SIEMENS

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April 30, 1997
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U.S. Nuclear Regulatory Commission
Attn: Ms. Susan Chotoo
Licensing Branch
Division of Fuel Cycle Safety and Safeguards, NMSS
Washington, DC 20555

Dear Ms. Chotoo:

Enclosed for your information and to include in Chapter 15 of Siemens Power Corporation's (SPC) license application are six copies each of pages 15-30h through 15-30l, 15-83 through 15-85i, 15-92 through 15-92f, 15-94 through 15-94b, 15-95 through 15-95b, and 15-97 through 15-105. These pages provide summaries of criticality safety analyses, respectively, Line-1 Process Recovery, NAF Fabrication, Gd Scrap Recovery, ELO Drain System, and the Lagoons. This completes the summaries for the Category II CSA's.

If you require additional information, please call me at 509-375-8663.

Very truly yours,

Loren Maas for

James B. Edgar
Staff Engineer, Licensing

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Enclosures

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15.1.6.6 Line 1 Process Recovery

Most of the uranium in the ADU processing stream is removed as solid ADU in the primary continuous P-600 centrifuges, but a small quantity of solid ADU and some soluble uranium (typically 100 ppm) remain in the aqueous effluent discharged from the P-600 centrifuges.

Effluent from the P-600 centrifuges drains by gravity to centrifuge accumulator tank TK-13 located near the centrifuges. The centrifuge effluent is pumped from TK-13 to a second stage high speed AS-16-P centrifuge for additional solids removal. Almost all of the remaining solids are removed by the AS-16-P centrifuges. The AS-16-P effluent drains to centrifuge accumulator tank TK-14. ADU remains in the centrifuge bowl which is manually emptied at the end of the batch on a routine basis, usually once every six hours.

A waste tank receives solution from TK-14 and feeds the uranium removal ion exchange (IX) columns. The IX column prefilters remove additional solids from the solutions immediately before ion exchange to minimize solids formation within the ion exchange columns. When solids collect in the pre-filters, the pre-filters are taken off line and acid washed and then flushed with water.

The IX columns remove most of the uranium remaining in solution. The IX columns are washed with water to remove the residual process solutions and the uranium is then eluted from the resin with a dilute nitric acid solution. All of the flush solutions, the filter wash, the ion exchange eluant and acid wash solutions are recycled to the conversion area.

The equipment is located in Rooms 131, 102A north and 102A south of the UO_2 Building. The major system components are:

- ADU waste tank and pump and IX prefilter
- Process waste tank and pump, IX booster pump and sumps
- IX columns, polishing centrifuge and effluent tank, ADU centrifuge effluent and tank and pumps.
- Eluant storage tanks and pumps

15.1.6.6.1 Criticality Safety

Criticality safety in the Line 1 process recovery equipment is provided by geometry and spacing of the tanks. The ADU waste tank and the individual tanks in the Line 1 process recovery system, except for the IX columns, were determined to be favorable

geometry at the optimum ADU/water mixture. The IX columns have a B_4C insert installed to maintain criticality safety.

- ADU Waste Tanks and Pumps and IX Prefilters

The pumps are safe by volume. A volume of 5 liters each is less than 15% of the 37 liter minimum critical volume for optimally moderated 5% enriched UO_2 and water. The IX prefilters are also favorable geometry. Their inner diameter (8.4 in.) is significantly less than the single unit minimum critical diameter for all forms of U compounds at 5 wt.% U^{235} enrichment. The ADU waste tanks, five of them, are favorable geometry for optimum ADU/H_2O mixtures.

Summary of Accident Conditions

Because the five tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A north. Such a spill would result in a solution depth of approximately 2.92 inches, well below the 3.6 inch safe slab thickness.

- Process Waste Tanks and Pumps and IX Booster Pump

There are six, 9.8 inch ID process waste tanks which are favorable geometry for optimum ADU/H_2O mixture. The pumps are safe volume.

Summary of Accident Conditions

Because the six tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A south. Such a spill would result in a solution depth of approximately 2.05 inches, well below the 3.6 inch safe slab thickness.

- IX Columns, Polishing Centrifuge and Effluent Tank, ADU Centrifuge and Effluent Tanks and Pumps

The centrifuge effluent tanks are two 9.8 inch ID tanks which are favorable geometry for optimum ADU/H_2O mixtures. The pumps are safe volume. The three IX columns are 18 inch ID by ten feet long and have a B_4C insert in the center. The IX columns are adequately subcritical for optimum 5% enriched ADU/H_2O solution. Due to their geometry the centrifuges are critically safe for optimum 5% enriched ADU/H_2O solutions.

Summary of Accident Conditions

The following potential accident scenarios have been evaluated:

- Lack of minimum density B_4C in poison insert.
- Removal of the B_4C poison insert with significant quantities of uranium compounds present in IX columns.
- UO_2 or U_3O_8 in large enough quantities such that the theoretical density of the U compound could exceed 5.53 g U/cc.
- Average discharge of > 1.5 ppm U to Lagoons 1 or 2 for extended periods of time.

In discussing the defenses against the four accident scenarios, it must first be recognized that because the IX columns contain resin which acts as a filter media, any upset condition which would allow significant solids to be introduced to the IX columns would quickly plug off the IX column preventing further introduction of material. Therefore, it can be concluded that the IX columns would be self limiting in this respect. In addition, there are pre-filters installed upstream of the IX columns which are designed to remove the solid particles from the liquid feed stream. Also, the resin bed pressure drop is normally monitored and alarmed and the feed to the IX columns is normally terminated when the pressure drop across the resin bed indicates that solids are accumulating in the column.

A minimum density of 1.25 g/cc with a minimum isotopic distribution of 18.3 wt% B-10 is required for the B_4C inserts. Procedures and testing assured that the B_4C used in the neutron absorbing inserts met these requirements when installed. The IX columns are pressurized while the B_4C insert is open to the atmosphere at the top. Periodic inspections also verify the continued presence of the B_4C. Any structural failure of the insert which could potentially remove the B_4C would result in leakage of solution out the top of the insert thereby alerting Operations to the structural failure. Flooding the insert reduces k_{eff}. The B_4C insert is secured in place by design and prevents its inadvertent removal. If the B_4C insert must be removed or partially withdrawn for maintenance the column is required to be eluted within 24 hours of such removal or withdrawal.

In addition to the self-limiting plugging described above, the Line 1 ADU system which feeds the Line 1 IX columns is controlled to minimize sources of UO_2 or U_3O_8. These controls assure that the theoretical density of the U compound in the IX column will not exceed 5.53 g U/cc.

The Line 1 effluent is discharged through two in-series IX columns. The U concentration of the effluent is monitored in between these IX columns. The U monitor alarms at ≤ 8 ppm and causes the lead column to be taken off line and a standby column to be placed on line. A single IX column will typically remove U from the effluent for over a day. Ensuring that two in-series IX columns are on line at all times prevents U concentrations in excess of 1.5 ppm from being discharged to the lagoon. The U monitor is checked for proper function daily when the line is operating. This daily check assures that on equipment failure would be detected before significant quantities of U are discharged to the lagoon.

- Eluant Storage Tanks and Pumps

The eluant storage tanks are six 10.02 inch ID polyethylene tanks which normally contain dilute UNH solution from the acid wash of the IX columns, but may also contain UNH solutions from filter washing and acid wash of precipitation tanks performed to eliminate U buildup. The tanks are critically safe by geometry for optimum ADU/H_2O solutions which bound the UNH solutions. The pumps are safety by volume.

Summary of Accident Conditions

The following potential accident scenario has been evaluated:

The discharge of the six eluant storage tanks to the floor of Room 185 was evaluated as a credible accident. The room is 12 feet by 20 feet. Should the tanks discharge to the floor, the resulting depth would be 3.28 inches. The minimum infinite slab thickness for a UO_2-H_2O mixture at 5.0 wt.% and 900 g U/l is greater than 6.0 inches. For uranyl nitrate solutions of the same uranium concentration, the minimum critical slab depth is greater than 10.0 inches.

15.1.6.6.2 Radiation Protection

Uranium recovery from process in Line-1 is performed in a controlled access, radiation-controlled area. Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of sealed process equipment which are maintained at negative pressure and HEPA filtered prior to entering the main exhaust ductwork.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the chemical conversion area. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such tests are described in Chapter 3.

15.1.6.6.3 Fire Protection

The UO_2 building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the chemical conversion area. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

15.1.6.6.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. Hoods are maintained at a negative pressure and HEPA filtered prior to entering the main exhaust ductwork. Floors are sealed and have no drains.

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Solvent rags from the controlled area are disposed of in special containers distributed throughout the chemical conversion area. The rags are treated as mixed hazardous waste and stored in a secured area for future processing or disposal.

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The IX columns remove most of the uranium remaining in solution. The IX columns are washed with water to remove the residual process solutions and the uranium is then eluted from the resin with a dilute nitric acid solution. All of the flush solutions, the filter wash, the ion exchange eluant and acid wash solutions are recycled to the conversion area.

The equipment is located in Rooms 131, 102A north and 102A south of the UO_2 Building. The major system components are:

- ADU waste tank and pump and IX prefilter
- Process waste tank and pump, IX booster pump and sumps
- IX columns, polishing centrifuge and effluent tank, ADU centrifuge effluent and tank and pumps.
- Eluant storage tanks and pumps

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geometry at the optimum ADU/water mixture. The IX columns have a B_4C insert installed to maintain criticality safety.

- ADU Waste Tanks and Pumps and IX Prefilters

The pumps are safe by volume. A volume of 5 liters each is less than 15% of the 37 liter minimum critical volume for optimally moderated 5% enriched UO_2 and water. The IX prefilters are also favorable geometry. Their inner diameter (8.4 in.) is significantly less than the single unit minimum critical diameter for all forms of U compounds at 5 wt.% U^{235} enrichment. The ADU waste tanks, five of them, are favorable geometry for optimum ADU/H_2O mixtures.

Summary of Accident Conditions

Because the five tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A north. Such a spill would result in a solution depth of approximately 2.92 inches, well below the 3.6 inch safe slab thickness.

- Process Waste Tanks and Pumps and IX Booster Pump

There are six, 9.8 inch ID process waste tanks which are favorable geometry for optimum ADU/H_2O mixture. The pumps are safe volume.

Summary of Accident Conditions

Because the six tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A south. Such a spill would result in a solution depth of approximately 2.05 inches, well below the 3.6 inch safe slab thickness.

- IX Columns, Polishing Centrifuge and Effluent Tank, ADU Centrifuge and Effluent Tanks and Pumps

The centrifuge effluent tanks are two 9.8 inch ID tanks which are favorable geometry for optimum ADU/H_2O mixtures. The pumps are safe volume. The three IX columns are 18 inch ID by ten feet long and have a B_4C insert in the center. The IX columns are adequately subcritical for optimum 5% enriched ADU/H_2O solution. Due to their geometry the centrifuges are critically safe for optimum 5% enriched ADU/H_2O solutions.

Summary of Accident Conditions

The following potential accident scenarios have been evaluated:

- Lack of minimum density B_4C in poison insert.
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- Average discharge of > 1.5 ppm U to Lagoons 1 or 2 for extended periods of time.

In discussing the defenses against the four accident scenarios, it must first be recognized that because the IX columns contain resin which acts as a filter media, any upset condition which would allow significant solids to be introduced to the IX columns would quickly plug off the IX column preventing further introduction of material. Therefore, it can be concluded that the IX columns would be self limiting in this respect. In addition, there are pre-filters installed upstream of the IX columns which are designed to remove the solid particles from the liquid feed stream. Also, the resin bed pressure drop is normally monitored and alarmed and the feed to the IX columns is normally terminated when the pressure drop across the resin bed indicates that solids are accumulating in the column.

A minimum density of 1.25 g/cc with a minimum isotopic distribution of 18.3 wt% B-10 is required for the B_4C inserts. Procedures and testing assured that the B_4C used in the neutron absorbing inserts met these requirements when installed. The IX columns are pressurized while the B_4C insert is open to the atmosphere at the top. Periodic inspections also verify the continued presence of the B_4C. Any structural failure of the insert which could potentially remove the B_4C would result in leakage of solution out the top of the insert thereby alerting Operations to the structural failure. Flooding the insert reduces k_{eff}. The B_4C insert is secured in place by design and prevents its inadvertent removal. If the B_4C insert must be removed or partially withdrawn for maintenance the column is required to be eluted within 24 hours of such removal or withdrawal.

