, equipment, and formulas which have been used routinely in removal of plutonium contamination. The methods include manual cleaning, mechanical agitation, degreasing, and blast cleaning. Formulas are given for general cleaners and for cleaners for some metals, skin, cloth, floors, or rubber pictures of the laboratory layout and some of the procedures and equipment are included.

The following material is an accumulation of ideas from many sources; all ideas, however, have been tried on numerous occasions and have proved

successful in some applications. In this type of work, each item to be decontaminated presents in itself, a different problem. No "cut and dried" rules can be established, therefore, the procedures and formulas listed herein are in general and should be looked up as guides rather than rules.

REFERENCE 20 - ORNL-2989 - Pu Release Incident of November 20, 1959 (1961)

Plutonium was released from the processing cell, probably as an aerosol of fine particles of plutonium oxide via three principal routes:

- 1) Cell ventilation system: 1.5g completely removed from the air stream by roughing the absolute filters
- 2) Cell 6 door, blown open (but not off) to the outside: 600 mg spread rapidly over limited area south and east of the building; Graphite Reactor Building was most contaminated.
- 3) Pipe passages and service openings from cell 6 to the interior Building 3019: 70 mg; required decontamination over several months.

Area and Building Decontamination

All facilities were useable on November 23, 1959, two days after release except for the Pilot Plant portion of Building 3019 and Graphite Reactor Building. Operation resumed December 22, 1959, following thorough decontamination.

REFERENCE 21 - GAMD-2657 - Decontamination Studies at General Atomic (1961)

The decontamination studies at General Atomic are directed toward developing methods for cleanup of gas-cooled reactor components, particularly those of high-temperature gas-cooled reactor (HTGR). Recent work has involved: decontamination tests using G.A. in-pile loop helium circulator parts, removal of nonradioactive oxide films from metals, and installation and testing of a decontamination test chamber.

REFERENCE 22 - TID-11396 - Effects of Turco Decontamination Agents on Stainless Steel, etc. (1960)

The contamination chemicals discolored and etched the 440 SS specimens $1\frac{1}{2}$ - $2\frac{1}{2}$ mils of thickness removal after subsection to six complete decontamination cycles.

Chemicals

240-250° . . . 1) Turco Decon 4501A

70° . . . 2) H₂O Rinse

190-200° . . . 3) Turco Decon 4502

Times

4) H₂O Rinse @ 70°F Decon. - 45 minutes

5) Turco Decon 4518 H₂O - 15 minutes
@ 190-200°F

6) H₂O Rinse @ 70°F

REFERENCE 23 - CRRIS-1071 - Special Equipment for Decontamination and Containment of Radiation Hazards at Chalk River (1962)

Describes some items of decontamination and monitoring equipment developed by the Radiation Hazards Control Blamelent Chalk River, the reasons for their construction, and the shape or form of the items. Operational performance is discussed.

- Mobile air exhaust units
- Mobile air sampler
- Mobile change room trailer
- Shielded settling box and shielded high efficiency filter
- Steam detergent decontamination gun
- Mobile, remote controlled, radiation monitor
- Inflatable tent

Operation experience has strongly influenced the development of equipment; attempts to restrain simplicity, versatility, and mobility of each unit.

Inflatable tent has been successfully used for decontamination of shipping flasks before transport from contaminated areas.

REFERENCE 24 - CF-60-6-54 - Pu Effects of Decontamination of Various Stainless Steel Suffite Finishes (1960)

Comparison data concerning SS platon sheet for use as lining in shielded cells. An investigation was made to obtain information concerning surface finish specifications, prices, and decontamination properties of 1/4" thick plate with #1 finish, 1/3" gage sheets with 2B finish, finishes vary considerably depending on production conditions.

R&C - The average overall decontamination factors for each of the three thicknesses of test specimens indicate that 2B finishes on the 1/8-inch thickness is better than No. 1 finish on 1/4-inch plate by a factor of 4. The No. 1 finish on 3/16-inch sheet is better than the No. 1 finish on 1/4-inch plate by a factor of 3.

Decontamination factors decrease when the contact time between the fission product solution and the stainless steel surfaces is increased.

REFERENCE 25 - CF-61-7-82 - Minutes of 3rd Meeting of Reactor Decontamination Information Exchange Group at ORNL (1961)

- 1) Decontamination of low temperature reactors (methods of processing liquid waste)
- 2) Decontamination of high temperature reactors (methods of processing liquid waste)
- 3) Decontamination of sm-1 steam generator
- 4) Decontamination waste disposal studies

Decontamination and Waste Disposal Studies

Methods of processing PWR liquid wastes to the environment at or below Mpe levels studied at Alco.

Work on disposal methods of spent decontamination solution wastes; lab studies of processing by chemicals precipitation and ion exchange. Goal to reduce activity to 1×10^{-7} mc/ml or less.

Liquid waste prepared by decontaminating SS tubing that has been exposed to the sm-1 primary system.

REFERENCE 26 - CF-60-9-57 - Pu Release Incidents at ORNL (1960)

A nonnuclear explosion involving an evaporator occurred in a shielded cell in the Radiochemical Processing Pilot Plant at Oak Ridge National Laboratory. Plutonium released from the processing cell contaminated areas in the Pilot Plant building and nearby sheets and building surfaces. The explosion is considered the result of rapid reaction of nitrated organic compounds formed by an inadvertent nitration of about 14 liters of a proprietary decontaminating reagent.

In cleanup, the contamination was bonded to the nearby street and building surfaces with tar, paint, roofing compound, or masonry sealer as appropriate to the surface. Decontamination of the interior of the Pilot Plant building, except the processing cells, was 95% complete on September 1, 1964.

Following criteria established subsequent incident applicable to radiochemical pilot plants, "hot" labs, and experimental setups, as well as ORNL reactors:

- 1) The maximum credible accident must be contained or confined to the degree necessary to preclude discharge into the laboratory area and its environment of concentrations or amounts of radioactive materials which are injurious to health or which will interfere with other laboratory programs.
- 2) Two lines of defense must be present to prevent the escape of radioactive materials from laboratory operations via waste streams. These criteria apply not only to future operations, but also to those in existence. A formal hazards report is required for those operations involving 1g of plutonium (or equivalent of other alpha emitters or isotopes of comparable hazards) or 1000 curies of beta and gamma emitters. The report will be submitted to the appropriate ORNL Review Committee and must be approved by the Committee and ORNL Management prior to initiation or resumption of operation.

REFERENCE 27 - AHSB-SR-32 - Principles and Recommended Practice for Decontamination of Radioactive Areas and Equipment (1961)

This report defines principles of design and operation which, if followed, will reduce contamination and help make decontamination procedures effective.

The report is concerned mainly with the principles and practice of decontamination both for routine work and for accidental spills.

Conclusions

Eliminating the need for decontamination should be the first objective of good design. Means to control the spread of activity should be "built-in" attention to details during design can materially reduce the risk of contamination and reduce decontamination costs and difficulties following an unforeseen incident.

The basis for decontamination procedure is essentially simple, differing only in degree from conventional cleaning. The normal process of cleaning an article is primarily concerned with removing visible dirt and soil to a level which is acceptable aesthetically and hygienically; unseen trace contamination is usually not important. Removal of radioactive toxins must be continued until these last traces are dislodged. To remove them will often require more vigorous processes with reagents tailored to the physical and chemical characteristics of particular isotopes.

Radioactive decontamination operations are complicated by the need to protect those who perform them. The greater hazards arise when decontamination equipment to which fine power adheres; e.g., the insides of

glove boxes previously used for grinding and machining the toxic metals such as plutonium. Inhalation of the dusts and bodily contamination by them must be impossible. Pressurized suit facilities will often be required. At the other extreme, removal of natural uranium contamination can be performed in open sinks with little more than gloves to prevent contact with the skin.

The cost of decontamination will invariably be greater than normal cleaning because of its greater complexity and the need to protect employees. The necessity for routine decontamination operations must be decided on a balance of cost between cleaning and disposal. The provision of facilities for routine decontamination is an essential feature of good design if costs are to be minimized.

Success with decontamination operations will depend upon a correct choice of reagent. Suitable reagents have been developed for decontamination surfaces which do not respond to conventional cleaning materials. A carefully prepared and diligently executed technique will greatly improve the speed and measure of success.

REFERENCE 28 - AECL-1531 - Decontamination of Buildings and Equipment, by J. Neil and A. M. Marko, 1962, L/C 70 (1962)

Summary - Description of the facilities of Chalk River for Decontamination of buildings and equipment and discusses briefly some special equipment developed to do the work.

REFERENCE 29 - DP-737 - Dissolving Pu Metal Sulfamic Acid, by William J. Jenkins (July 1962)

Summary

Plutonium metal dissolves readily in sulfamic acid and in mixtures of sulfamic acid and nitric acid. The dissolution can be performed without severe corrosion of stainless steel equipment.

The dissolution of plutonium in sulfamic acid is rapid and proceeds to complete utilization of the hydrogenion. The dissolution is best carried out at room temperature and in the absence of nitric acid or other oxidizing agents. At higher temperatures in the presence of nitric acid, the sulfamic acid is decomposed by a side reaction and the excess sulfate acid is decomposed by a side reaction, and the excess sulfate causes a sludge to form in the solution. When 1.7M sulfamic acid was used as the dissolvent at solution temperatures below 40 C, plutonium concentrations as high as 134 grams per liter were obtained with very little sludge formation.