In addition to the self-limiting plugging described above, the Line 1 ADU system which feeds the Line 1 IX columns is controlled to minimize sources of UO_2 or U_3O_8. These controls assure that the theoretical density of the U compound in the IX column will not exceed 5.53 g U/cc.

The Line 1 effluent is discharged through two in-series IX columns. The U concentration of the effluent is monitored in between these IX columns. The U monitor alarms at ≤ 8 ppm and causes the lead column to be taken off line and a standby column to be placed on line. A single IX column will typically remove U from the effluent for over a day. Ensuring that two in-series IX columns are on line at all times prevents U concentrations in excess of 1.5 ppm from being discharged to the lagoon. The U monitor is checked for proper function daily when the line is operating. This daily check assures that on equipment failure would be detected before significant quantities of U are discharged to the lagoon.

- Eluant Storage Tanks and Pumps

The eluant storage tanks are six 10.02 inch ID polyethylene tanks which normally contain dilute UNH solution from the acid wash of the IX columns, but may also contain UNH solutions from filter washing and acid wash of precipitation tanks performed to eliminate U buildup. The tanks are critically safe by geometry for optimum ADU/H_2O solutions which bound the UNH solutions. The pumps are safety by volume.

Summary of Accident Conditions

The following potential accident scenario has been evaluated:

The discharge of the six eluant storage tanks to the floor of Room 185 was evaluated as a credible accident. The room is 12 feet by 20 feet. Should the tanks discharge to the floor, the resulting depth would be 3.28 inches. The minimum infinite slab thickness for a UO_2-H_2O mixture at 5.0 wt.% and 900 g U/l is greater than 6.0 inches. For uranyl nitrate solutions of the same uranium concentration, the minimum critical slab depth is greater than 10.0 inches.

15.1.6.6.2 Radiation Protection

Uranium recovery from process in Line-1 is performed in a controlled access, radiation-controlled area. Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of sealed process equipment which are maintained at negative pressure and HEPA filtered prior to entering the main exhaust ductwork.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the chemical conversion area. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such tests are described in Chapter 3.

15.1.6.6.3 Fire Protection

The UO_2 building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the chemical conversion area. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

15.1.6.6.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. Hoods are maintained at a negative pressure and HEPA filtered prior to entering the main exhaust ductwork. Floors are sealed and have no drains.

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Solvent rags from the controlled area are disposed of in special containers distributed throughout the chemical conversion area. The rags are treated as mixed hazardous waste and stored in a secured area for future processing or disposal.

15.1.6.6 Line 1 Process Recovery

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Effluent from the P-600 centrifuges drains by gravity to centrifuge accumulator tank TK-13 located near the centrifuges. The centrifuge effluent is pumped from TK-13 to a second stage high speed AS-16-P centrifuge for additional solids removal. Almost all of the remaining solids are removed by the AS-16-P centrifuges. The AS-16-P effluent drains to centrifuge accumulator tank TK-14. ADU remains in the centrifuge bowl which is manually emptied at the end of the batch on a routine basis, usually once every six hours.

A waste tank receives solution from TK-14 and feeds the uranium removal ion exchange (IX) columns. The IX column prefilters remove additional solids from the solutions immediately before ion exchange to minimize solids formation within the ion exchange columns. When solids collect in the pre-filters, the pre-filters are taken off line and acid washed and then flushed with water.

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The equipment is located in Rooms 131, 102A north and 102A south of the UO_2 Building. The major system components are:

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geometry at the optimum ADU/water mixture. The IX columns have a B_4C insert installed to maintain criticality safety.

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The pumps are safe by volume. A volume of 5 liters each is less than 15% of the 37 liter minimum critical volume for optimally moderated 5% enriched UO_2 and water. The IX prefilters are also favorable geometry. Their inner diameter (8.4 in.) is significantly less than the single unit minimum critical diameter for all forms of U compounds at 5 wt.% U^{235} enrichment. The ADU waste tanks, five of them, are favorable geometry for optimum ADU/H_2O mixtures.

Summary of Accident Conditions

Because the five tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A north. Such a spill would result in a solution depth of approximately 2.92 inches, well below the 3.6 inch safe slab thickness.

- Process Waste Tanks and Pumps and IX Booster Pump

There are six, 9.8 inch ID process waste tanks which are favorable geometry for optimum ADU/H_2O mixture. The pumps are safe volume.

Summary of Accident Conditions

Because the six tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A south. Such a spill would result in a solution depth of approximately 2.05 inches, well below the 3.6 inch safe slab thickness.

- IX Columns, Polishing Centrifuge and Effluent Tank, ADU Centrifuge and Effluent Tanks and Pumps

The centrifuge effluent tanks are two 9.8 inch ID tanks which are favorable geometry for optimum ADU/H_2O mixtures. The pumps are safe volume. The three IX columns are 18 inch ID by ten feet long and have a B_4C insert in the center. The IX columns are adequately subcritical for optimum 5% enriched ADU/H_2O solution. Due to their geometry the centrifuges are critically safe for optimum 5% enriched ADU/H_2O solutions.

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The following potential accident scenarios have been evaluated:

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In discussing the defenses against the four accident scenarios, it must first be recognized that because the IX columns contain resin which acts as a filter media, any upset condition which would allow significant solids to be introduced to the IX columns would quickly plug off the IX column preventing further introduction of material. Therefore, it can be concluded that the IX columns would be self limiting in this respect. In addition, there are pre-filters installed upstream of the IX columns which are designed to remove the solid particles from the liquid feed stream. Also, the resin bed pressure drop is normally monitored and alarmed and the feed to the IX columns is normally terminated when the pressure drop across the resin bed indicates that solids are accumulating in the column.

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- ADU Waste Tanks and Pumps and IX Prefilters

The pumps are safe by volume. A volume of 5 liters each is less than 15% of the 37 liter minimum critical volume for optimally moderated 5% enriched UO_2 and water. The IX prefilters are also favorable geometry. Their inner diameter (8.4 in.) is significantly less than the single unit minimum critical diameter for all forms of U compounds at 5 wt.% U^{235} enrichment. The ADU waste tanks, five of them, are favorable geometry for optimum ADU/H_2O mixtures.

Summary of Accident Conditions

Because the five tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A north. Such a spill would result in a solution depth of approximately 2.92 inches, well below the 3.6 inch safe slab thickness.

- Process Waste Tanks and Pumps and IX Booster Pump

There are six, 9.8 inch ID process waste tanks which are favorable geometry for optimum ADU/H_2O mixture. The pumps are safe volume.

Summary of Accident Conditions

Because the six tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A south. Such a spill would result in a solution depth of approximately 2.05 inches, well below the 3.6 inch safe slab thickness.

- IX Columns, Polishing Centrifuge and Effluent Tank, ADU Centrifuge and Effluent Tanks and Pumps

The centrifuge effluent tanks are two 9.8 inch ID tanks which are favorable geometry for optimum ADU/H_2O mixtures. The pumps are safe volume. The three IX columns are 18 inch ID by ten feet long and have a B_4C insert in the center. The IX columns are adequately subcritical for optimum 5% enriched ADU/H_2O solution. Due to their geometry the centrifuges are critically safe for optimum 5% enriched ADU/H_2O solutions.

Summary of Accident Conditions

The following potential accident scenarios have been evaluated:

- Lack of minimum density B_4C in poison insert.

- Removal of the B_4C poison insert with significant quantities of uranium compounds present in IX columns.

- UO_2 or U_3O_8 in large enough quantities such that the theoretical density of the U compound could exceed 5.53 g U/cc.

- Average discharge of > 1.5 ppm U to Lagoons 1 or 2 for extended periods of time.

In discussing the defenses against the four accident scenarios, it must first be recognized that because the IX columns contain resin which acts as a filter media, any upset condition which would allow significant solids to be introduced to the IX columns would quickly plug off the IX column preventing further introduction of material. Therefore, it can be concluded that the IX columns would be self limiting in this respect. In addition, there are pre-filters installed upstream of the IX columns which are designed to remove the solid particles from the liquid feed stream. Also, the resin bed pressure drop is normally monitored and alarmed and the feed to the IX columns is normally terminated when the pressure drop across the resin bed indicates that solids are accumulating in the column.

A minimum density of 1.25 g/cc with a minimum isotopic distribution of 18.3 wt% B-10 is required for the B_4C inserts. Procedures and testing assured that the B_4C used in the neutron absorbing inserts met these requirements when installed. The IX columns are pressurized while the B_4C insert is open to the atmosphere at the top. Periodic inspections also verify the continued presence of the B_4C. Any structural failure of the insert which could potentially remove the B_4C would result in leakage of solution out the top of the insert thereby alerting Operations to the structural failure. Flooding the insert reduces k_{eff}. The B_4C insert is secured in place by design and prevents its inadvertent removal. If the B_4C insert must be removed or partially withdrawn for maintenance the column is required to be eluted within 24 hours of such removal or withdrawal.

In addition to the self-limiting plugging described above, the Line 1 ADU system which feeds the Line 1 IX columns is controlled to minimize sources of UO_2 or U_3O_8. These controls assure that the theoretical density of the U compound in the IX column will not exceed 5.53 g U/cc.

The Line 1 effluent is discharged through two in-series IX columns. The U concentration of the effluent is monitored in between these IX columns. The U monitor alarms at $\leq$ 8 ppm and causes the lead column to be taken off line and a standby column to be placed on line. A single IX column will typically remove U from the effluent for over a day. Ensuring that two in-series IX columns are on line at all times prevents U concentrations in excess of 1.5 ppm from being discharged to the lagoon. The U monitor is checked for proper function daily when the line is operating. This daily check assures that on equipment failure would be detected before significant quantities of U are discharged to the lagoon.

- Eluant Storage Tanks and Pumps

The eluant storage tanks are six 10.02 inch ID polyethylene tanks which normally contain dilute UNH solution from the acid wash of the IX columns, but may also contain UNH solutions from filter washing and acid wash of precipitation tanks performed to eliminate U buildup. The tanks are critically safe by geometry for optimum ADU/H_2O solutions which bound the UNH solutions. The pumps are safety by volume.

Summary of Accident Conditions

The following potential accident scenario has been evaluated:

The discharge of the six eluant storage tanks to the floor of Room 185 was evaluated as a credible accident. The room is 12 feet by 20 feet. Should the tanks discharge to the floor, the resulting depth would be 3.28 inches. The minimum infinite slab thickness for a UO_2-H_2O mixture at 5.0 wt.% and 900 g U/l is greater than 6.0 inches. For uranyl nitrate solutions of the same uranium concentration, the minimum critical slab depth is greater than 10.0 inches.

15.1.6.6.2 Radiation Protection

Uranium recovery from process in Line-1 is performed in a controlled access, radiation-controlled area. Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of sealed process equipment which are maintained at negative pressure and HEPA filtered prior to entering the main exhaust ductwork.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the chemical conversion area. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such tests are described in Chapter 3.

15.1.6.6.3 Fire Protection

The UO_2 building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the chemical conversion area. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

15.1.6.6.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. Hoods are maintained at a negative pressure and HEPA filtered prior to entering the main exhaust ductwork. Floors are sealed and have no drains.

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Solvent rags from the controlled area are disposed of in special containers distributed throughout the chemical conversion area. The rags are treated as mixed hazardous waste and stored in a secured area for future processing or disposal.

15.1.6.6 Line 1 Process Recovery

Most of the uranium in the ADU processing stream is removed as solid ADU in the primary continuous P-600 centrifuges, but a small quantity of solid ADU and some soluble uranium (typically 100 ppm) remain in the aqueous effluent discharged from the P-600 centrifuges.

Effluent from the P-600 centrifuges drains by gravity to centrifuge accumulator tank TK-13 located near the centrifuges. The centrifuge effluent is pumped from TK-13 to a second stage high speed AS-16-P centrifuge for additional solids removal. Almost all of the remaining solids are removed by the AS-16-P centrifuges. The AS-16-P effluent drains to centrifuge accumulator tank TK-14. ADU remains in the centrifuge bowl which is manually emptied at the end of the batch on a routine basis, usually once every six hours.

A waste tank receives solution from TK-14 and feeds the uranium removal ion exchange (IX) columns. The IX column prefilters remove additional solids from the solutions immediately before ion exchange to minimize solids formation within the ion exchange columns. When solids collect in the pre-filters, the pre-filters are taken off line and acid washed and then flushed with water.

The IX columns remove most of the uranium remaining in solution. The IX columns are washed with water to remove the residual process solutions and the uranium is then eluted from the resin with a dilute nitric acid solution. All of the flush solutions, the filter wash, the ion exchange eluant and acid wash solutions are recycled to the conversion area.

The equipment is located in Rooms 131, 102A north and 102A south of the UO_2 Building. The major system components are:

- ADU waste tank and pump and IX prefilter
- Process waste tank and pump, IX booster pump and sumps
- IX columns, polishing centrifuge and effluent tank, ADU centrifuge effluent and tank and pumps.
- Eluant storage tanks and pumps

15.1.6.6.1 Criticality Safety

Criticality safety in the Line 1 process recovery equipment is provided by geometry and spacing of the tanks. The ADU waste tank and the individual tanks in the Line 1 process recovery system, except for the IX columns, were determined to be favorable

geometry at the optimum ADU/water mixture. The IX columns have a B_4C insert installed to maintain criticality safety.

- ADU Waste Tanks and Pumps and IX Prefilters

The pumps are safe by volume. A volume of 5 liters each is less than 15% of the 37 liter minimum critical volume for optimally moderated 5% enriched UO_2 and water. The IX prefilters are also favorable geometry. Their inner diameter (8.4 in.) is significantly less than the single unit minimum critical diameter for all forms of U compounds at 5 wt.% U^{235} enrichment. The ADU waste tanks, five of them, are favorable geometry for optimum ADU/H_2O mixtures.

Summary of Accident Conditions

Because the five tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A north. Such a spill would result in a solution depth of approximately 2.92 inches, well below the 3.6 inch safe slab thickness.

- Process Waste Tanks and Pumps and IX Booster Pump

There are six, 9.8 inch ID process waste tanks which are favorable geometry for optimum ADU/H_2O mixture. The pumps are safe volume.

Summary of Accident Conditions

Because the six tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A south. Such a spill would result in a solution depth of approximately 2.05 inches, well below the 3.6 inch safe slab thickness.

- IX Columns, Polishing Centrifuge and Effluent Tank, ADU Centrifuge and Effluent Tanks and Pumps

The centrifuge effluent tanks are two 9.8 inch ID tanks which are favorable geometry for optimum ADU/H_2O mixtures. The pumps are safe volume. The three IX columns are 18 inch ID by ten feet long and have a B_4C insert in the center. The IX columns are adequately subcritical for optimum 5% enriched ADU/H_2O solution. Due to their geometry the centrifuges are critically safe for optimum 5% enriched ADU/H_2O solutions.

Summary of Accident Conditions

The following potential accident scenarios have been evaluated:

- Lack of minimum density B_4C in poison insert.

- Removal of the B_4C poison insert with significant quantities of uranium compounds present in IX columns.

- UO_2 or U_3O_8 in large enough quantities such that the theoretical density of the U compound could exceed 5.53 g U/cc.

- Average discharge of > 1.5 ppm U to Lagoons 1 or 2 for extended periods of time.

In discussing the defenses against the four accident scenarios, it must first be recognized that because the IX columns contain resin which acts as a filter media, any upset condition which would allow significant solids to be introduced to the IX columns would quickly plug off the IX column preventing further introduction of material. Therefore, it can be concluded that the IX columns would be self limiting in this respect. In addition, there are pre-filters installed upstream of the IX columns which are designed to remove the solid particles from the liquid feed stream. Also, the resin bed pressure drop is normally monitored and alarmed and the feed to the IX columns is normally terminated when the pressure drop across the resin bed indicates that solids are accumulating in the column.

A minimum density of 1.25 g/cc with a minimum isotopic distribution of 18.3 wt% B-10 is required for the B_4C inserts. Procedures and testing assured that the B_4C used in the neutron absorbing inserts met these requirements when installed. The IX columns are pressurized while the B_4C insert is open to the atmosphere at the top. Periodic inspections also verify the continued presence of the B_4C. Any structural failure of the insert which could potentially remove the B_4C would result in leakage of solution out the top of the insert thereby alerting Operations to the structural failure. Flooding the insert reduces k_{eff}. The B_4C insert is secured in place by design and prevents its inadvertent removal. If the B_4C insert must be removed or partially withdrawn for maintenance the column is required to be eluted within 24 hours of such removal or withdrawal.

In addition to the self-limiting plugging described above, the Line 1 ADU system which feeds the Line 1 IX columns is controlled to minimize sources of UO_2 or U_3O_8. These controls assure that the theoretical density of the U compound in the IX column will not exceed 5.53 g U/cc.

The Line 1 effluent is discharged through two in-series IX columns. The U concent ation of the effluent is monitored in between these IX columns. The U monitor alarms at ≤ 8 ppm and causes the lead column to be taken off line and a standby column to be placed on line. A single IX column will typically remove U from the effluent for over a day. Ensuring that two in-series IX columns are on line at all times prevents U concentrations in excess of 1.5 ppm from being discharged to the lagoon. The U monitor is checked for proper function daily when the line is operating. This daily check assures that on equipment failure would be detected before significant quantities of U are discharged to the lagoon.

- Eluant Storage Tanks and Pumps

The eluant storage tanks are six 10.02 inch ID polyethylene tanks which normally contain dilute UNH solution from the acid wash of the IX columns, but may also contain UNH solutions from filter washing and acid wash of precipitation tanks performed to eliminate U buildup. The tanks are critically safe by geometry for optimum ADU/H_2O solutions which bound the UNH solutions. The pumps are safety by volume.

Summary of Accident Conditions

The following potential accident scenario has been evaluated:

The discharge of the six eluant storage tanks to the floor of Room 185 was evaluated as a credible accident. The room is 12 feet by 20 feet. Should the tanks discharge to the floor, the resulting depth would be 3.28 inches. The minimum infinite slab thickness for a UO_2-H_2O mixture at 5.0 wt.% and 900 g U/l is greater than 6.0 inches. For uranyl nitrate solutions of the same uranium concentration, the minimum critical slab depth is greater than 10.0 inches.

15.1.6.6.2 Radiation Protection

Uranium recovery from process in Line-1 is performed in a controlled access, radiation-controlled area. Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of sealed process equipment which are maintained at negative pressure and HEPA filtered prior to entering the main exhaust ductwork.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the chemical conversion area. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such tests are described in Chapter 3.

15.1.6.6.3 Fire Protection

The UO_2 building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the chemical conversion area. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

15.1.6.6.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. Hoods are maintained at a negative pressure and HEPA filtered prior to entering the main exhaust ductwork. Floors are sealed and have no drains.

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Solvent rags from the controlled area are disposed of in special containers distributed throughout the chemical conversion area. The rags are treated as mixed hazardous waste and stored in a secured area for future processing or disposal.

15.1.6.6 Line 1 Process Recovery

Most of the uranium in the ADU processing stream is removed as solid ADU in the primary continuous P-600 centrifuges, but a small quantity of solid ADU and some soluble uranium (typically 100 ppm) remain in the aqueous effluent discharged from the P-600 centrifuges.

Effluent from the P-600 centrifuges drains by gravity to centrifuge accumulator tank TK-13 located near the centrifuges. The centrifuge effluent is pumped from TK-13 to a second stage high speed AS-16-P centrifuge for additional solids removal. Almost all of the remaining solids are removed by the AS-16-P centrifuges. The AS-16-P effluent drains to centrifuge accumulator tank TK-14. ADU remains in the centrifuge bowl which is manually emptied at the end of the batch on a routine basis, usually once every six hours.

A waste tank receives solution from TK-14 and feeds the uranium removal ion exchange (IX) columns. The IX column prefilters remove additional solids from the solutions immediately before ion exchange to minimize solids formation within the ion exchange columns. When solids collect in the pre-filters, the pre-filters are taken off line and acid washed and then flushed with water.

The IX columns remove most of the uranium remaining in solution. The IX columns are washed with water to remove the residual process solutions and the uranium is then eluted from the resin with a dilute nitric acid solution. All of the flush solutions, the filter wash, the ion exchange eluant and acid wash solutions are recycled to the conversion area.

The equipment is located in Rooms 131, 102A north and 102A south of the UO_2 Building. The major system components are:

- ADU waste tank and pump and IX prefilter
- Process waste tank and pump, IX booster pump and sumps
- IX columns, polishing centrifuge and effluent tank, ADU centrifuge effluent and tank and pumps.
- Eluant storage tanks and pumps

15.1.6.6.1 Criticality Safety

Criticality safety in the Line 1 process recovery equipment is provided by geometry and spacing of the tanks. The ADU waste tank and the individual tanks in the Line 1 process recovery system, except for the IX columns, were determined to be favorable

geometry at the optimum ADU/water mixture. The IX columns have a B_4C insert installed to maintain criticality safety.

- ADU Waste Tanks and Pumps and IX Prefilters

The pumps are safe by volume. A volume of 5 liters each is less than 15% of the 37 liter minimum critical volume for optimally moderated 5% enriched UO_2 and water. The IX prefilters are also favorable geometry. Their inner diameter (8.4 in.) is significantly less than the single unit minimum critical diameter for all forms of U compounds at 5 wt.% U^{235} enrichment. The ADU waste tanks, five of them, are favorable geometry for optimum ADU/H_2O mixtures.

Summary of Accident Conditions

Because the five tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A north. Such a spill would result in a solution depth of approximately 2.92 inches, well below the 3.6 inch safe slab thickness.

- Process Waste Tanks and Pumps and IX Booster Pump

There are six, 9.8 inch ID process waste tanks which are favorable geometry for optimum ADU/H_2O mixture. The pumps are safe volume.

Summary of Accident Conditions

Because the six tanks are favorable geometry, the only credible accident with criticality safety implications is the tanks all failing and spilling their contents on the floor of Room 102A south. Such a spill would result in a solution depth of approximately 2.05 inches, well below the 3.6 inch safe slab thickness.

- IX Columns, Polishing Centrifuge and Effluent Tank, ADU Centrifuge and Effluent Tanks and Pumps

The centrifuge effluent tanks are two 9.8 inch ID tanks which are favorable geometry for optimum ADU/H_2O mixtures. The pumps are safe volume. The three IX columns are 18 inch ID by ten feet long and have a B_4C insert in the center. The IX columns are adequately subcritical for optimum 5% enriched ADU/H_2O solution. Due to their geometry the centrifuges are critically safe for optimum 5% enriched ADU/H_2O solutions.

Summary of Accident Conditions

The following potential accident scenarios have been evaluated:

- Lack of minimum density B_4C in poison insert.
- Removal of the B_4C poison insert with significant quantities of uranium compounds present in IX columns.
- UO_2 or U_3O_8 in large enough quantities such that the theoretical density of the U compound could exceed 5.53 g U/cc.
- Average discharge of > 1.5 ppm U to Lagoons 1 or 2 for extended periods of time.

In discussing the defenses against the four accident scenarios, it must first be recognized that because the IX columns contain resin which acts as a filter media, any upset condition which would allow significant solids to be introduced to the IX columns would quickly plug off the IX column preventing further introduction of material. Therefore, it can be concluded that the IX columns would be self limiting in this respect. In addition, there are pre-filters installed upstream of the IX columns which are designed to remove the solid particles from the liquid feed stream. Also, the resin bed pressure drop is normally monitored and alarmed and the feed to the IX columns is normally terminated when the pressure drop across the resin bed indicates that solids are accumulating in the column.

A minimum density of 1.25 g/cc with a minimum isotopic distribution of 18.3 wt% B-10 is required for the B_4C inserts. Procedures and testing assured that the B_4C used in the neutron absorbing inserts met these requirements when installed. The IX columns are pressurized while the B_4C insert is open to the atmosphere at the top. Periodic inspections also verify the continued presence of the B_4C. Any structural failure of the insert which could potentially remove the B_4C would result in leakage of solution out the top of the insert thereby alerting Operations to the structural failure. Flooding the insert reduces k_{eff}. The B_4C insert is secured in place by design and prevents its inadvertent removal. If the B_4C insert must be removed or partially withdrawn for maintenance the column is required to be eluted within 24 hours of such removal or withdrawal.