REFERENCE 30 - DT ST-62-162 - Minutes of 4th Meeting of Reactor
Decontamination Information Exchange Group at SRP,
November 30 - December 1, 1961

It was agreed that the group should discuss items associated with decontamination such as disposal of spent decontaminants, cost, crud transport, and redistribution. However, such discussions should be limited.

Summaries by each member presented and attached.

AECL

Decontamination of the X-4 loop
Solutions, etc.
Decontamination of X-6 loop

ALCO products

Engineering for decontamination of the sm-1 steam generator
Decontamination waste disposal studies
Construction and testing of liquid waste disposal skid
Provisions for evaporation, desludging, and ion exchange treatment of wastes

ANL Report

Expected BWR contaminants and decontamination

GA Report

Cleanup of gas-cooled reactor
Decontamination of Gail Helium circulators
Rust found - Turco 4512 used
Removal of metal oxide films from CS and SS, Tungsten, Magnesium, and Aluminum
Decontamination test chamber

HAPO Report

Dissolution of uranium oxides
Ammonium acid citrate evaluations (chemical used)
Corrosion of Haynes Stellite in alkaline permanganate
Alkaline permanganate rinse aid
Evaluation of inhibited sodium bisulfate
Redisposition work
Decontamination of low temperature water-cooled reactors

ORNL Report

Development of oxalate peroxide mixtures

VAL Report - S. Siegel

BWR system decontamination
Carbon steel loop decontamination
Superheat systems decontamination
Single solution decontamination treatment of nuclear reactor systems (steel carbon 410 SS, etc.)

SRL Report - A. B. Carlson

SRP heat exchanger decontamination

Decontamination of pump line specimens by two step APAC process

Decontamination of heat exchanger core rod and tubing by multi-treatments with various reagents
acids

REFERENCE 31 - ORNL-3100 - Decontamination Cells 6 and 7, Building 3019, Following Plutonium-Release Incident, by J. R. Parrott (1961)

Summary Abs.

As a result of the evaporation explosion in the radiochemical processing pilot plant on November 20, 1959, two cells were contaminated with plutonium to a transferable level 108 d/n/100 sq cm. The area involved measures 40x20x27 ft high with a total surface area, including equipment, debris, and shielding blocks and flushing with 43,600 liters of various decontaminating reagents. The remaining contamination (10^4 - 10^5 d/m/100 sq cm) was fixed to the surface with three coats of paint. The general beta-gamma radiation background was decreased from 2,000 to 30 mr/hr and the long-lived alpha contamination in the air was reduced from 2×10^{-10} to 8×10^{-13} mc/cc. Approximately 141 g of plutonium was flushed from the cell surfaces. The total direct effort expended was 3,000 manhours including 250 entries into the cell, 175 of which were made in plastic air suits. There were no overexposures from beta-gamma radiation and no detectable increase in body burden of plutonium of any individual involved.

REFERENCE 32 - ORNL-2811 - Decontamination Testing of Highly Contaminated Porous Castings (1960)

Measurement (0) of 34 protective coatings (primary vinyls and epoxies) and 10 comparative control surfaces (metals, glass, and plastics) highly contaminated with mixed fission products, from typical purex waste or ORNL thorex waste did not indicate any unusual improvement over coatings listed in 1950.

REFERENCE 33 - TID-7599 - Proceedings of the 8th Conference on Hot Laboratories and Equipment, San Francisco, California, December 13-15, 1960, ANS (1960)

1. The Design and Construction of the Site 401 Disassembly Facility, William H. Moran, Lawrence Radiation Laboratory, UC, Livermore, California

2. A Study in the Construction of a Cell Assembly for the Semi-Industrial Treatment of Irradiated Fuels (motion picture, not a paper), Commissaria al Energie Atomique, France
3. Session VI, Glovebox Design and Specialized Equipment, Modification and Repair of the HRE-2 Core Vessel, E. C. Hise, Oak Ridge National Laboratory, Oak Ridge, Tennessee
4. Low Cost Glove Boxes, R. F. Malecha, H. O. Smith, J. H. Schraidt, J. V. Natale, N. E. Ross, H. O. Brown, Jr., Argonne National Laboratory, Argonne, Illinois
5. Atmosphere Handling and Control for a Glove Box Facility, L. F. Coleman, J. H. Schraidt, R. L. Breyne, J. V. Natale, Argonne National Laboratory, Argonne, Illinois
6. Pressure Regulation in Activity Enclosure, J. Stafford Peck, LRL, University of California
7. New Hot Cells and Hot Laboratories, Y. Duvaux, M. Jacquemin, A. Junca, and E. Derobien, Commissariat al Energie Atomique, France
8. Cell Location - General Description

REFERENCE 34 - NAA-SR-8314 - Ammonia Cleaning of a Sodium Heat Exchanger at the Hallam Nuclear Power Facility, by R. L. Robb (Consumers Public Power District) (1963)

ABSTRACT

This project was initiated to clean a sodium-to-sodium shell and tube heat exchanger. The object was to remove any metallic sodium remaining after the heat exchanger was removed from the heat transfer system. Internal cleaning was necessary to allow opening of the heat exchanger to atmosphere for investigation and subsequent repair work required as the result of a tube failure in the exchanger.

REFERENCE 35 - GEAP-3372 - Vallecitos Boiling Water Reactor Decontamination Program, by D. W. Danielson and M. L. Brewer (1960)

Introduction Abs.

A test program was carried out to determine the corrosion effects and decontamination efficiency of selected decontamination solutions for use in the VBWR System. System decontamination plans were prepared but cancelled in favor of local decontamination with a power wire brush. The VBWR contamination levels were not as high nor as troublesome as anticipated so the use of any of the currently recognized system decontamination treatments, effective or not, could not be justified in terms of overall cost saving.

REFERENCE 36 - TID-15779 - Contamination and Decontamination Studies
Related to Boiling Water Reactors (1962)

Compares BWR with PWR's, etc.

The following facts were deduced:

- 1) The most significant fission products released were fission product gases.
- 2) Fission products which had no fission gas as a precursor, such as radioiodines or MO^{99} were not released from the fuel to a significant extent.
- 3) The most significant activities found in the turbine and condenser after operation were some Ba-La¹⁴⁰, Sr-y⁹⁰, Sa⁸⁹, and Cs¹³⁷. These are all decay products from short-lived fission product gases.

Introduction: Where direct maintenance of nuclear energy facilities is practiced, techniques must be available for readily decontaminating such facilities should the need arise. Such decontamination techniques have been considered for solvent extraction recovery plants.

REFERENCE 37 - WAPD-PWR-Cp-3052 - Decontamination of Structural Materials and Surface Coatings (1957)

An investigation has been made of the comparative characteristics of structural materials and surface coatings, such as might be exposed on the walls and floors of the Shippingport PWR reactor plant, in regard to the retentivity of their surfaces for fission product activity and the ease with which their surfaces might be cleaned of activity by ordinary janitorial procedures. Fifteen common building materials and six commercial surface coatings were evaluated under standardized, reproducible conditions that permitted valid comparison of the characteristics in question. Reproducibility of the cleaning procedure was attained by designing a mechanical washing apparatus which permitted cleaning the activity-contaminated surfaces under rigorously invariant conditions. Physical properties such as strength, wear resistance, resistance to fracture, etc., and chemical resistance were not evaluated.

Specific data on the cleanup properties of the materials have been obtained and tabulated. In general, structural materials such as masonite or plywood coated with amercoat, silicone resin varnish, or even with enamel paint have favorable characteristics superior to stainless steel, in being easily cleaned of fission product activities by custodial procedures. Bare cement surfaces are especially retentive of fission products and require a suitable surface coating to render them cleanable. Flat paint surfaces are undesirable, and rubber-base paint is particularly undesirable,

as its surface cannot be washed free of activity. The addition of citric acid to a detergent solution markedly improves its performance in cleaning activity from structural material and surface coating surfaces.

REFERENCE 38 - ORNL-NSIC-65 - Reactor Technology - Design, Construction, and Testing of High-Efficiency Air Filtration Systems for Nuclear Application, by C. A. Burchsted and A. B. Fuller (January 1970)

1.2 SCOPE

There are no published standards for the design and construction of nuclear plant exhaust systems. Information available on the subject is mostly in the form of topical reports, technical papers, and job specifications that are not readily available. The purposes of this handbook are to summarize the available information in a manner which is useful to the designer, to point out shortcomings in current practice, and to provide guides for future design. The handbook summarizes the findings from an extensive survey of the literature and of air cleaning practices at atomic energy and industrial plants, and laboratories throughout the United States and Canada. The judgments and recommendations presented reflect the experience of users and stem from conditions that exist in actual systems where problems of operation, maintenance, and system reliability are being met on a day-to-day basis, often in situations where personnel have had to live with, or adapt to, serious deficiencies in design or construction.

The handbook is limited to the mechanical design, construction, and testing of air cleaning systems. Functional design, including the sizing of systems and establishing the components required for a particular application, is beyond its scope. The design of the ventilating system, of which the air cleaning system is but one part, is also beyond the scope of the handbook except as the ventilating system affects the operation or reliability of the air cleaning system or, conversely, as the air cleaning system affects the ventilating system. Functional design of ventilating systems is covered in Safety Monograph No. 17 of the International Atomic Energy Agency, INDUSTRIAL VENTILATION, USA Standard Z9.2, the ASHRAE GUIDE AND DATA BOOK, and numerous texts. Nor does the manual cover the theory of air filtration or adsorption; these topics are discussed in a state-of-the-art report issued by the Oak Ridge National Laboratory and in a textbook entitled HIGH EFFICIENCY AIR FILTRATION, by Smith and White. The use of high-efficiency air cleaning as an engineered safeguard in water-cooled nuclear reactors is discussed in USAEC report ORNL-NSIC-25.

REFERENCE 39 - WASH-1174-74 - The Nuclear Industry - 1974

SUMMARY

In 1974, the trend towards expansion of nuclear energy's contribution to the economy continued. By the end of the third quarter, 52 commercial

nuclear power reactors, representing almost 34,000 Mw of capacity, held operating licenses; applications to operate another 29 units totalling over 27,000 Mw of capacity were under regulatory review.

Despite uncertainties related to prospective load growth rates, and despite financial concerns over rising construction costs and high interest rates for new funds, utilities placed orders for 29 new nuclear units, with an aggregate capacity of over 34,000 Mw, during the first nine months of the year. By September 30, 1974, 221 power plants, totalling nearly 215,000 Mw of capacity, were operational, under construction, or on order in the United States.

The magnitude of American investment in nuclear power can be best illustrated by the fact that over \$102 billion are presently committed to the nuclear power program. Forecasts indicate that by 1985, uranium will fuel nearly 30% of all domestic electric power generation, and that by the end of the century, it will supply more than half of our greatly expanded needs for electricity.

Administration efforts to decrease American reliance upon imported petroleum products imply that new construction of electrical generating facilities will concentrate on nuclear power and coal as baseload fuel, at least until more exotic energy sources have been delineated into practical technologies.

To attain economical use of our uranium resources, a fast breeder reactor power project is being developed. The pilot project for a 350 Mw demonstration plant is underway near Oak Ridge, Tennessee, under the joint sponsorship of the Government and industry. Through utilization of the fast breeder, reliance on the Nation's uranium can be extended to hundreds of years. The breeder reactor option is planned to assure the production of power at a low cost, free from problems of fuel supply and of atmospheric pollution. Major construction of the Clinch River Breeder Reactor plant is scheduled to begin in 1976.

REFERENCE 40 - HEDL-SA-705 - Quantities and Characteristics of Commercial Alpha Contaminated Solid Wastes in the U.S., by
A. G. Blasewitz, C. R. Cooley, G. L. Richardson (1974)

ABSTRACT

To date, most alpha-contaminated wastes have been generated in Atomic Energy Commission facilities. With the advent of a rapidly growing nuclear power industry, however, this situation has changed markedly; and within a few years, commercial operations will represent the most significant source of these wastes. Analyses are being made of the current waste generation rates and projected trends for fuel fabrication, fuel reprocessing, and reactor operations. Data regarding the volumes and plutonium content of the various waste streams, together with pertinent information concerning their physical and chemical characteristics and point of origin in the processing operations, will be compiled.

The information will provide the background which is essential for the following assessments: (1) establishing areas wherein process changes could lead to an improvement in terms of reduced volume and/or plutonium content of the waste, and (2) defining areas wherein research and development are required for improved waste treatment. Studies of this nature have been started.

REFERENCE 41 - HEDL-TME 74-3, Vol. 3, UC-79 d-e-p - Reactor and Safety Engineering, by R. J. Slember (October 1974)
Criticality Analysis

D. R. Marr

Criticality reviews of the various FFTF fuel handling facilities are necessary to assure the safety of each facility and its method of operation. As part of this effort, reference sets of criticality data for FTR fuel units are being calculated. The sets are designed to have a wide range of applicability for situations likely to be encountered in the FFTF.

Fuel will be handled in FFTF in the form of pins or intact subassemblies. The calculations for pins immersed in air, sodium, Mobiltherm and water have been completed.

The reflective properties of the surroundings also influence the reactivity of an assemblage. Seven materials (water, Mobiltherm, steel, sodium, ordinary concrete, 210 lb/ft³ concrete, and 280 lb/ft³ concrete) were considered as possible reflectors. Water and Mobiltherm were the most effective reflectors and were used for those cases where the interstitial material was, respectively, water or Mobiltherm. With interstitial sodium or air, it is unlikely that water or Mobiltherm could exist as a reflector. Thus, the next most effective reflector, 210 lb/ft³ concrete, was used for these cases. This is a material which occurs frequently as walls within FFTF.

REFERENCE 42 - ARH-ST-106, UC-2 - P-11 Facility Cleanup Summary Report, by M. N. Raile, Development Engineering Department, Research and Engineering Division (December 1974)

This report summarizes methods and techniques employed for the cleanup of the plutonium-contaminated P-11 Facility accomplished during fiscal years 1974 and 1975, with physical completion achieved on October 16, 1974. Details of the exact scope of the work involved, responsibilities, plans, procedures, and techniques are covered for possible application on other Atomic Energy Commission programs of environmental concern.

SUMMARY

Demolition and removal work to clean up the P-11 Facility was started on April 4, 1974, with site preparation and the addition of an airlock and ventilation exhaustor to the 120 Building for contamination control. Removal of the plutonium-contaminated 120 Building, auxiliaries, and waste crib was completed on October 16, 1974. Final site restoration, seeding, and removal of auxiliary services and structures was completed on November 19, 1974. As a result of the cleanup activity, potential airborne contamination and migration of radioactive particulates were eliminated. The radioactively contaminated materials exceeding the minimum transuranic concentration of ten nanocuries per gram, as provided by Atomic Energy Commission policy guidelines, were sealed in approved containers for 20-year retrievable storage. Although a total of six weeks lost time resulted from two separate construction craft strikes, the cleanup work was completed within two weeks of original schedule and at a cost of approximately \$265,000. No major injuries or contamination to personnel or environs occurred during the course of the cleanup work. The prime objectives of the decommissioning program were achieved in total with considerable knowledge gained in plutonium contamination control, demolition methods, and special work techniques.

REFERENCE 43 - LAMS-2319, Radioactive Waste, (TID-4500, 15th Ed.) - Procedures for Decontamination of Plutonium from Various Surfaces, by E. L. Christensen (1959)

ABSTRACT

Decontamination solutions, procedures, and their effectiveness in the removal of plutonium from various types of surfaces are reported.

SOME GENERAL CONSIDERATIONS

1. Type of surface to be cleaned is more important than type of decontamination solution handy.
2. Major portion of decontamination is usually accomplished in the first 15 minutes of application. In other words, usually the removal of the first solution and application of a new portion for 15 minutes will give better decontamination than if the first solution is left for 30 minutes.
3. The successive alternate application of two selected decontamination solutions usually is much more effective than either alone. Best results obtained if one solution is basic, other acidic. In some cases, it appears to be important which of the two solutions is used first.
4. Each of the solutions should be rated in each case by consideration of the 10 factors listed previously before decontamination is attempted.

5. The initial step in each decontamination procedure should be in accordance with factor Number 3 listed under "Discussion." Obviously, use only as many steps in the procedure as is necessary to reduce count to desired level.
6. Decontamination factor (D.F.) is defined as initial activity in c/m divided by final activity in c/m.

The D.F.'s listed are rough estimates since variations in solution contact time, surface history, and amount and type of abrasive action applied will change the value considerably.

7. Areas and equipment which will be subject to contamination should, where possible and desirable, be protected with a removable coating such as a plastic or paint. Rubber items have not, however, been successfully protected and subsequently decontaminated with this procedure.

REFERENCE 44 - ARH-SA-117, CONF-720903--11 - Remote Welding Program for Atlantic Richfield Hanford Company's Waste Encapsulation and Storage Facility, by John C. Wormeli, Senior Welding Engineer (May 4, 1972)

INTRODUCTION

The Atlantic Richfield Hanford Company (ARHCO) is responsible for managing the radioactive wastes currently being generated at the Atomic Energy Commission's Hanford reservation, and also for stored wastes accumulated from prior production. The approach chosen for processing the high-level wastes includes the separation of the long-lived, high heat-producing radioisotopes, strontium-90, and cesium-137. After a 3-5 year decay period for short-lived fission products, the residual waste is evaporated to produce a salt cake for interim storage in underground tanks. The Atlantic Richfield Hanford Company is now building a plant to convert the stored nitrates into strontium fluoride and cesium chloride and doubly encapsulate these solid compounds for storage in deionized water.

REFERENCE 45 - BNWL-SA-557, CONF-666516 - Plutonium Recycle Test Reactor Experience, 1962-1966 (a), by R. H. Purcell (b) - Plutonium Recycle Test Reactor Experience, 1962-1966 (April 15, 1966)

INTRODUCTION

This paper is the second report to the Association on the experience of the Plutonium Recycle Test Reactor (PRTR). The first report was presented at the 1962 Annual Conference and covered the reactor's experience

from startup to that date.¹ The experience gained since the first report is included in this paper. Brief references to items already covered have been included where necessary to present the complete story.