In addition to the self-limiting plugging described above, the Line 1 ADU system which feeds the Line 1 IX columns is controlled to minimize sources of UO_2 or U_3O_8. These controls assure that the theoretical density of the U compound in the IX column will not exceed 5.53 g U/cc.

The Line 1 effluent is discharged through two in-series IX columns. The U concentration of the effluent is monitored in between these IX columns. The U monitor alarms at ≤ 8 ppm and causes the lead column to be taken off line and a standby column to be placed on line. A single IX column will typically remove U from the effluent for over a day. Ensuring that two in-series IX columns are on line at all times prevents U concentrations in excess of 1.5 ppm from being discharged to the lagoon. The U monitor is checked for proper function daily when the line is operating. This daily check assures that on equipment failure would be detected before significant quantities of U are discharged to the lagoon.

- Eluant Storage Tanks and Pumps

The eluant storage tanks are six 10.02 inch ID polyethylene tanks which normally contain dilute UNH solution from the acid wash of the IX columns, but may also contain UNH solutions from filter washing and acid wash of precipitation tanks performed to eliminate U buildup. The tanks are critically safe by geometry for optimum ADU/H_2O solutions which bound the UNH solutions. The pumps are safety by volume.

Summary of Accident Conditions

The following potential accident scenario has been evaluated:

The discharge of the six eluant storage tanks to the floor of Room 185 was evaluated as a credible accident. The room is 12 feet by 20 feet. Should the tanks discharge to the floor, the resulting depth would be 3.28 inches. The minimum infinite slab thickness for a UO_2-H_2O mixture at 5.0 wt.% and 900 g U/l is greater than 6.0 inches. For uranyl nitrate solutions of the same uranium concentration, the minimum critical slab depth is greater than 10.0 inches.

15.1.6.6.2 Radiation Protection

Uranium recovery from process in Line-1 is performed in a controlled access, radiation-controlled area. Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of sealed process equipment which are maintained at negative pressure and HEPA filtered prior to entering the main exhaust ductwork.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the chemical conversion area. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such tests are described in Chapter 3.

15.1.6.6.3 Fire Protection

The UO_2 building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the chemical conversion area. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

15.1.6.6.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. Hoods are maintained at a negative pressure and HEPA filtered prior to entering the main exhaust ductwork. Floors are sealed and have no drains.

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Solvent rags from the controlled area are disposed of in special containers distributed throughout the chemical conversion area. The rags are treated as mixed hazardous waste and stored in a secured area for future processing or disposal.

15.2.2 Neutron Absorber Fuel Fabrication

Neutron absorber fuel (NAF) fabrication takes place in Rooms 174 and 180 of the Specialty Fuels Building. The process begins with powder preparation and ends with scrap recycle. The major pieces of equipment used in this process include:

1) The NAF powder preparation system; i.e., a 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood and vacuum transfer intermediate hood;

2) Mezzanine bucket storage, bucket lift, bucket lift storage rack, five tier bucket storage rack, and bucket storage racks for the powder preparation hoods and bucket tumblers;

3) The pellet press, pellet boat conveyors and NAF pellet boat transport cart;

4) The grinder line, NAF open face pellet storage rack, bucket-pellet storage rack and QA inspection room;

5) The scrap recovery systems; i.e., a bowl cleaning hood, oven, die lube green scrap hood, burnback hood and moderated storage grid.

6) Sintering boats;

7) Sintering boat storage racks;

8) Sintering furnace; and

9) The sintering furnace dust collector.

The equipment described in 1) - 5) above is located in Room 174. The equipment described in 6) - 9) is located in Room 180.

NAF pellets consist of a mixture of uranium dioxide (UO_2) and gadolinium oxide (Gd_2O_3) pressed and sintered basically the same as the standard UO_2 fuel pellets. Gadolinium oxide is mixed with UO_2 powder to provide the feed for the NAF pelletizing operation.

The function of the NAF powder preparation system is to blend, mill, compact and granulate the mixture of UO_x/Gd_2O_3 powder and special additives in preparation for

pellet pressing. After Operations has determined the total batch of powder to be placed in the blender will contain less than 9.5 kgs of moisture (or, if the powder contains at least 1.0 wt% Gd_2O_3, it may contain up to 1.0 wt% water), the 45 gallon barrel's contents are vacuum transferred to the 10.2 cubic foot dry powder blender. The vacuum transfer system uses room air for the transport medium. The certified dry powder is also transferred from the barrel to five gallon buckets located at the 5-gallon bucket download station south and east of the barrel download station. These 5-gallon buckets of certified dry powder are then taken to the powder additive hood were measured quantities of Gd_2O_3 and zinc stearate are added to the powder, and then placed in the mixer addback hood for vacuum transfer into the 10.2 cubic foot dry powder blender to be mixed with the certified dry powder. Aluminum oxide (Al_2O_3) and recycle material such as UO_2 or U_3O_8 (containing Gd_2O_3) are vacuum transferred to the blender from the add-back hood. The powder is then blended prior to transfer to the hammermill, where it is milled and gravity-fed to the roll compactor and granulator. The powder eventually falls through the transfer chutes into 5-gallon buckets. The buckets are stored in five tier bucket storage rack until pressing. Additional storage for 5-gallon buckets containing Gd is available in the mezzanine bucket storage.

The powder press equipment presses UO_x/Gd_2O_3 powder into "green" pellets which are conveyed from the press table to the stacker where they are loaded into molybdenum ("moly") sintering boats.

Boats of green pellets are transferred from the boat load mechanism in Room 174 to the green boat storage racks and their associated conveyors in Room 180. The boats may also be transferred directly to the sintering furnaces. The boats are transferred from the storage racks or from a cart to a conveyor leading to the sintering furnace. A single line of boats is transferred through the furnace which heats the pellets in a reducing atmosphere.

The boats of sintered pellets from the furnace are transferred either to the boat storage racks and associated conveyors or directly to the grinder area via a system of conveyors and/or carts.

15.2.2.1 Criticality Safety

The equipment in Room 174 has been analyzed to minimize reliance on Gd poison to make operations in NAF as similar as possible to those in the UO_2 building. In addition, the material control of Gd was analyzed to provide redundant double contingency control based on Gd poison. Consequently, operations downstream of the blender have the added assurance of Gd poison.

The process flow is controlled to assure that the powder contains ≥ 1 wt% Gd_2O_3. Urania powder, certified is contain less than 1.0 wt.% moisture, is downloaded to 5-gallon buckets. A measured amount of Gd_2O_3 is added to these buckets which are then uploaded to the blender. As a minimum the following controls are implemented in SOPs to assure that the resulting powder can be certified to contain ≥ 1 wt% Gd_2O_3:

- Measured amount of Gd_2O_3 added to blender will be ≥ 1 wt%
- After blending the Gd_2O_3 into the powder in the blender, enough powder will be recycled through powder prep equipment back to the blender to assure that no hold up of non-Gd_2O_3 powder exists.
- Blend recycled material in blender.
- Drop Gd_2O_3 containing powder to color coded buckets which are used only for powder containing ≥ 1 wt% Gd_2O_3.
- Analyze the first three, the last three and every third bucket for Gd_2O_3 wt% before further processing.

Moderation and enrichment controls are used for the powder portion of the system including the blender, powder preparation equipment and the feed to the pellet press. Slab geometry control as well as the neutron absorption characteristics of the moly boats are used from the pellet press stacker to the grinder line. Once the pellets are stacked on pellet trays, criticality safety relies on the geometry and the carbon steel in the pellet tray.

- <u>NAF Powder Preparation System: the 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood, and vacuum transfer intermediate hood</u>

Criticality safety for the NAF blender and powder preparation equipment is dependent upon restricting the amount of moderator inside the equipment. The only parameters controlled to prevent criticality in the blender and portions of the powder preparation equipment are moderation and enrichment until Gd_2O_3 is added. Geometry control is not practical for the blending portion of the operation due to the need to blend large volumes of material. With the controls on moderation required herein, criticality safety is maintained on a double contingency basis without requiring favorable geometry. Moderation control is also required in the NAF scrap oxidation hood and the certified dry powder storage locations.

Criticality safety in the blender is predicated on maintaining the moisture content of the powder to ≤1 wt.%. The total amount of moderator in the blender is also limited to a maximum of 9.5 kg moisture equivalent until Gd_2O_3 is added.

Criticality safety in the powder preparation equipment is predicated upon limiting moderation in the UO_x to a maximum of 1 wt.% water equivalent of moisture and approved additive.

Summary of Accident Conditions

There are two general accident scenarios involving moderator intrusion with respect to the blenders: one is getting moderator into the vicinity of the blender and the second involves actually getting moderator into the blender itself.

During accident conditions, three methods exist for moderator intrusion into the vicinity of the blender and vacuum transfer lines. There are 1) liquid spray, 2) liquid floods, and 3) liquid carried in the air.

- Liquid spray can be caused by cracked or broken piping, or by leaks from the roof or the roof drains. Distance covered by a spray leak is a function of hole size, hole shape and location, and fluid pressure. For purposes of this evaluation, the assumption is made that the powder preparation equipment enclosures can be wetted by a leaking roof. Therefore, these enclosures must be capable of deflecting sprays and preventing significant amounts of liquid from getting inside enclosure.

- Floods can result from sprays, if they last long enough, or can result from a major liquid supply line break. The vacuum transfer system of powder to the NAF blender is accomplished by manually operating a vacuum wand. This arrangement allows operator intervention to stop transfers in the event of a flood.

- Moderator content in the air, to the extent that water would be added to the UO_x powder via condensation, can be caused by supersaturating the air from a steam leak and then having moist air drawn into the powder preparation system via the Vac-U-Max™ pneumatic powder transport system. There are no steam sources in room 174.

Metal framed, Lexan™ paneled hoods enclose the hammermill, roll compactor and granulator. Barrels of powder emptied to the blender, or buckets filled below the granulator are also enclosed in hoods during filling and emptying. The hoods' primary purpose is to contain loose UO_x powder and keep airborne uranium concentrations as low as reasonably achievable. However, these enclosures also provide protection against water wetting the powder preparation equipment

enclosed within the hoods. Not all of the doors and penetrations into the hoods are sealed. Nonetheless, selective use of spray shields combined with the equipment enclosures is an effective barrier if a water spray were directed at the hoods. If the floor were to flood, the hoods would provide a barrier to slow the rate of water entry. If water were allowed to continue flooding, it would, however, eventually reach a high enough depth to enter the hoods through the unsealed penetration openings and through some of the doors and could seep into the enclosure where it is attached to the floor pad.

Room 174, where the blender is located, has no water sources in the south portion of the room, thus decreasing the possibility of liquid sprays. Use of water for fire fighting is prohibited in this area and is so identified. Water sources are available in the north portion of Room 174 so flooding into the room is possible. Liquid water detectors on the floor of Room 174 are interlocked to shut down the vacuum transfer system if water is present.

The blender is fabricated from steel but is not totally enclosed in a secondary housing such as a hood. Sample ports, inspection/maintenance ports and Vac-U-Max™ filter ports exist on the blender. Inspection/maintenance ports are opened only when the blender is empty. During operation, all ports are normally closed both to prevent air from leaking into the blender (which could lead to powder oxidation) and to keep UO_x powder from leaking out of the blender (which would lead to high airborne uranium concentrations).

The type of accident that has the greatest impact on criticality safety is getting moderation inside the equipment.

The two limiting conditions involving the blender are: (1) approximately 4.0 wt.% moisture uniformly distributed through a full blender of 4.0 g/cc UO_x powder; and (2) approximately 19 kg of water that is optimally interspersed in a 36 cm diameter sphere of UO_x that is reflected by dry UO_x powder. There are three potential pathways in Room 174 for moderator to get into the blender. The three pathways, which do not include breaching the wall of the blender or deliberate opening of inspection/maintenance ports, are:

1) Vacuum transfer lines into the blender.
2) Vacuum exhaust line.
3) Blender drive system lubricant.

Moderator Entry Via Vacuum Transfer Lines

Excess moderator can get into the blender by transferring powder with a high moderator content and by transferring moderator with the air used to transport the powder. The following defenses are in place to prevent such transfers.

- The powder in the 45-gallon poisoned barrels or 5-gallon buckets has been sampled and confirmed by analysis to contain less than 1.0 wt.% water. Additionally, no more than a total of 9.5 kg of water is allowed in the blender with the UO_2 powder until it contains at least 1.0 wt% Gd_2O_3.