The PRTR is being utilized as part of a fuel cycle development effort for the use of plutonium as a reactor fuel. Its major use has been for the irradiation testing of plutonium-bearing fuel elements.

REFERENCE 46 - Protective Packaging, Inc. Literature (1975)

Please find enclosed literature on the several packagings developed by Protective Packaging, Inc. for transportation of Type B and Large Quantities of fissile, transuranic, and other radioactive materials.

Of these, perhaps the Super Tiger is most well known. This packaging is basically a proprietary polyurethane foam sandwiched between steel shells. This packaging was both tested and analyzed thoroughly prior to issuance of the U.S. D.O.T. Special Permit No. 6400, and currently holds a Certificate of Compliance from U.S.A.E.C.

Protective Packaging, Inc. and its parent company, Nuclear Engineering Company, Inc. offer a wide variety of usage and availability possibilities.

REFERENCE 47 - Design Criteria for the DP Site Plutonium Processing Facilities Tech Area -55, Plutonium Facilities Site (Revised March 2, 1972)

GENERAL

- A. The documents listed below are applicable in the design of the Plutonium Processing Facilities:

"MODIFIED Minimum Criteria for New Plutonium Facilities," dated February 8, 1972

AECM Chapter 6301 General Design Criteria (Revision including Plutonium Facilities, if issued)

Occupational Safety and Health Administration (OSHA), dated May 29, 1971

Environmental Statement (WASH-1506) - "Plutonium Facility - LASL" - USAEC, dated January 1972

- C. The attached Appendices A, B, and C are presented for guidance.

REFERENCE 48 - RFP-1411 - ATMX-600 Railcars for Radioactive Waste Shipments, by Frank E. Adcock, Dow Chemical Company, Rocky Flats Division, Golden, Colorado (1970)

Abstract. The Dow Chemical Company, Rocky Flats Division, has been assigned Department of Transportation Special Permit 5948 for shipping fissile and large quantities of radioactive waste materials in ATMX-600 Series railcars. These massive (119,000 pounds light weight) double-walled steel cars, built and owned by the AEC, are ideal for shipping large volumes of waste materials to a burial site.

Three roof sections of the car may be removed to expose the 9x9x50-foot cargo hold. The load limit is 101,000 pounds.

Material may be packaged in either steel drums or plywood crates. Rapid loading and unloading is accomplished by prepackaging the waste containers in USASI-ISO Standard 8x8x20-foot steel cargo containers.

REFERENCE 49 - CONF-555-14 - Economics of Building Decontamination, by Peter Loysen, Health and Safety Laboratory, U.S.A.E.C., New York, N.Y. - Presented at International Symposium on Surface Contamination, Gatlinburg, Tennessee (June 12, 1964)

ABSTRACT

The Health and Safety Laboratory has accumulated information about the decontamination of five buildings contaminated with radioactive materials. The buildings varied in area, type of structure, contaminant, and standard of cleanliness required. The degree of cleanliness that was achieved by decontamination varied depending on the future use of the facility. The contaminated areas ranged in size from about 8,000 sq ft to 30,000 sq ft. The five sites included a truck terminal accidentally contaminated with plutonium, two uranium and beryllium fabrication shops, a plutonium processing facility, and a radium dial painting factory.

Valuable information regarding the best approaches to decontamination problems can be gleaned from the actual experiences reported. In evaluating the economics of decontaminating the buildings, the costs for labor, health physics surveillance, supplies and equipment, and waste disposal are all considered. While definite conclusions cannot be drawn from the cost data alone because of the many variables involved in each case, the choice of residual contamination limits was found to be a major influence on the costs of decontamination.

REFERENCE 50 - A Report on the Termination of the Special Metallurgical (SM) Building at Mound Laboratory, by W. R. Harris, B. R. Kokenge, and G. C. Marsh (October 29, 1973)

RECOMMENDATIONS

The design of new facilities for the handling and processing of plutonium-238 should be made with termination in mind. All walls should be seamless and have a smooth durable surface. "Sandwich" walls, such as those used in the SM Building should be avoided because of the difficulty that can be encountered in their decontamination.

Processing areas should be compartmentalized in order to more effectively control the movement of any release of radioactivity. Sealed off access areas behind processing lines are highly recommended as they offer an effective means of controlling radioactivity while at the same time provide the proper work area to perform maintenance and installation work in contaminated glove boxes.

Building and glove box services should not be located overhead, but should be located either beneath the floor level (service level) or in some area away from the laboratories. Overhead services containing radioactive materials present a hazard to laboratory personnel, in that leaks developing in these services can affect the laboratory work area and personnel in these areas. In addition, building and process support equipment should be located out of the laboratory areas and access areas in order to minimize the risk of contamination. Complete building systems, such as house vacuum, corrosive vapor removal systems, and glove box exhaust systems should be located in isolated areas. This approach is not only useful in the termination effort, but provides a safe and appropriate area for maintenance work to be performed with little effect on the operations.

REFERENCE 51 - Supplement to a Report on the Termination of the Special Metallurgical (SM) Building at Mound Laboratory, by W. R. Harris, B. R. Kokenge, G. C. Marsh (1974)

The information presented in this document is provided at the request of the AEC as a supplement to the original report* on the termination of the Special Metallurgical Building, issued by Mound Laboratory on October 30, 1973. The data and information is presented in five separate sections in order to more clearly identify the responses to the information requested by M. B. Biles, AEC/HQ (Memo M. B. Biles to H. C. Donnelly, November 28, 1973, Subject: Report on the Termination of the Special Metallurgical (SM) Building at Mound Laboratory) and J. F. Burke, AEC/ALO (Memo J. F. Burke to R. L. Wainwright, December 21, 1973, Subject: Report on the Termination of the Special Metallurgical (SM) Building at Mound Laboratory).

REFERENCE 52 - ARH-3032 - Specifications and Standards for the Packaging, Storage, and Disposal of Richland Operations Solid Wastes, by J. D. Anderson (April 29, 1974)

PRELIMINARY REPORT

The purpose of this document is to provide specifications and standards which will assure that all solid wastes handled by ARHCO are packaged and stored or disposed of in accordance with: (1) ARHCO Waste Management Program Objectives; (2) ARH-220, July 1, 1972, "Radiation Protection Standards and Controls;" (3) AEC Manual Chapter 0510, March 7, 1968, "Waste Disposal," its Richland Operations Office (RL) Supplement and Appendix; and (4) AEC Manual Chapter 0511, September 19, 1973, "Radioactive Waste Management."

REFERENCE 53 - Mound Laboratory FSAR on Plutonium Processing Facility

4. DESCRIPTION OF FACILITY

FSAR

4.1 Introduction

The PP Building was located to the south of the SM Building (Figure 1-2) in order to utilize several existing functions which would be common to both buildings. These were the 200-ft stack, the change room, the underground tanks for handling low-level radioactive liquid wastes, and such support as analytical labs, electronics, and maintenance shops, and offices.

4.2 Building Layout and Location of Functions

4.3 Design Considerations

The basic features incorporated in the design of the PP Building to control contamination and radiation were:

1. High degree of containment to minimize the release and spread of radioactive material to the building environment.
2. Simplified decontamination in the event of a release of radioactivity.
3. Radiation shielding and remote operations to adequately protect operating personnel.

REFERENCE 54 - WASH-1507 - Rocky Flats Plutonium Facility Design,
Rocky Flats Plant (January 1972)

A key feature of the facility design will be the provision of multiple containment barriers that would serve under accident conditions to prevent the spread of fire or the release of contaminants. First of all, the hot cells, glove boxes, and equipment within which plutonium is processed will be designed to keep the plutonium contained under normal as well as accident conditions. Secondly, the rooms in which the plutonium operations are performed will be of modular construction so that processes are separated into relatively small compartments to further contain released plutonium and to prevent the spread of fire in the event of mishap. Finally, construction of the buildings containing the various plutonium processing modules will utilize reinforced concrete for walls, floors, and roofs presenting a strong protective barrier against the spread of fire or the release of radioactive contaminants.

REFERENCE 55 - ARH-2651 - Design Criteria - Mining Phase; Mining, Packaging, and Storage Contaminated Soil Removal Facility, by T. R. Haddad (1973)

SUMMARY

The mining facilities will remove, assay, and package the top 12 inches of soil from the 30-ft by 60-ft flat portion of the trench floor (1800 cu ft of soil) within a one-year operating period. The soil flow rate, based on a schedule of five eight-hour shifts per week and a 90% onstream factor, will be 7.7 cu ft of soil per shift. The specification for distinguishing between soils containing recoverable and nonrecoverable quantities of plutonium is six grams of plutonium per cu ft of soil. Soil containing recoverable quantities of plutonium is hereafter identified as scrap and soil with nonrecoverable quantities as waste. Scrap, awaiting chemical processing, will be temporarily stored in the canyon of 221-U Building. Waste will be directly transferred to existing transuranic waste repositories. Provision of the transuranic waste repositories is not included in the project.

Upon removal of the top 12 inches of soil, a trench survey may reveal the necessity of additional soil removal from some portions of the trench floor.

The installation for mining, assaying, and packaging of the trench soil will be located at the trench site, about 600 ft east of the 234-5 Building.

REFERENCE 56 - BNWL-1876 - Disposition of Retired, Contaminated (Future WMT) Facilities at Hanford, by K. M. Harmon, Project Manager (1974)

SUMMARY

The program has been revised, a work plan prepared, and six retired Hanford facilities have been selected as candidates for demonstration disposition projects. Evaluation of the six candidates was started to permit ranking them for the first project.

A "disposition resource book" was planned to summarize the information collected in pursuit of the first program objective (establish methods, costs, and priorities...). Published information related to retired liquid radioactive waste disposal sites in the 200 Areas was collected, and preparation of facility summaries on these sites was initiated for incorporation in the appendix of the resource book.

A literature search relating to the disposition of contaminated nuclear facilities was completed and work begun on setting up an information center on decontaminating, decommissioning, and disposing of nuclear facilities.

REFERENCE 57 - ORNL-TM-3277 - Sources of Transuranium Solid Waste and Their Influence on the Proposed National Radioactive Waste Repository, by H. W. Godbee and J. P. Nichols (1971)

1. SUMMARY

This report presents estimates of sources of transuranium solid wastes in the United States and an evaluation of the quantities of these wastes that are conditionally acceptable for receipt at the Alpha Facility of the Proposed National Radioactive Waste Repository in Lyons, Kansas. It is assumed that transuranium solid waste has transuranium alpha radioactivity of greater than $10 \mu\text{Ci/kg}$. This assumption has the effect of excluding most of the very large volume of waste that is generated within the normally occupied work areas of transuranium processing and fabrication plants. It is assumed that wastes containing less than $10 \mu\text{Ci/kg}$ of transuranium nuclides will continue to be buried on site or shipped, generally as LSA or Type A Quantity material, to surface burial grounds.

It is assumed that transuranium wastes that have excessive unit size or radiation level for receipt at the Repository will be stored or buried on site in a potentially retrievable form separate from nontransuranium wastes. These types of transuranium waste are generated predominantly at AEC or commercial plants for reprocessing spent fuel and, as generated, are primarily a hazard because of their fission product content.

4.3 Conclusions and Recommendations

In generating, collecting, packaging, and shipping some 30 to 80x10³ ft of 238-Pu contaminated solid waste per year, Mound has had no spontaneous combustion or explosions in these wastes. No release of activity from containers has occurred except in instances that could be attributed to unauthorized handling of the waste or container. No waste packaging containing valuable components have been shipped from the site - gamma scanning and normal holdup or storage on site prevent this happening. Volumes of waste shipped by Mound are subject to change depending upon economic analysis of scrap recovery versus waste disposal.

REFERENCE 58 - BNWL-B-90 - Equipment Decontamination with Special Attention to Solid Waste Treatment - Survey Report (1971)

This report is a summary of all pertinent information on methods for decontamination of equipment that has been used at a nuclear installation and has become contaminated with radionuclides.

Contamination complicates and limits use of equipment, sometimes to such an extent that it may be of no further value and must be discarded or decontaminated. Contaminated equipment, especially if the activity levels are very high or if the contamination is easily removed, is usually decontaminated prior to storage or disposal, to facilitate handling, reduce exposure levels to personnel, and decrease probability of contaminating the surroundings.

As contamination levels of equipment increase, evaluations must be made to determine whether it is more economical to continue using the contaminated equipment, to decontaminate and reuse, to decontaminate and discard (or store), or to discard (or store) without decontamination. A realistic study of the economics of decontamination and disposal must include a careful consideration of many different factors, including waste disposal, which is assuming an ever greater importance. Final disposal of contaminated solid waste is expensive. Usually it is buried or stored in a controlled area. Any method to reduce the amount of contaminated waste will decrease the overall cost of the operation.

This report attempts to include, along with a discussion of the different decontamination processes, an evaluation of each method.

CONCLUSIONS AND RECOMMENDATIONS

Utilization of proper decontamination methods in a correctly designed decontamination installation will result in a considerable reduction of the volume of solid wastes.

Empirical approaches, while they may be occasionally necessary for solving problems on a crash basis, may prove to be exceedingly expensive,

and should be supplemented by a long-term systematic investigation of the fundamentals, especially studies of film characteristics and mechanisms of contamination and decontamination.

Improved procedures and materials have been studied by different groups, but progress has been slow because the effort has not been sufficiently organized. Often the work is a minor part of another task and has been done on a low priority basis and ultimately abandoned without clear-cut results or recommendations. Lack of communication or delays in transmittal of information among the groups potentially interested has contributed to the lack of progress.

An evaluation should be made of procedures that may prove to be much more efficient and reduce manpower requirements, exposure levels, and waste volumes. The ones that appear especially worthy of investigation now include: ultrasonics, electrolytic polishing and deplating, foamed decontaminants, gels, and strippable films. Simultaneously, new decontaminant formulations that will result in low final waste volumes should be evaluated. Especially promising are the organic reagents and others that can be removed more or less quantitatively by destruction, sorption, extraction, or volatilization.

REFERENCE 59 - Decommissioning of Division of Military Application Equipment at Richland Operations Office for Period Ending December 31, 1974 - Compiled by Atlantic Richfield Hanford Company - Contract AT(45-1)-2130 - Issued by Nuclear Materials Management and Processing Branch, Production and Waste Management Programs Division, Richland Operations Office - United States Atomic Energy Commission (January 16, 1975)

The scope of the decommissioning work provides for (1) the removal of all Division of Military Application (DH) fabrication and inspection equipment held in standby status in the 234-5Z Building, (2) disposition of all equipment and materials removed by packaging for 20-year retrievable storage, (3) reclamation of salvagable materials and equipment for use on site by other Atomic Energy Commission contractors, and (4) restoration of cleared out areas for other future Richland Operations Office programs.

SUMMARY

Decommissioning of the DMA facilities is estimated at 27% complete compared to 35% forecast at the start of the program. Transfer of the six Inspection Area glove boxes to 20-year retrievable storage has been delayed pending completion of the first ten Fiberglass Reinforced Polyester (FRP) plywood containment boxes and until weather conditions are more favorable. Counting of the A-Line glove boxes for plutonium content using a portable sodium iodide (NaI) gamma detector has indicated some residual plutonium present. The transfer of one of the A-Line glove boxes, HA-26D and B, was postponed until the indicated plutonium content of about 150 grams can be verified and disposal limits mutually concurred on between the AEC and

ARHCO. Removal of appurtenances and services from the A-Line and C-Line fabrication glove boxes is estimated at 75% complete. The fiscal year 1975 cost through December 29, 1974 was \$367,296. Compiled with the \$118,307 expended in fiscal year 1974, the total DMA cost through the second quarter of fiscal year 1975 was \$485,603 compared to the original \$853,167 forecast. The lower expenditure rate reflects previously reported work stoppages due to construction craft strikes and a later procurement schedule for retrievable FRP storage containers from original forecast.

REFERENCE 60 CONF-740115 Plutonium Information Meeting for an Ad Hoc Subcommittee of the Advisory Committee on Reactor Safeguards Los Alamos, New Mexico (January 4-5, 1974)

WELCOMING REMARKS

By Dr. R. E. Schreiber, Deputy Director
Los Alamos Scientific Laboratory
Los Alamos, New Mexico

Members of the ad hoc group, ladies, and gentlemen: I am happy to welcome this group to Los Alamos and the frigid Southwest. We are glad you could come here. We think it is particularly appropriate, as Bill Stratton undoubtedly told you, that you come here for this discussion of the characteristics of plutonium. Incidentally, I think you are very ambitious to cover this in two days.

I understand that you are going to hear technical information from a number of sources today. I would simply add a small historic note to this in that I believe it is true that we have probably, at Los Alamos, had longer, more continuous experience in dealing with the properties of plutonium, both in the practical problems of fabrication of the metal and its alloys and in the studies of the physical, chemical, and metallurgical characteristics, all of which are very complicated, than any other area in the country.

In terms of facilities, we started out with the first work in D Building, which was over not too far from where you stayed last night. The building itself is safely resting underground in one of our burial sites at the moment. We then, almost simultaneously, started building the DP site opposite the airport. That now is an obsolete structure and a new plutonium facility is being constructed out on Pajarito Road. There is nothing to see but a great big hole in the ground, but it will be a plutonium facility built in accordance with the current standards. And if you want to know how complicated that is, Bill Maraman, I am sure, can occupy half the day talking about the specifications.

REFERENCE 61 - CMB-11-9726 - Criteria for a Plutonium Facility at Los Alamos (March 11, 1971)

The following criteria were developed for a plutonium facility at Los Alamos to assure that the design fully encompasses the requirements of radiation protection for those who will work in the facility and the protection of the environment from any possible deleterious effects of radioactive materials or toxic chemicals which may escape either in normal operations or in potential accidents (See: AECMC 0510). A cardinal principle in the formulation of these criteria has been that of "minimum practicable" as expounded in the recommendations of the National Committee on Radiation Protection and the International Commission on Radiological Protection. Under this principle, the standards for exposure of people or emissions to the environs serve as an absolute ceiling to the conditions which must be met with, however, the additional stipulation that the design be such that exposures and emissions be kept as far below this ceiling as is technically and economically feasible.