- Uranium powders that have moderating pressing additives are not allowed in the blender, or in hoods that have vacuum lines connected to the blender, without permission from Criticality Safety.

- Drums of UO_x with additives have special controls on labeling and allowable storage locations.

- Normal amounts of additive allowed result in much less than 1.0 wt.% moisture equivalent at normal powder moisture.

- Each transfer line to the blender is equipped with a locking valve which is locked at all times except for during a transfer of confirmed dry powder.

In addition, the following defenses are in place to preclude excess moisture in the vacuum transfer system:

- The two vacuum transfer lines into the blender are moveable vacuum wands that are attended by an operator during transfer;

- The vacuum is interlocked to shut down if the operator leaves his work station.

- No water sources are present in the portion of Room 174 which contains the certified dry powder;

- Water for fire fighting is prohibited in this room.

- Vacuum is interlocked to shut down when fire alarm sounds.

Moderator entry via the vacuum relief line is not credible because the pressure relief device on the blender relieves at about 3.0 psi and it is unlikely that this device will be activated. It is not credible to get water into the blender via this route in part because this route is only open if the blender is at a higher pressure than the room.

Moderator Entry Via the Room 174 Exhaust System

The vacuum exhaust lines from Room 174 discharge to the K-6 exhaust system. The K-6 exhaust system has a significant elevation rise before entering any moderation control areas which prevents intrusion of liquid moderators.

Moderator Entry via the Blender-Drive System Lubricant

The blender drive system contains halocarbon oils and grease. Small amounts of lubricant leaking into the blender are anticipated. However, a 19 Kg leak of lubricant in a short time is not credible given the volume of lubricant used in the system. There are several defenses that prevent large amounts of hydrogenous lubricant from entering the blender.

- ECO inspections will detect significant leaks of lubricant.
- Only trained and authorized maintenance personnel are allowed to service the blender.
- The PM procedure clearly specifies and the blender is clearly posted that only halocarbon lubricants may be used in the blender drive mechanism.
- The lubricant used in the blender has a controlled release to ensure it is not mixed with other lubricants.

- Mezzanine Bucket Storage, Bucket Lift, Bucket Lift Storage Rack, Five Tier Bucket Storage Rack, Bucket Storage Racks for the Powder Preparation Hoods and Bucket Tumblers

Criticality safety in the storage areas depends upon moderation control, enrichment control, mass control and maintenance of adequate spacing. Vertical arrays of 5-gallon buckets are limited to 1 deep by 5 high. Horizontal arrays of 5-gallon buckets are limited to 2 deep by 2 high. Batch size is limited to 45% of minimum critical mass per bucket.

PART II - SAFETY DEMONSTRATION REV.

Summary of Accident Conditions

This analysis of the 5-gallon bucket storage racks in Room 174 considers combined upset conditions of double batching powder allowed in each bucket, double batching moderator in the powder and spacing violations. With these three accident conditions and abnormally high interstitial moderation, the arrays are adequately subcritical (k_{eff} <0.95).

- Pellet Press, Pellet Boat Conveyors and NAF Pellet Boat Transfer Cart

The powder portion of the pellet press area is dependent on enrichment and moderation controls to assure criticality safety. It has been demonstrated that all systems are safe with the maximum credible powder density and at least 8 wt.% moisture in the powder (four times the allowed moisture). Criticality safety in the press area is dependent upon moderation control, geometry control (slab thickness), and the presence of neutron absorbers (in the molybdenum pellet boats) and at least 1 wt% Gd in the pellets.

Summary of Accident Conditions

A powder spill in the UO_2 pellet press hood, about 450 to 500 kg of UO_2 at 4.0 gU/cc and 8 wt.% water is safe in a reflected spherical geometry. Since 300 kg is a conservative upper limit for the powder mass in a drum and since the drum contains not more than 2 wt.% of moisture equivalent, the maximum credible powder spill in the UO_2 press hood has a large safety margin. Because the NAF pellet press is fed by 5-gallon drums rather than 45-gallon barrels, the safety margin is significantly greater in most areas of the NAF process.

The pellet boats rely on geometry control (slab depth) and the neutron absorbing characteristics of the moly boats for criticality safety. Moderation control and Gd_2O_3 neutron absorption are also used for maintaining criticality safety. The pellet boat storage rack and NAF pellet transport cart rely on slab geometry of the pellet boats and the designed vertical spacing. The NAF pellet transport carts maintain moderation and geometry (slab depth) controls if the pellets being transported contain < 1 wt% Gd.

For pellets containing ≥ 1 wt% Gd_2O_3, process control is maintained such that non-Gd containing pellets are not accidentally loaded on the cart in greater than safe batch quantities.

- Sintering Furnace (including the Dust Collector) and Pellet Boat Storage

Criticality safety in the sintering furnace depends upon moderation and geometry (slab depth) controls. Criticality safety in the sintering furnace dust collector depends upon mass control in the collection bucket (which is alarmed to indicate when it is full), moderation control, and process control which results in very small amounts of U-bearing dust being released up the stack.

Criticality safety in pellet boat storage depends upon the presence of neutron absorbers (the molybdenum in the boats), geometry control (slab depth), moderation control and spacing control.

Summary of Accident Conditions

The sintering furnace is modeled as a row of end-to-end pellet boats on a conveyor. Pellets of 100% theoretical density in boats overloaded by 0.5 inch on a square pitch, fully flooded, with close ceramic reflection, were considered. Under these accident conditions, k_{eff} was slightly greater than 0.95. No credible set of conditions exists which would produce an unacceptable k_{eff} in the sintering furnace dust collector.

Analysis of loaded pellet boats in storage racks and on conveyors resulted in the conclusion that all of the following conditions would have to occur simultaneously for an unacceptable k_{eff} to be generated.

- Full loading of all racks and all conveyors (normal).
- Flooding of all boats (abnormal).
- Spacing of the pellets in all boats to produce a V_w/V_f in the region 2.0 to 3.0 (incredible-random pellet spacing will result in a $V_w/V_f < 1.0$).
- Close-fitted full water reflection at all sides and above and below rack plus the equivalent of about 5-10 volume % water between tiers (incredible).
- Overloading of all boats by about 0.5" with moderated pellets (abnormal).
- No spacing between modules of the racks (abnormal).

This set of conditions is judged not to be credible, but the sintered boat storage racks would still be substantially subcritical.

- Grinder Line, NAF Open Face Pellet Storage Rack, Bucket-Pellet Storage Rack, QA Inspection Room, Centrifuge and Centrifuge Reservoir Tank

Criticality safety in these areas relies on geometry control (slab thickness), spacing, moderation control, mass control, and neutron absorption.

Summary of Accident Conditions

Even with optimum moderation and full water reflection, the maximum k_{eff} for normal operating conditions (ten trays per stack and stacks arranged end-to-end) is 0.74. No single error will produce a condition that is inadequately subcritical in the storage racks. The highest k_{eff} generated during the sensitivity studies (ten trays per stack, stacks arranged side-by-side) was 0.90. These calculations account for he poison effect and spacing control provided by the stainless steel pellet outgas trays.

The grinder line is designed such that the only areas where a significant accumulation of material which could potentially exceed a slab geometry are the feeder bowl and pellet hopper. One boat at a time is manually placed in the boat dumper. This boat is then lifted and tipped so the pellets flow into a sloping feed tray. The pellets are vibrated into the feeder bowl (18 inch diameter by 4 inches high) when a sensor detects that the pellets are running low. Since the system does not automatically dump boats, an operator would have to load and dump boats to exceed the slab height in the feed bowl and the sensor would have to fail. The depth of pellets with significant moderation would have to exceed 5.9 inches before k_{eff} becomes unacceptable. The equipment is enclosed in a hood which facilitates moderation control.

Filling the centrifuge reservoir with > 8 inches of UO_2 slurry was identified as a potential accident condition. The centrifuge removes most of the UO_2. In addition, an overflow which limits the depth of liquid to ≤ 8 inches is a required design feature to preclude overfilling.

The QC inspection room handles small individual samples under slab control and no conditions which could produce an unacceptable k_{eff} are credible.

- Scrap Recovery - Bowl Cleaning Hood, Oven, Moderated Storage Grids and Burnback Hood

The burnback hood relies on moderation control and is bounded by the analysis on the powder preparation equipment. The moderated storage grids rely on spacing and mass control and are documented in the analysis on the pellet press.

Summary of Accident Conditions

The hoods where miscellaneous material processes are performed maintain criticality safety through either moderation, geometry or mass/volume control. The centrifuge bowls have been analyzed in specific geometries combined with materials of construction.

Analyses for the centrifuge bowl demonstrate that limiting the number of centrifuge bowls in the drying hood to a maximum of two assures that $k_{eff} \leq 0.97$.

The moderated bucket grids with one foot spacing meet the accident conditions requirement of $k_{eff} \leq 0.97$.

15.2.2.2 Radiation Protection

The NAF fabrication activities are performed in a limited access radiation controlled area. Personnel are required to wear protective clothing and eye protection while in the area. This area is operated at a pressure slightly below atmospheric to preclude egress of airborne contamination, and extensive use is made of enclosures around process equipment which contains readily dispersible uranium oxide and surface contamination. The air is sampled for radioactivity and evaluated on a frequency determined by historical experience.

15.2.2.3 Fire Protection

The SF building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the NAF fabrication areas. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

All flammable and combustible liquids of greater than one pint in volume used in the process are stored in fire rated containers.

15.2.2.4 Environmental Safety

Materials processed in the NAF fabrication areas are confined within containers, closed cones/transfer chutes, or ventilation hoods until they have been pressed into pellets. The concrete floors are sealed to be liquid tight and contain no floor drains. The areas are serviced by a "once-through" HVAC system that is continuously monitored for radioactive contamination. The exhaust systems for the area are double HEPA filtered and have deluge systems to protect the final filters from fire.

15.2.2 Neutron Absorber Fuel Fabrication

Neutron absorber fuel (NAF) fabrication takes place in Rooms 174 and 180 of the Specialty Fuels Building. The process begins with powder preparation and ends with scrap recycle. The major pieces of equipment used in this process include:

1) The NAF powder preparation system; i.e., a 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood and vacuum transfer intermediate hood;

2) Mezzanine bucket storage, bucket lift, bucket lift storage rack, five tier bucket storage rack, and bucket storage racks for the powder preparation hoods and bucket tumblers;

3) The pellet press, pellet boat conveyors and NAF pellet boat transport cart;

4) The grinder line, NAF open face pellet storage rack, bucket-pellet storage rack and QA inspection room;

5) The scrap recovery systems; i.e., a bowl cleaning hood, oven, die lube green scrap hood, burnback hood and moderated storage grid.

6) Sintering boats;

7) Sintering boat storage racks;

8) Sintering furnace; and

9) The sintering furnace dust collector.

The equipment described in 1) - 5) above is located in Room 174. The equipment described in 6) - 9) is located in Room 180.

NAF pellets consist of a mixture of uranium dioxide (UO_2) and gadolinium oxide (Gd_2O_3) pressed and sintered basically the same as the standard UO_2 fuel pellets. Gadolinium oxide is mixed with UO_2 powder to provide the feed for the NAF pelletizing operation.

The function of the NAF powder preparation system is to blend, mill, compact and granulate the mixture of UO_x/Gd_2O_3 powder and special additives in preparation for

pellet pressing. After Operations has determined the total batch of powder to be placed in the blender will contain less than 9.5 kgs of moisture (or, if the powder contains at least 1.0 wt% Gd_2O_3, it may contain up to 1.0 wt% water), the 45 gallon barrel's contents are vacuum transferred to the 10.2 cubic foot dry powder blender. The vacuum transfer system uses room air for the transport medium. The certified dry powder is also transferred from the barrel to five gallon buckets located at the 5-gallon bucket download station south and east of the barrel download station. These 5-gallon buckets of certified dry powder are then taken to the powder additive hood were measured quantities of Gd_2O_3 and zinc stearate are added to the powder, and then placed in the mixer addback hood for vacuum transfer into the 10.2 cubic foot dry powder blender to be mixed with the certified dry powder. Aluminum oxide (Al_2O_3) and recycle material such as UO_2 or U_3O_8 (containing Gd_2O_3) are vacuum transferred to the blender from the add-back hood. The powder is then blended prior to transfer to the hammermill, where it is milled and gravity-fed to the roll compactor and granulator. The powder eventually falls through the transfer chutes into 5-gallon buckets. The buckets are stored in five tier bucket storage rack until pressing. Additional storage for 5-gallon buckets containing Gd is available in the mezzanine bucket storage.