REFERENCE 62 - HVAC System - Plutonium Recovery and Waste Treatment - Buildings 371-374, by A. J. Oliver - Presented at ERDA Safety Review (March 26, 1975)

SAFETY REVIEW

The HVAC systems are essential for confining plutonium within the processing areas. These systems prevent the dispersion of radioactive aerosols, noxious fumes, and vapors into areas normally occupied by personnel. They also control the release of such contaminants from the Facility to the lowest practicable levels, both under normal operating conditions and under all accident conditions postulated for the Facility, including earthquake and tornado.

The HVAC systems include not only air ventilation systems but also an inert gas (nitrogen) ventilation system. The nitrogen system provides environmental control and fire protection for several specific areas within the Plutonium Recovery Facility.

REFERENCE 63 - Basic Ventilation Criteria for Plutonium Processing Facilities at Rocky Flats (Letter from K. J. Freiberg to L. F. Grill) (1973)

Attached is the General Ventilation Criteria for Plutonium Processing Facilities at Rocky Flats. This basic criteria has been agreed to by representatives from Health Physics, Facilities and Utilities and is submitted for general use on new construction and renovation work at Rocky Flats.

Section H. Unirradiated Enriched Uranium Storage Facilities

1. Coverage

- a. These criteria cover the design of new facilities to be used for the storage of unirradiated enriched uranium (enriched in the isotope U-235) where the enrichment level is 5% or more and the relationship $KxE^{1.5}$ is equal to or greater than 0.35*, where

K = total quantity of uranium (by weight in kilograms)

E = level of enrichment in the isotope U-235 (percentage expressed in decimals)

These criteria may be applied to enrichment levels below 5% and $KxE^{1.5}$ relationships of less than 0.35 where potential health or safety hazards to operation personnel or to the public could be involved.

- b. These criteria are not applicable to (1) "in-process" or "in-use" material, (2) material in assembly cells for use in weapons or peaceful nuclear explosives, or (3) material which is packaged in accordance with AECM 0529, awaiting transportation.

REFERENCE 65 - ARH-3079 - Work Plan for Removal of Division of Military Application Equipment, 234-5Z Building, by H. E. Johnson (1974)

OBJECTIVE

This document presents the work plan for accomplishing the removal and burial of fabrication equipment (Division of Military Application (DMA) equipment in the 234-5Z Building.

BACKGROUND

The DMA equipment located in the 234-5Z Building was used for the fabrication of plutonium weapon components from 1949 to 1965. Since 1965, the equipment with certain exceptions has remained in layaway status although tied into building services for contamination control and safety.

WORK TASK RESPONSIBILITIES

The Atlantic Richfield Hanford Company (ARHCO) will:

Have overall management of and final responsibility for the program.

Assume those responsibilities assigned to it in ARH-3032 (unclassified), April 29, 1974, J. D. Anderson, "Specifications and Standards for the Burial of Richland Operations Solid Wastes," including the surveying of the solid radioactive waste containers as specified in paragraph 4.1.4 of ARH-3032 and detailed in reference 2. Portable equipment furnished by ARHCO will be used.

REFERENCE 66 - A Report on the Decontamination and Decommissioning of the Technical (T) Building at Mound Laboratory, by K. V. Gilbert, E. M. Wright, and R. D. Madding (December 31, 1974)

RECOMMENDATIONS

Experience in decontaminating and decommissioning the T Building reinforces the conclusions reached during the SM Building termination project with respect to facility design. All walls should be seamless and have smooth durable surfaces. "Sandwich" walls should be avoided because of difficulty that can be encountered in their decontamination.

Processing areas should be compartmentalized in order to more effectively control the movement of any release of radioactivity. Sealed access areas behind processing lines are highly recommended, as they offer an effective means of controlling radioactivity while at the same time providing the proper work area to perform maintenance and installation work in contaminated glove boxes.

Building and glove box services should not be located overhead, but should be located either beneath the floor level (service level) or in some area away from the laboratories. Overhead services, containing radioactive materials, present a hazard to laboratory personnel, in that leaks developing in these services can affect the laboratory work area and personnel in these areas. In addition, building and process support equipment should be located out of the laboratory areas and access areas in order to minimize the risk of contamination. Complete building systems, such as house vacuum, corrosive vapor removal systems, and glove box exhaust systems should be located in isolated areas. This approach is not only useful in the termination effort, but provides a safe and appropriate area for maintenance work to be performed with little effect on the operations.

REFERENCE 67 - BNWL-SA-4899 - A Methodology for Risk Analysis of Nuclear Waste Management Systems, by T. H. Smith, W. K. Winegardner, G. Janson, Jr., L. D. Williams, T. I. McSweeney (1974)

I. Introduction and Summary

Radioactive waste is generated in a variety of forms by operations in the nuclear fuel cycle. Numerous management systems have been devised to immobilize and isolate these wastes. Such systems include miltisite processing operations, transportation, and storage/disposal.

Evaluation of waste management systems is a complex process. Assessments of proposed systems include technical feasibility, research and development needs, timing, cost, policy, environmental impact, and the calculated and publicly perceived safety.

Risk analysis is a method of assessing the safety of proposed systems. Through such an analysis, consequences of postulated releases of radioactive material can be placed in perspective by viewing the events relative to their probability of occurrence.

This paper describes a methodology for risk assessment of nuclear waste management systems. The required information and calculations are discussed, along with computer codes used for inventory calculations, fault tree evaluation, liquid and airborne transport, and dose to man.

REFERENCE 68 - ARH-3065 - Equipment Decommissioning Technology Program, by Bruce B. Harshbarger and Milton H. Campbell (July 1974)

An initial step in decommissioning Hanford as an operating facility will be the decommissioning of contaminated equipment. The optimum output from the equipment decommissioning stage will be minimum volume product with radionuclides essentially immobilized or at a level where the product can be disposed of within Atomic Energy Commission limits for minimal containment burial.

The individual processes postulated to handle every configuration of equipment and contamination level are:

1. Decontamination by chemical cleaning, by electrochemical cleaning, by ultrasonically stimulated chemical cleaning, or by fused salt decontamination.
2. Size reduction without accompanying phase change by sawing, by electric arc cutting, or by compacting and shearing.
3. Materials handling for whole pieces of and fragmented equipment using cranes, mechanical conveyors, and rotating arm rakes.

4. Bulk volume reduction by melting of fragmented equipment in an induction furnace.
5. Bulk volume reduction by Thermite melting of equipment, intact or fragmented.
6. Solid product forming by casting melt into ingots for storage or into other geometries for reuse.

OBJECTIVE

The goal of this report is the development of processes and selection of equipment to demonstrate the decommissioning of equipment and other metallic components. The selection or design of a processing facility is a potential consequence of this goal.

REFERENCE 69 - ARH-SA-181 - The Hanford Decontamination Facility,
by M. J. Szulinski (June 1974)

To conclude, I would like to summarize this presentation and cover a few points which discussion time did not permit.

1. Highly-contaminated equipment can be decontaminated for inspection and repair or modification.
2. In a fuels reprocessing plant, the economics are favorable.
3. Considering disposal of equipment and eventual decommissioning, decontamination may be a necessity.
4. Further research and development on contamination/decontamination needs to be done, and new tools are available.
5. Decontamination procedures need to consider the objective of the operation and the disposition of the transferred radioactivity; i.e., waste management.
6. Whenever possible, equipment and facilities should be designed with consideration for contamination/decontamination.

I have given you a picture tour of the Hanford Decontamination Center and I would like to end on the note that economic considerations can be very complex when a large-scale decontamination effort is required.

REFERENCE 70 - A Rule Prohibiting Commercial Burial in Soil -
AEC Clearing House (September 16, 1974)

A RULE PROHIBITING COMMERCIAL BURIAL IN SOIL of transuranium elements in waste is being proposed by the AEC. The rule would provide for such waste materials to be transferred to the AEC for storage and ultimate disposal.

Included in the rule is the first reassertion by the AEC of licensing authority transferred to Agreement States. This proposed action, according to statements made at an AEC press briefing last week, has met with the favor of states having regulatory agreements with the AEC and who are "quite pleased" with it.

Current regulations permit the disposal of specified small quantities of transuranium elements by burial without specific approval of the AEC. Under the proposed amendment, this provision would be eliminated.

The proposed management plan would require transuranium element waste to be solidified (if liquid), packaged, and transferred to the AEC for storage as soon as practicable but within five years after its generation. Responsibility for all subsequent storage, treatment, and disposal of such wastes would rest with the AEC, which would take title to the waste upon delivery and levy a charge to the generator of the waste to cover the cost of all such subsequent activities.

REFERENCE 71 - Design Criteria for a New Plutonium Recovery Facility
at Rocky Flats National Laboratory (1972)

SUMMARY

This section summarizes the principal design features, process descriptions, and safety characteristics of the new Plutonium Recovery and Waste Treatment Facility.

2.1 SUMMARY DESCRIPTION OF THE FACILITY

The new Facility will consist of a building complex for recovering plutonium from Rocky Flats Plant scrap streams, for treating waste effluents, and for providing support services for the plutonium recovery and waste treatment operations. The Facility will produce pure, reusable plutonium metal and americium oxide from scrap, and it will reduce wastes to a minimum. Effluents released, both liquid and particulate, will be well within applicable Federal, State, County, and Company internal requirements and standards. The design will comply with all applicable standards for industrial, fire, nuclear, and radiation safety, and containment control under both normal and credible accident conditions. The specific standards are detailed or referenced at appropriate places throughout this Safety Analysis Report.

REFERENCE 72 - LA-5170 - Performance of Multiple HEPA Filters Against Plutonium Aerosols, by Harry J. Ettinger, Project Manager; John C. Elder, and Manuel Gonzales (1972)

ABSTRACT

The field sampling program has been completed at four of the five original locations in three AEC plutonium processing plants. Size characteristics have been defined in terms of aerosol activity median aerodynamic diameter (amad) and geometric standard deviation (g) using the Andersen eight-stage impactor. While size parameters show day-to-day variations, these can generally be classified within sufficiently narrow limits to permit development of typical criteria. Three locations yielded amad ranging from 0.9 to 4.0 μm ; g, from 1.5 to 4.0. The remaining site exhibited much higher activity concentrations and smaller amad (0.1 to 1.0 μm).

The laboratory experimental system to test multiple HEPA filters has been assembled. Its design will permit definition of series filter efficiency as a function of particle size using plutonium aerosols closely approximating those defined by the field sampling program. Initial tests of an aerosol generator which nebulizes a water suspension of ball-milled 238-Pu resulted in an aerosol amad of 0.85 μm , g of 2.4, and activity concentration of 8×10^6 dpm/m³. Selective ball-milling of the bulk powder, addition of anionic surfactant to the suspension, and ultrasonic agitation of the suspension provide control of size characteristics over the range of interest.

Calculations to evaluate the possibility of 238-Pu particles being sufficiently hot to damage the HEPA filter glass fibers indicate surface temperatures for 238-Pu particles under 150 μm amad much lower than the softening point of borosilicate glass fibers in HEPA filters.

REFERENCE 73 - WASH-1202(73), UC-70 - Plan for the Management of AEC-Generated Radioactive Wastes - Dr. Frank K. Pittman, Director - Division of Waste Management and Transportation (July 1973)

In the assignment of priorities for the decontamination and decommissioning of excess AEC facilities for possible beneficial use by others, favorable weighting should be given to:

- a. Cases where there is a specific pending application for use by others, particularly one with a highly favorable economic impact on the area.
- b. Cases where favorable qualities of the site make future applications likely, even though none are pending.

- c. Cases where decontamination will permit the complete release of a site, or the release of a significant portion of a large site.
- d. Cases where decontamination and decommissioning will be more difficult at a later time because people knowledgeable about the facility will no longer be available.
- e. Cases where experience gained in decontamination and decommissioning will be valuable in planning such activities at similar facilities or valuable in the design of new facilities, including licensed facilities.

REFERENCE 74 - CONF-750202-1 - BNWL-SA-5216 - Applied Systems Ecology; Models, Data, and Statistical Methods, by L. L. Eberhardt (1975)

1. INTRODUCTION

1.1 What is systems ecology?

To address the question posed for this conference ("Systems ecology--where do we go from here:") calls for a definition of systems ecology. I do not believe that we have yet arrived at a suitable definition, and suspect that the analysis of ecosystems is not yet far enough along to support a universally acceptable definition. Historically speaking, ecology was initially equated with natural history. As the subject evolved, the word, "ecosystem," became popular, and the problems of definition began to ramify (cf. Evans, 1956). In the 1950's, an emphasis on the flow of energy through natural systems began to pervade the literature and held a dominant role until the early 1960's, when "systems analysis" began to emerge as a key phrase. I suspect this particular shift of emphasis resulted from a growing appreciation of the difficulties of actually measuring the flux of energy in nature, combined with a realization that no single variable could be depended on as an adequate measure of ecosystem dynamics.

REFERENCE 75 - WASH-1520 - Contaminated Soil Removal Facility, Richland, Washington, Environmental Statement (1972)

I. SUMMARY

The U.S. Atomic Energy Commission plans to remove plutonium contaminated soil from the floor of an existing enclosed trench (Z-9) used between July 1955 and June 1962 as a subsurface disposal facility for plutonium-contaminated liquids from the Plutonium Finishing Plant on the Hanford Reservation near Richland, Washington. It is estimated that the soil to be removed contains approximately 100 kilograms of plutonium in a volume of approximately 1800 cubic feet.

It is proposed to construct facilities at Z-9 to permit excavation and packaging of contaminated soil, to add equipment to the existing Plutonium Finishing Plant to permit recovery of plutonium from the contaminated soil, and to construct an Underground Storage Vault 14 ft wide by 8 ft high by 400 ft long for interim storage of contaminated soil.

REFERENCE 76 - Plutonium-238 Fuel Fabrication Facility, Savannah River, South Carolina - Environmental Statement (1972)

I. SUMMARY

Plutonium-238 (^{238}Pu) fueled RTG's have been used by the National Aeronautics and Space Administration (NASA) and Department of Defense (DOD) to provide electrical power aboard communications and weather satellites and on the surface of the moon. The 238-Pu isotope that supplies the heat energy for these devices is produced at SRP. Currently, this isotope is processed to the oxide form for shipment to other AEC sites for further processing into a stable fuel form, followed by encapsulation into heat sources. Because of increased 238-Pu requirements and the desire to upgrade the environmental protection features of its processing operations, AEC proposes to transfer the fuel form fabrication processing operations to SRP.

REFERENCE 77 - ANSI N14.10.1-1973 - American National Standard Administrative Guide for Packaging and Transporting Radioactive Materials

2. Scope

This standard provides a step-by-step procedure for the shipper of radioactive materials to follow in evaluating the material to be shipped both for radioactivity and contamination, in selecting the proper container with respect to size and structure, and in determining the correct labeling.

REFERENCE 78 - D&D of 233-S (Redox Plutonium Concentration) Building - Project Evaluation, by K. M. Harmon, Project Manager*

The facility was used for the concentration (by evaporation) of plutonium and neptunium nitrate product solutions from Redox. Following concentration, the product solutions were loaded into shipping containers and stored until shipment. For a brief period, the facility also provided final purification of Redox plutonium product by means of a moving-bed ion exchange process.

The reference letter recommended that the 233-S (Redox Plutonium Concentration) Building be selected for the first demonstration project under the Disposition (D&D)-at-Hanford program. The letter also stated that we would proceed with project planning based on that recommendation. Accordingly, we have identified a number of alternative disposition strategies and corresponding D&D procedures, and have started an evaluation of the alternatives. Our evaluation includes an assessment of applicable D&D technology; identification of advanced procedures which might be tested during the 233-S project, a qualitative assessment of the operating, short-term and long-term risk associated with each alternative; and a very preliminary estimate of the project cost for each alternative.

REFERENCE 79 - Disposal of Retired, Contaminated (Future WMT) Facilities at Hanford, by K. M. Harmon, Program Manager

SUMMARY

The decision was made to recommend to the AEC that the 233-S (Redox Plutonium Concentration Building) in the 200 West Area be selected for the first disposition demonstration project. Alternatives for disposition of this facility were identified, and work has started on the preliminary definition of decontamination and dismantling (D&D) procedures, to provide a basis for estimating project costs.

Work continued on tabulation of published information on retired liquid waste disposal areas for incorporation in the "Disposition Resource Book." A list of ten liquid disposal cribs in the 200 Areas was supplied by ARHCO as candidates for a future crib disposition project.

The various references on the disposition of nuclear facilities which have been assembled are now being cataloged. The references are being indexed by author, subject (key words), and report number. The cataloging will be completed in October; and the information will be available as a computer printout. As additional references are obtained, they will be stockpiled, cataloged on a semiannual basis, and added to the computer printout.

REFERENCE 80 - CONF-740115 - Capabilities for Control of Plutonium in Processing, by Allen M. Valentine - Los Alamos Scientific Laboratory - Los Alamos, New Mexico (1974)

My mission will be one of explaining how we can work with tons of plutonium, control plutonium releases to the environment to microgram quantities, prevent workers from being exposed to penetrating plutonium radiation levels, and prevent significant plutonium intakes by workers.

As has been discussed in earlier papers, there has been considerable experience in handling plutonium on an industrial scale over the past 30 years. This experience has led to considerable refinement of processing and handling techniques that relate to the control of plutonium, both released to the environment and available for exposure to the workers.

Before we get into discussing current controls for plutonium processing operations, I would like to review briefly the development of facilities that have been used for such operations.

REFERENCE 81 - Federal Register 49CFR173

(b) "Large quantity radioactive materials" means a quantity the aggregate radioactivity of which exceeds that specified as follows:

- (1) Groups I or II (see paragraph (h) of this section) radionuclides: 20 curies.
- (2) Groups III or IV radionuclides: 200 curies.
- (3) Group V radionuclides: 5,000 curies.
- (4) Groups VI or VII radionuclides: 50,000 curies.
- (5) Special form material: 5,000 curies.