The powder press equipment presses UO_x/Gd_2O_3 powder into "green" pellets which are conveyed from the press table to the stacker where they are loaded into molybdenum ("moly") sintering boats.

Boats of green pellets are transferred from the boat load mechanism in Room 174 to the green boat storage racks and their associated conveyors in Room 180. The boats may also be transferred directly to the sintering furnaces. The boats are transferred from the storage racks or from a cart to a conveyor leading to the sintering furnace. A single line of boats is transferred through the furnace which heats the pellets in a reducing atmosphere.

The boats of sintered pellets from the furnace are transferred either to the boat storage racks and associated conveyors or directly to the grinder area via a system of conveyors and/or carts.

15.2.2.1 Criticality Safety

The equipment in Room 174 has been analyzed to minimize reliance on Gd poison to make operations in NAF as similar as possible to those in the UO_2 building. In addition, the material control of Gd was analyzed to provide redundant double contingency control based on Gd poison. Consequently, operations downstream of the blender have the added assurance of Gd poison.

PART II - SAFETY DEMONSTRATION REV.

The process flow is controlled to assure that the powder contains ≥ 1 wt% Gd_2O_3. Urania powder, certified is contain less than 1.0 wt.% moisture, is downloaded to 5-gallon buckets. A measured amount of Gd_2O_3 is added to these buckets which are then uploaded to the blender. As a minimum the following controls are implemented in SOPs to assure that the resulting powder can be certified to contain ≥ 1 wt% Gd_2O_3:

- Measured amount of Gd_2O_3 added to blender will be ≥ 1 wt%
- After blending the Gd_2O_3 into the powder in the blender, enough powder will be recycled through powder prep equipment back to the blender to assure that no hold up of non-Gd_2O_3 powder exists.
- Blend recycled material in blender.
- Drop Gd_2O_3 containing powder to color coded buckets which are used only for powder containing ≥ 1 wt% Gd_2O_3.
- Analyze the first three, the last three and every third bucket for Gd_2O_3 wt% before further processing.

Moderation and enrichment controls are used for the powder portion of the system including the blender, powder preparation equipment and the feed to the pellet press. Slab geometry control as well as the neutron absorption characteristics of the moly boats are used from the pellet press stacker to the grinder line. Once the pellets are stacked on pellet trays, criticality safety relies on the geometry and the `carbon steel in the pellet tray.

- NAF Powder Preparation System: the 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood, and vacuum transfer intermediate hood

Criticality safety for the NAF blender and powder preparation equipment is dependent upon restricting the amount of moderator inside the equipment. The only parameters controlled to prevent criticality in the blender and portions of the powder preparation equipment are moderation and enrichment until Gd_2O_3 is added. Geometry control is not practical for the blending portion of the operation due to the need to blend large volumes of material. With the controls on moderation required herein, criticality safety is maintained on a double contingency basis without requiring favorable geometry. Moderation control is also required in the NAF scrap oxidation hood and the certified dry powder storage locations.

Criticality safety in the blender is predicated on maintaining the moisture content of the powder to ≤1 wt.%. The total amount of moderator in the blender is also limited to a maximum of 9.5 kg moisture equivalent until Gd_2O_3 is added.

Criticality safety in the powder preparation equipment is predicated upon limiting moderation in the UO_x to a maximum of 1 wt.% water equivalent of moisture and approved additive.

Summary of Accident Conditions

There are two general accident scenarios involving moderator intrusion with respect to the blenders: one is getting moderator into the vicinity of the blender and the second involves actually getting moderator into the blender itself.

During accident conditions, three methods exist for moderator intrusion into the vicinity of the blender and vacuum transfer lines. There are 1) liquid spray, 2) liquid floods, and 3) liquid carried in the air.

- Liquid spray can be caused by cracked or broken piping, or by leaks from the roof or the roof drains. Distance covered by a spray leak is a function of hole size, hole shape and location, and fluid pressure. For purposes of this evaluation, the assumption is made that the powder preparation equipment enclosures can be wetted by a leaking roof. Therefore, these enclosures must be capable of deflecting sprays and preventing significant amounts of liquid from getting inside enclosure.

- Floods can result from sprays, if they last long enough, or can result from a major liquid supply line break. The vacuum transfer system of powder to the NAF blender is accomplished by manually operating a vacuum wand. This arrangement allows operator intervention to stop transfers in the event of a flood.

- Moderator content in the air, to the extent that water would be added to the UO_x powder via condensation, can be caused by supersaturating the air from a steam leak and then having moist air drawn into the powder preparation system via the Vac-U-Max™ pneumatic powder transport system. There are no steam sources in room 174.

Metal framed, Lexan™ paneled hoods enclose the hammermill, roll compactor and granulator. Barrels of powder emptied to the blender, or buckets filled below the granulator are also enclosed in hoods during filling and emptying. The hoods' primary purpose is to contain loose UO_x powder and keep airborne uranium concentrations as low as reasonably achievable. However, these enclosures also provide protection against water wetting the powder preparation equipment

enclosed within the hoods. Not all of the doors and penetrations into the hoods are sealed. Nonetheless, selective use of spray shields combined with the equipment enclosures is an effective barrier if a water spray were directed at the hoods. If the floor were to flood, the hoods would provide a barrier to slow the rate of water entry. If water were allowed to continue flooding, it would, however, eventually reach a high enough depth to enter the hoods through the unsealed penetration openings and through some of the doors and could seep into the enclosure where it is attached to the floor pad.

Room 174, where the blender is located, has no water sources in the south portion of the room, thus decreasing the possibility of liquid sprays. Use of water for fire fighting is prohibited in this area and is so identified. Water sources are available in the north portion of Room 174 so flooding into the room is possible. Liquid water detectors on the floor of Room 174 are interlocked to shut down the vacuum transfer system if water is present.

The blender is fabricated from steel but is not totally enclosed in a secondary housing such as a hood. Sample ports, inspection/maintenance ports and Vac-U-Max™ filter ports exist on the blender. Inspection/maintenance ports are opened only when the blender is empty. During operation, all ports are normally closed both to prevent air from leaking into the blender (which could lead to powder oxidation) and to keep UO_x powder from leaking out of the blender (which would lead to high airborne uranium concentrations).

The type of accident that has the greatest impact on criticality safety is getting moderation inside the equipment.

The two limiting conditions involving the blender are: (1) approximately 4.0 wt.% moisture uniformly distributed through a full blender of 4.0 g/cc UO_x powder; and (2) approximately 19 kg of water that is optimally interspersed in a 36 cm diameter sphere of UO_x that is reflected by dry UO_x powder. There are three potential pathways in Room 174 for moderator to get into the blender. The three pathways, which do not include breaching the wall of the blender or deliberate opening of inspection/maintenance ports, are:

1) Vacuum transfer lines into the blender.
2) Vacuum exhaust line.
3) Blender drive system lubricant.

Moderator Entry Via Vacuum Transfer Lines

Excess moderator can get into the blender by transferring powder with a high moderator content and by transferring moderator with the air used to transport the powder. The following defenses are in place to prevent such transfers.

- The powder in the 45-gallon poisoned barrels or 5-gallon buckets has been sampled and confirmed by analysis to contain less than 1.0 wt.% water. Additionally, no more than a total of 9.5 kg of water is allowed in the blender with the UO_2 powder until it contains at least 1.0 wt% Gd_2O_3.

- Uranium powders that have moderating pressing additives are not allowed in the blender, or in hoods that have vacuum lines connected to the blender, without permission from Criticality Safety.

- Drums of UO_x with additives have special controls on labeling and allowable storage locations.

- Normal amounts of additive allowed result in much less than 1.0 wt.% moisture equivalent at normal powder moisture.

- Each transfer line to the blender is equipped with a locking valve which is locked at all times except for during a transfer of confirmed dry powder.

In addition, the following defenses are in place to preclude excess moisture in the vacuum transfer system:

- The two vacuum transfer lines into the blender are moveable vacuum wands that are attended by an operator during transfer;

- The vacuum is interlocked to shut down if the operator leaves his work station.

- No water sources are present in the portion of Room 174 which contains the certified dry powder;

- Water for fire fighting is prohibited in this room.

- Vacuum is interlocked to shut down when fire alarm sounds.

Moderator entry via the vacuum relief line is not credible because the pressure relief device on the blender relieves at about 3.0 psi and it is unlikely that this device will be activated. It is not credible to get water into the blender via this route in part because this route is only open if the blender is at a higher pressure than the room.

Moderator Entry Via the Room 174 Exhaust System

The vacuum exhaust lines from Room 174 discharge to the K-6 exhaust system. The K-6 exhaust system has a significant elevation rise before entering any moderation control areas which prevents intrusion of liquid moderators.

Moderator Entry via the Blender-Drive System Lubricant

The blender drive system contains halocarbon oils and grease. Small amounts of lubricant leaking into the blender are anticipated. However, a 19 Kg leak of lubricant in a short time is not credible given the volume of lubricant used in the system. There are several defenses that prevent large amounts of hydrogenous lubricant from entering the blender.

- ECO inspections will detect significant leaks of lubricant.
- Only trained and authorized maintenance personnel are allowed to service the blender.
- The PM procedure clearly specifies and the blender is clearly posted that only halocarbon lubricants may be used in the blender drive mechanism.
- The lubricant used in the blender has a controlled release to ensure it is not mixed with other lubricants.

• Mezzanine Bucket Storage, Bucket Lift, Bucket Lift Storage Rack, Five Tier Bucket Storage Rack, Bucket Storage Racks for the Powder Preparation Hoods and Bucket Tumblers

Criticality safety in the storage areas depends upon moderation control, enrichment control, mass control and maintenance of adequate spacing. Vertical arrays of 5-gallon buckets are limited to 1 deep by 5 high. Horizontal arrays of 5-gallon buckets are limited to 2 deep by 2 high. Batch size is limited to 45% of minimum critical mass per bucket.

Summary of Accident Conditions

This analysis of the 5-gallon bucket storage racks in Room 174 considers combined upset conditions of double batching powder allowed in each bucket, double batching moderator in the powder and spacing violations. With these three accident conditions and abnormally high interstitial moderation, the arrays are adequately subcritical (k_{eff} <0.95).

- Pellet Press, Pellet Boat Conveyors and NAF Pellet Boat Transfer Cart

The powder portion of the pellet press area is dependent on enrichment and moderation controls to assure criticality safety. It has been demonstrated that all systems are safe with the maximum credible powder density and at least 8 wt.% moisture in the powder (four times the allowed moisture). Criticality safety in the press area is dependent upon moderation control, geometry control (slab thickness), and the presence of neutron absorbers (in the molybdenum pellet boats) and at least 1 wt% Gd in the pellets.

Summary of Accident Conditions

A powder spill in the UO_2 pellet press hood, about 450 to 500 kg of UO_2 at 4.0 gU/cc and 8 wt.% water is safe in a reflected spherical geometry. Since 300 kg is a conservative upper limit for the powder mass in a drum and since the drum contains not more than 2 wt.% of moisture equivalent, the maximum credible powder spill in the UO_2 press hood has a large safety margin. Because the NAF pellet press is fed by 5-gallon drums rather than 45-gallon barrels, the safety margin is significantly greater in most areas of the NAF process.

The pellet boats rely on geometry control (slab depth) and the neutron absorbing characteristics of the moly boats for criticality safety. Moderation control and Gd_2O_3 neutron absorption are also used for maintaining criticality safety. The pellet boat storage rack and NAF pellet transport cart rely on slab geometry of the pellet boats and the designed vertical spacing. The NAF pellet transport carts maintain moderation and geometry (slab depth) controls if the pellets being transported contain < 1 wt% Gd.

For pellets containing ≥ 1 wt% Gd_2O_3, process control is maintained such that non-Gd containing pellets are not accidentally loaded on the cart in greater than safe batch quantities.

- Sintering Furnace (including the Dust Collector) and Pellet Boat Storage

Criticality safety in the sintering furnace depends upon moderation and geometry (slab depth) controls. Criticality safety in the sintering furnace dust collector depends upon mass control in the collection bucket (which is alarmed to indicate when it is full), moderation control, and process control which results in very small amounts of U-bearing dust being released up the stack.

Criticality safety in pellet boat storage depends upon the presence of neutron absorbers (the molybdenum in the boats), geometry control (slab depth), moderation control and spacing control.

Summary of Accident Conditions

The sintering furnace is modeled as a row of end-to-end pellet boats on a conveyor. Pellets of 100% theoretical density in boats overloaded by 0.5 inch on a square pitch, fully flooded, with close ceramic reflection, were considered. Under these accident conditions, k_{eff} was slightly greater than 0.95. No credible set of conditions exists which would produce an unacceptable k_{eff} in the sintering furnace dust collector.

Analysis of loaded pellet boats in storage racks and on conveyors resulted in the conclusion that all of the following conditions would have to occur simultaneously for an unacceptable k_{eff} to be generated.

- Full loading of all racks and all conveyors (normal).
- Flooding of all boats (abnormal).
- Spacing of the pellets in all boats to produce a V_w/V_f in the region 2.0 to 3.0 (incredible-random pellet spacing will result in a $V_w/V_f < 1.0$).
- Close-fitted full water reflection at all sides and above and below rack plus the equivalent of about 5-10 volume % water between tiers (incredible).
- Overloading of all boats by about 0.5" with moderated pellets (abnormal).
- No spacing between modules of the racks (abnormal).

This set of conditions is judged not to be credible, but the sintered boat storage racks would still be substantially subcritical.

- Grinder Line, NAF Open Face Pellet Storage Rack, Bucket-Pellet Storage Rack, QA Inspection Room, Centrifuge and Centrifuge Reservoir Tank

Criticality safety in these areas relies on geometry control (slab thickness), spacing, moderation control, mass control, and neutron absorption.

Summary of Accident Conditions

Even with optimum moderation and full water reflection, the maximum k_{eff} for normal operating conditions (ten trays per stack and stacks arranged end-to-end) is 0.74. No single error will produce a condition that is inadequately subcritical in the storage racks. The highest k_{eff} generated during the sensitivity studies (ten trays per stack, stacks arranged side-by-side) was 0.90. These calculations account for he poison effect and spacing control provided by the stainless steel pellet outgas trays.

The grinder line is designed such that the only areas where a significant accumulation of material which could potentially exceed a slab geometry are the feeder bowl and pellet hopper. One boat at a time is manually placed in the boat dumper. This boat is then lifted and tipped so the pellets flow into a sloping feed tray. The pellets are vibrated into the feeder bowl (18 inch diameter by 4 inches high) when a sensor detects that the pellets are running low. Since the system does not automatically dump boats, an operator would have to load and dump boats to exceed the slab height in the feed bowl and the sensor would have to fail. The depth of pellets with significant moderation would have to exceed 5.9 inches before k_{eff} becomes unacceptable. The equipment is enclosed in a hood which facilitates moderation control.

Filling the centrifuge reservoir with > 8 inches of UO_2 slurry was identified as a potential accident condition. The centrifuge removes most of the UO_2. In addition, an overflow which limits the depth of liquid to ≤ 8 inches is a required design feature to preclude overfilling.

The QC inspection room handles small individual samples under slab control and no conditions which could produce an unacceptable k_{eff} are credible.

- Scrap Recovery - Bowl Cleaning Hood, Oven, Moderated Storage Grids and Burnback Hood

The burnback hood relies on moderation control and is bounded by the analysis on the powder preparation equipment. The moderated storage grids rely on spacing and mass control and are documented in the analysis on the pellet press.

Summary of Accident Conditions

The hoods where miscellaneous material processes are performed maintain criticality safety through either moderation, geometry or mass/volume control. The centrifuge bowls have been analyzed in specific geometries combined with materials of construction.

Analyses for the centrifuge bowl demonstrate that limiting the number of centrifuge bowls in the drying hood to a maximum of two assures that $k_{eff} \leq 0.97$.

The moderated bucket grids with one foot spacing meet the accident conditions requirement of $k_{eff} \leq 0.97$.

15.2.2.2 Radiation Protection

The NAF fabrication activities are performed in a limited access radiation controlled area. Personnel are required to wear protective clothing and eye protection while in the area. This area is operated at a pressure slightly below atmospheric to preclude egress of airborne contamination, and extensive use is made of enclosures around process equipment which contains readily dispersible uranium oxide and surface contamination. The air is sampled for radioactivity and evaluated on a frequency determined by historical experience.

15.2.2.3 Fire Protection

The SF building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the NAF fabrication areas. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

All flammable and combustible liquids of greater than one pint in volume used in the process are stored in fire rated containers.

15.2.2.4 Environmental Safety

Materials processed in the NAF fabrication areas are confined within containers, closed cones/transfer chutes, or ventilation hoods until they have been pressed into pellets. The concrete floors are sealed to be liquid tight and contain no floor drains. The areas are serviced by a "once-through" HVAC system that is continuously monitored for radioactive contamination. The exhaust systems for the area are double HEPA filtered and have deluge systems to protect the final filters from fire.

15.2.2 Neutron Absorber Fuel Fabrication

Neutron absorber fuel (NAF) fabrication takes place in Rooms 174 and 180 of the Specialty Fuels Building. The process begins with powder preparation and ends with scrap recycle. The major pieces of equipment used in this process include:

1) The NAF powder preparation system; i.e., a 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood and vacuum transfer intermediate hood;

2) Mezzanine bucket storage, bucket lift, bucket lift storage rack, five tier bucket storage rack, and bucket storage racks for the powder preparation hoods and bucket tumblers;

3) The pellet press, pellet boat conveyors and NAF pellet boat transport cart;

4) The grinder line, NAF open face pellet storage rack, bucket-pellet storage rack and QA inspection room;

5) The scrap recovery systems; i.e.. a bowl cleaning hood, oven, die lube green scrap hood, burnback hood and moderated storage grid.

6) Sintering boats;

7) Sintering boat storage racks;

8) Sintering furnace; and

9) The sintering furnace dust collector.

The equipment described in 1) - 5) above is located in Room 174. The equipment described in 6) - 9) is located in Room 180.

NAF pellets consist of a mixture of uranium dioxide (UO_2) and gadolinium oxide (Gd_2O_3) pressed and sintered basically the same as the standard UO_2 fuel pellets. Gadolinium oxide is mixed with UO_2 powder to provide the feed for the NAF pelletizing operation.

The function of the NAF powder preparation system is to blend, mill, compact and granulate the mixture of UO_x/Gd_2O_3 powder and special additives in preparation for

pellet pressing. After Operations has determined the total batch of powder to be placed in the blender will contain less than 9.5 kgs of moisture (or, if the powder contains at least 1.0 wt% Gd_2O_3, it may contain up to 1.0 wt% water), the 45 gallon barrel's contents are vacuum transferred to the 10.2 cubic foot dry powder blender. The vacuum transfer system uses room air for the transport medium. The certified dry powder is also transferred from the barrel to five gallon buckets located at the 5-gallon bucket download station south and east of the barrel download station. These 5-gallon buckets of certified dry powder are then taken to the powder additive hood were measured quantities of Gd_2O_3 and zinc stearate are added to the powder, and then placed in the mixer addback hood for vacuum transfer into the 10.2 cubic foot dry powder blender to be mixed with the certified dry powder. Aluminum oxide (Al_2O_3) and recycle material such as UO_2 or U_3O_8 (containing Gd_2O_3) are vacuum transferred to the blender from the add-back hood. The powder is then blended prior to transfer to the hammermill, where it is milled and gravity-fed to the roll compactor and granulator. The powder eventually falls through the transfer chutes into 5-gallon buckets. The buckets are stored in five tier bucket storage rack until pressing. Additional storage for 5-gallon buckets containing Gd is available in the mezzanine bucket storage.

The powder press equipment presses UO_x/Gd_2O_3 powder into "green" pellets which are conveyed from the press table to the stacker where they are loaded into molybdenum ("moly") sintering boats.

Boats of green pellets are transferred from the boat load mechanism in Room 174 to the green boat storage racks and their associated conveyors in Room 180. The boats may also be transferred directly to the sintering furnaces. The boats are transferred from the storage racks or from a cart to a conveyor leading to the sintering furnace. A single line of boats is transferred through the furnace which heats the pellets in a reducing atmosphere.

The boats of sintered pellets from the furnace are transferred either to the boat storage racks and associated conveyors or directly to the grinder area via a system of conveyors and/or carts.

15.2.2.1 Criticality Safety

The equipment in Room 174 has been analyzed to minimize reliance on Gd poison to make operations in NAF as similar as possible to those in the UO_2 building. In addition, the material control of Gd was analyzed to provide redundant double contingency control based on Gd poison. Consequently, operations downstream of the blender have the added assurance of Gd poison.

The process flow is controlled to assure that the powder contains ≥ 1 wt% Gd_2O_3. Urania powder, certified is contain less than 1.0 wt.% moisture, is downloaded to 5-gallon buckets. A measured amount of Gd_2O_3 is added to these buckets which are then uploaded to the blender. As a minimum the following controls are implemented in SOPs to assure that the resulting powder can be certified to contain ≥ 1 wt% Gd_2O_3:

- Measured amount of Gd_2O_3 added to blender will be ≥ 1 wt%
- After blending the Gd_2O_3 into the powder in the blender, enough powder will be recycled through powder prep equipment back to the blender to assure that no hold up of non-Gd_2O_3 powder exists.
- Blend recycled material in blender.
- Drop Gd_2O_3 containing powder to color coded buckets which are used only for powder containing ≥ 1 wt% Gd_2O_3.
- Analyze the first three, the last three and every third bucket for Gd_2O_3 wt% before further processing.

Moderation and enrichment controls are used for the powder portion of the system including the blender, powder preparation equipment and the feed to the pellet press. Slab geometry control as well as the neutron absorption characteristics of the moly boats are used from the pellet press stacker to the grinder line. Once the pellets are stacked on pellet trays, criticality safety relies on the geometry and the carbon steel in the pellet tray.

- NAF Powder Preparation System: the 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood, and vacuum transfer intermediate hood

Criticality safety for the NAF blender and powder preparation equipment is dependent upon restricting the amount of moderator inside the equipment. The only parameters controlled to prevent criticality in the blender and portions of the powder preparation equipment are moderation and enrichment until Gd_2O_3 is added. Geometry control is not practical for the blending portion of the operation due to the need to blend large volumes of material. With the controls on moderation required herein, criticality safety is maintained on a double contingency basis without requiring favorable geometry. Moderation control is also required in the NAF scrap oxidation hood and the certified dry powder storage locations.

Criticality safety in the blender is predicated on maintaining the moisture content of the powder to ≤1 wt.%. The total amount of moderator in the blender is also limited to a maximum of 9.5 kg moisture equivalent until Gd_2O_3 is added.

PART II - SAFETY DEMONSTRATION REV.

Criticality safety in the powder preparation equipment is predicated upon limiting moderation in the UO_x to a maximum of 1 wt.% water equivalent of moisture and approved additive.

<u>Summary of Accident Conditions</u>

There are two general accident scenarios involving moderator intrusion with respect to the blenders: one is getting moderator into the vicinity of the blender and the second involves actually getting moderator into the blender itself.

During accident conditions, three methods exist for moderator intrusion into the vicinity of the blender and vacuum transfer lines. There are 1) liquid spray, 2) liquid floods, and 3) liquid carried in the air.

- Liquid spray can be caused by cracked or broken piping, or by leaks from the roof or the roof drains. Distance covered by a spray leak is a function of hole size, hole shape and location, and fluid pressure. For purposes of this evaluation, the assumption is made that the powder preparation equipment enclosures can be wetted by a leaking roof. Therefore, these enclosures must be capable of deflecting sprays and preventing significant amounts of liquid from getting inside enclosure.

- Floods can result from sprays, if they last long enough, or can result from a major liquid supply line break. The vacuum transfer system of powder to the NAF blender is accomplished by manually operating a vacuum wand. This arrangement allows operator intervention to stop transfers in the event of a flood.

- Moderator content in the air, to the extent that water would be added to the UO_x powder via condensation, can be caused by supersaturating the air from a steam leak and then having moist air drawn into the powder preparation system via the Vac-U-Max™ pneumatic powder transport system. There are no steam sources in room 174.