(c) "Low specific activity material" means any of the following:

- (1) Uranium or thorium ores and physical or chemical concentrates of those ores;
- (2) Unirradiated natural or depleted uranium or unirradiated natural thorium;
- (3) Tritium oxide in aqueous solutions provided the concentration does not exceed 5 millicuries per milliliter;
- (4) Material in which the activity is essentially uniformly distributed and in which the estimated average concentration per gram of contents does not exceed:
 - (i) 0.0001 millicuries of Group I (see 173.389 (h) radionuclides; or
 - (ii) 0.005 millicuries of Group II radionuclides; or
 - (iii) 0.3 millicuries of Groups III or IV radionuclides.

Note: This includes, but is not limited to, materials of low radioactivity concentration such as residues or solutions from chemical processing; wastes such as building rubble, metal, wood, and fabric scrap, glassware, paper and cardboard; solid or liquid plant waste, sludges, and ashes.

- (5) Objects of nonradioactive material externally contaminated with radioactive material, provided that the radioactive material is not readily dispersible and the surface contamination when averaged over an area of 1 square meter, does not exceed 0.00001 millicurie (220,000 disintegrations per minute) per square centimeter of Group I radionuclides or 0.001 millicurie (2,200,000 disintegrations per minute) per square centimeter of other radionuclides.

REFERENCE 82 - LA-5755 - Demolition of Building 12, An Old Plutonium Filter Facility, by E. L. Christensen, R. Garde, and A. M. Valentine (1975)

ABSTRACT

This report discusses the decommissioning and disposal of a plutonium-contaminated air filter facility that provided ventilation for the main plutonium processing plant at Los Alamos from 1945 until 1973. The health physics, waste management, and environmental aspects of the demolition are also discussed.

REFERENCE 83 - ANL-7066 - Removal of Plutonium Hexafluoride from Cell Exhaust Air by Hydrolysis and Filtration, by R. W. Kessie and D. Ramaswami (1975)

ABSTRACT

The fluoride volatility process for recovering fissionable plutonium from spent reactor fuel as the volatile plutonium hexafluoride (PuF_6) requires a demonstrated ability to contain the highly toxic plutonium.

The experimental studies indicate that at low concentrations of PuF_6 and moisture, the hydrolysis reaction rate is directly proportional to both the partial pressure of the PuF_6 and moisture and to the area of the solid surfaces available for reaction. Adsorbed PuF_6 and HF reduce the reaction rate at partial pressures greater than 0.001 mm Hg .

At high concentrations of PuF_6 and moisture, the reaction proceeds rapidly in the gas phase to produce a finely dispersed product PuO_2F_2 . Most of the particles are smaller than 0.1 micron. With air containing excess moisture, the fraction of released plutonium penetrating two high-efficiency filters in series amounted to between 10^{-9} and 10^{-6} at a filter-media velocity of 1.0 cm/sec .

Filter efficiency is increased by the agglomeration of particles before filtration and by loading effects of the collected particles on the filters. When an excess of moisture is available, agglomeration effects tend to limit the maximum discharge rate of plutonium, and loading effects tend to limit the maximum total quantity of plutonium that can be discharged from a single filter. Design criteria of practical air clean-up systems are presented.

REFERENCE 84 ORNL-TM-1593 Plutonium-Related Safety Aspects in Designing the Fluidized-Bed Volatility Pilot Plant, by F. W. Miles (1966)

ABSTRACT

The purpose of this study is to provide needed design criteria for equipment to ensure safety in handling plutonium in the Fluidized-Bed Volatility Pilot Plant (FBVPP). This pilot plant will recover uranium and plutonium from UO_2 power reactor fuels. The quantity of plutonium to be handled per run will vary from about 200 to 1,250 g while the in-plant inventory may reach a limit of 10 kg. To accomplish this purpose, literature from a number of AEC installations was reviewed. The characteristics of plutonium pertinent to the FBVPP are tabulated. These characteristics include nuclear, physical, chemical, and biological properties. Radiation hazards relative to plutonium are investigated, and critical masses of pertinent plutonium compounds are listed. Containment philosophies and design criteria for equipment are established. Problem areas that require more detailed studies are: (1) neutron and gamma shielding of the PuF_4 product; (2) removal of accidentally released PuF_6 from ventilation air streams; and (3) methods of avoiding criticality during the various stages of operation.

REFERENCE 85 - WASH-1506 - U.S. Atomic Energy Commission Environmental Statement Plutonium Facility Los Alamos Scientific Laboratory (January 1972)

I. SUMMARY

Criteria for use in the design of the Los Alamos Scientific Laboratory were developed and has been utilized during a pre-Title I study of the project. Title I, preliminary design work, is just beginning. The primary features of the new facility design will be increased assurance of containment of potentially harmful materials in the event of accidents, as well as improved protection for the workers. Buildings and processes will be designed and built to more recent and more demanding criteria than those previously used in the construction of older facilities. In addition, it will be possible to decrease routine emissions as compared to the present facilities because of the ease of incorporating advanced treatment facilities.

REFERENCE 86 - 13th AEC Air Cleaning Conference - Emission Monitoring Systems for Plutonium Facilities, by K. J. Freiberg and C. G. Haynes

I. Abstract

The primary purposes of monitoring gaseous effluent are to ensure that environmental discharges conform to specified guidelines and to evaluate the performance of the air-cleaning system. This paper describes a system, at a plutonium facility, whose important characteristics are:

1. continuous monitoring with central readout of the amounts of radioactive and chemical pollutants,
2. extensive fixed sample collection, and
3. measurement of the total effluent volume.

Also described is a technique for inservice contamination surveys of filter plenums. The system meets the requirements set forth in the "Minimum Design Requirements for New Plutonium Facilities."

REFERENCE 87 - Foreign Travel Report - Review of Waste Management Programs in the United Kingdom - October 3-11, 1974, by United States Team: R. W. Ramsey, Jr., AEC/HQS; G. H. Daly, AEC/HQS; R. A. Wolfe, AEC/HQS; E. L. Albenesius, duPont, Savannah River Plant; L. J. Johnson, Los Alamos Scientific Laboratory; E. L. Christensen, Los Alamos Scientific Laboratory; J. B. Owen, Dow, Rocky Flats Plant; C. R. Cooley, Hanford Engineering Development Laboratory

4.0 Summary of Impressions

The technical personnel at Windscale have a strong and varied program in solid waste management. Particularly impressive was the spirit and enthusiasms of the involved personnel; one comes away with the feeling that these competent people have an abundance of real problems to deal with and they are really going after them. Good planning effort seems to have gone into the program to reduce the generation of alpha waste, the design of the waste-sorting center and the incinerator. These executions on observed aspects of this program is enthusiastic and generally good with some reservation about their overall concern for safety in much of this operation, e.g., little or no attention appears to be given to fire risk in waste storage and handling locations. As for the future program, the impression here is that they are a little muddled at what can or should come next. In small instances time after time, this feeling was generated, e.g., what to do with the ash after incineration-leaching, what to do with the rather large backlog of stored waste at Drigg and

oresumably tucked away in corners of obsolete buildings. In sum, (1) they have a fine program to manage the problem of current wastes, and (2) they are verbally dedicated to solving the problems of future wastes but appear not to have yet come to grips with a sound alternative plan if sea dumping should be cut off.

5.0 Conclusion

Windscale is a true production site with a no-nonsense, get-the-job-done outlook. These were a valuable two days for the U.S. team because the Windscale approaches to the solid waste management problems were like a mirror through which we could reflect and evaluate a number of specific features of the varied U.S. program. This comparison was particularly valuable because the broad scope of the Windscale program contains a number of active approaches which are dissimilar to U.S. approaches, and these are especially thought provoking.

REFERENCE 88 - Management of Radioactive Wastes from Fuel Reprocessing, Proceedings, OECD (1972)

The Symposium, which was held at OECD Headquarters in Paris from 27 November to 1 December 1972, gathered together 240 specialists representing 26 countries and eight international organizations. The 46 papers presented during the various sessions, as well as the ensuing discussions, showed the considerable evolution in these past few years, of the methods for the control of gaseous effluent releases and for the treatment and storage of highly radioactive wastes. These Proceedings, therefore, record a very distinct phase of this evolution, the main purpose of which is to provide satisfactory solutions to the problems of the storage and disposal of radioactive waste, that will guarantee no adverse consequences in the short or the long-term to man and his environment.

In view of the prospective development of nuclear energy as a source of electricity, the problems connected with the management of radioactive wastes from fuel reprocessing will present special importance in the future. Large amounts of irradiated fuels will have to be reprocessed on a limited number of sites, which will consequently have to handle significant quantities of various types of wastes. The treatment and storage of highly radioactive fission product solutions, the management of wastes contaminated by long-lived transuranium elements, and the treatment of gaseous wastes require particular attention in this respect. The amounts of radioactivity involved are by far the largest ones handled by the nuclear industry, and their long-term management must be planned for time-scales of the order of centuries, or even of thousands of years in the case of plutonium contaminated wastes.

In this perspective, the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) decided to organize jointly a Symposium dealing specifically with the waste management problems

associated with the reprocessing of irradiated fuel elements, and whose main purpose was to give an overall picture of the present situation in this field and to review the current research and development work directly related to the possible future solutions of the problems involved. At present, only a limited number of countries have an irradiated fuel reprocessing industry, but many other countries show special interest in these problems which will certainly concern them in the near future.

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