Metal framed, Lexan™ paneled hoods enclose the hammermill, roll compactor and granulator. Barrels of powder emptied to the blender, or buckets filled below the granulator are also enclosed in hoods during filling and emptying. The hoods' primary purpose is to contain loose UO_x powder and keep airborne uranium concentrations as low as reasonably achievable. However, these enclosures also provide protection against water wetting the powder preparation equipment

enclosed within the hoods. Not all of the doors and penetrations into the hoods are sealed. Nonetheless, selective use of spray shields combined with the equipment enclosures is an effective barrier if a water spray were directed at the hoods. If the floor were to flood, the hoods would provide a barrier to slow the rate of water entry. If water were allowed to continue flooding, it would, however, eventually reach a high enough depth to enter the hoods through the unsealed penetration openings and through some of the doors and could seep into the enclosure where it is attached to the floor pad.

Room 174, where the blender is located, has no water sources in the south portion of the room, thus decreasing the possibility of liquid sprays. Use of water for fire fighting is prohibited in this area and is so identified. Water sources are available in the north portion of Room 174 so flooding into the room is possible. Liquid water detectors on the floor of Room 174 are interlocked to shut down the vacuum transfer system if water is present.

The blender is fabricated from steel but is not totally enclosed in a secondary housing such as a hood. Sample ports, inspection/maintenance ports and Vac-U-Max™ filter ports exist on the blender. Inspection/maintenance ports are opened only when the blender is empty. During operation, all ports are normally closed both to prevent air from leaking into the blender (which could lead to powder oxidation) and to keep UO_x powder from leaking out of the blender (which would lead to high airborne uranium concentrations).

The type of accident that has the greatest impact on criticality safety is getting moderation inside the equipment.

The two limiting conditions involving the blender are: (1) approximately 4.0 wt.% moisture uniformly distributed through a full blender of 4.0 g/cc UO_x powder; and (2) approximately 19 kg of water that is optimally interspersed in a 36 cm diameter sphere of UO_x that is reflected by dry UO_x powder. There are three potential pathways in Room 174 for moderator to get into the blender. The three pathways, which do not include breaching the wall of the blender or deliberate opening of inspection/maintenance ports, are:

1) Vacuum transfer lines into the blender.
2) Vacuum exhaust line.
3) Blender drive system lubricant.

Moderator Entry Via Vacuum Transfer Lines

Excess moderator can get into the blender by transferring powder with a high moderator content and by transferring moderator with the air used to transport the powder. The following defenses are in place to prevent such transfers.

- The powder in the 45-gallon poisoned barrels or 5-gallon buckets has been sampled and confirmed by analysis to contain less than 1.0 wt.% water. Additionally, no more than a total of 9.5 kg of water is allowed in the blender with the UO_2 powder until it contains at least 1.0 wt% Gd_2O_3.

- Uranium powders that have moderating pressing additives are not allowed in the blender, or in hoods that have vacuum lines connected to the blender, without permission from Criticality Safety.

- Drums of UO_x with additives have special controls on labeling and allowable storage locations.

- Normal amounts of additive allowed result in much less than 1.0 wt.% moisture equivalent at normal powder moisture.

- Each transfer line to the blender is equipped with a locking valve which is locked at all times except for during a transfer of confirmed dry powder.

In addition, the following defenses are in place to preclude excess moisture in the vacuum transfer system:

- The two vacuum transfer lines into the blender are moveable vacuum wands that are attended by an operator during transfer;

- The vacuum is interlocked to shut down if the operator leaves his work station.

- No water sources are present in the portion of Room 174 which contains the certified dry powder;

- Water for fire fighting is prohibited in this room.

- Vacuum is interlocked to shut down when fire alarm sounds.

Moderator entry via the vacuum relief line is not credible because the pressure relief device on the blender relieves at about 3.0 psi and it is unlikely that this device will be activated. It is not credible to get water into the blender via this route in part because this route is only open if the blender is at a higher pressure than the room.

Moderator Entry Via the Room 174 Exhaust System

The vacuum exhaust lines from Room 174 discharge to the K-6 exhaust system. The K-6 exhaust system has a significant elevation rise before entering any moderation control areas which prevents intrusion of liquid moderators.

Moderator Entry via the Blender-Drive System Lubricant

The blender drive system contains halocarbon oils and grease. Small amounts of lubricant leaking into the blender are anticipated. However, a 19 Kg leak of lubricant in a short time is not credible given the volume of lubricant used in the system. There are several defenses that prevent large amounts of hydrogenous lubricant from entering the blender.

- ECO inspections will detect significant leaks of lubricant.
- Only trained and authorized maintenance personnel are allowed to service the blender.
- The PM procedure clearly specifies and the blender is clearly posted that only halocarbon lubricants may be used in the blender drive mechanism.
- The lubricant used in the blender has a controlled release to ensure it is not mixed with other lubricants.

• Mezzanine Bucket Storage, Bucket Lift, Bucket Lift Storage Rack, Five Tier Bucket Storage Rack, Bucket Storage Racks for the Powder Preparation Hoods and Bucket Tumblers

Criticality safety in the storage areas depends upon moderation control, enrichment control, mass control and maintenance of adequate spacing. Vertical arrays of 5-gallon buckets are limited to 1 deep by 5 high. Horizontal arrays of 5-gallon buckets are limited to 2 deep by 2 high. Batch size is limited to 45% of minimum critical mass per bucket.

PART II - SAFETY DEMONSTRATION REV.

Summary of Accident Conditions

This analysis of the 5-gallon bucket storage racks in Room 174 considers combined upset conditions of double batching powder allowed in each bucket, double batching moderator in the powder and spacing violations. With these three accident conditions and abnormally high interstitial moderation, the arrays are adequately subcritical ($k_{eff} < 0.95$).

- Pellet Press, Pellet Boat Conveyors and NAF Pellet Boat Transfer Cart

The powder portion of the pellet press area is dependent on enrichment and moderation controls to assure criticality safety. It has been demonstrated that all systems are safe with the maximum credible powder density and at least 8 wt.% moisture in the powder (four times the allowed moisture). Criticality safety in the press area is dependent upon moderation control, geometry control (slab thickness), and the presence of neutron absorbers (in the molybdenum pellet boats) and at least 1 wt% Gd in the pellets.

Summary of Accident Conditions

A powder spill in the UO_2 pellet press hood, about 450 to 500 kg of UO_2 at 4.0 gU/cc and 8 wt.% water is safe in a reflected spherical geometry. Since 300 kg is a conservative upper limit for the powder mass in a drum and since the drum contains not more than 2 wt.% of moisture equivalent, the maximum credible powder spill in the UO_2 press hood has a large safety margin. Because the NAF pellet press is fed by 5-gallon drums rather than 45-gallon barrels, the safety margin is significantly greater in most areas of the NAF process.

The pellet boats rely on geometry control (slab depth) and the neutron absorbing characteristics of the moly boats for criticality safety. Moderation control and Gd_2O_3 neutron absorption are also used for maintaining criticality safety. The pellet boat storage rack and NAF pellet transport cart rely on slab geometry of the pellet boats and the designed vertical spacing. The NAF pellet transport carts maintain moderation and geometry (slab depth) controls if the pellets being transported contain < 1 wt% Gd.

For pellets containing ≥ 1 wt% Gd_2O_3, process control is maintained such that non-Gd containing pellets are not accidentally loaded on the cart in greater than safe batch quantities.

- Sintering Furnace (including the Dust Collector) and Pellet Boat Storage

Criticality safety in the sintering furnace depends upon moderation and geometry (slab depth) controls. Criticality safety in the sintering furnace dust collector depends upon mass control in the collection bucket (which is alarmed to indicate when it is full), moderation control, and process control which results in very small amounts of U-bearing dust being released up the stack.

Criticality safety in pellet boat storage depends upon the presence of neutron absorbers (the molybdenum in the boats), geometry control (slab depth), moderation control and spacing control.

Summary of Accident Conditions

The sintering furnace is modeled as a row of end-to-end pellet boats on a conveyor. Pellets of 100% theoretical density in boats overloaded by 0.5 inch on a square pitch, fully flooded, with close ceramic reflection, were considered. Under these accident conditions, k_{eff} was slightly greater than 0.95. No credible set of conditions exists which would produce an unacceptable k_{eff} in the sintering furnace dust collector.

Analysis of loaded pellet boats in storage racks and on conveyors resulted in the conclusion that all of the following conditions would have to occur simultaneously for an unacceptable k_{eff} to be generated.

- Full loading of all racks and all conveyors (normal).
- Flooding of all boats (abnormal).
- Spacing of the pellets in all boats to produce a V_w/V_f in the region 2.0 to 3.0 (incredible-random pellet spacing will result in a $V_w/V_f < 1.0$).
- Close-fitted full water reflection at all sides and above and below rack plus the equivalent of about 5-10 volume % water between tiers (incredible).
- Overloading of all boats by about 0.5" with moderated pellets (abnormal).
- No spacing between modules of the racks (abnormal).

This set of conditions is judged not to be credible, but the sintered boat storage racks would still be substantially subcritical.

- Grinder Line, NAF Open Face Pellet Storage Rack, Bucket-Pellet Storage Rack, QA Inspection Room, Centrifuge and Centrifuge Reservoir Tank

Criticality safety in these areas relies on geometry control (slab thickness), spacing, moderation control, mass control, and neutron absorption.

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Even with optimum moderation and full water reflection, the maximum k_{eff} for normal operating conditions (ten trays per stack and stacks arranged end-to-end) is 0.74. No single error will produce a condition that is inadequately subcritical in the storage racks. The highest k_{eff} generated during the sensitivity studies (ten trays per stack, stacks arranged side-by-side) was 0.90. These calculations account for he poison effect and spacing control provided by the stainless steel pellet outgas trays.

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The hoods where miscellaneous material processes are performed maintain criticality safety through either moderation, geometry or mass/volume control. The centrifuge bowls have been analyzed in specific geometries combined with materials of construction.

Analyses for the centrifuge bowl demonstrate that limiting the number of centrifuge bowls in the drying hood to a maximum of two assures that $k_{eff} \leq 0.97$.

The moderated bucket grids with one foot spacing meet the accident conditions requirement of $k_{eff} \leq 0.97$.

15.2.2.2 Radiation Protection

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The SF building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the NAF fabrication areas. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

All flammable and combustible liquids of greater than one pint in volume used in the process are stored in fire rated containers.

15.2.2.4 Environmental Safety

Materials processed in the NAF fabrication areas are confined within containers, closed cones/transfer chutes, or ventilation hoods until they have been pressed into pellets. The concrete floors are sealed to be liquid tight and contain no floor drains. The areas are serviced by a "once-through" HVAC system that is continuously monitored for radioactive contamination. The exhaust systems for the area are double HEPA filtered and have deluge systems to protect the final filters from fire.

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Neutron absorber fuel (NAF) fabrication takes place in Rooms 174 and 180 of the Specialty Fuels Building. The process begins with powder preparation and ends with scrap recycle. The major pieces of equipment used in this process include:

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2) Mezzanine bucket storage, bucket lift, bucket lift storage rack, five tier bucket storage rack, and bucket storage racks for the powder preparation hoods and bucket tumblers;

3) The pellet press, pellet boat conveyors and NAF pellet boat transport cart;

4) The grinder line, NAF open face pellet storage rack, bucket-pellet storage rack and QA inspection room;

5) The scrap recovery systems; i.e., a bowl cleaning hood, oven, die lube green scrap hood, burnback hood and moderated storage grid.

6) Sintering boats;

7) Sintering boat storage racks;

8) Sintering furnace; and

9) The sintering furnace dust collector.

The equipment described in 1) - 5) above is located in Room 174. The equipment described in 6) - 9) is located in Room 180.

NAF pellets consist of a mixture of uranium dioxide (UO_2) and gadolinium oxide (Gd_2O_3) pressed and sintered basically the same as the standard UO_2 fuel pellets. Gadolinium oxide is mixed with UO_2 powder to provide the feed for the NAF pelletizing operation.

The function of the NAF powder preparation system is to blend, mill, compact and granulate the mixture of UO_x/Gd_2O_3 powder and special additives in preparation for

pellet pressing. After Operations has determined the total batch of powder to be placed in the blender will contain less than 9.5 kgs of moisture (or, if the powder contains at least 1.0 wt% Gd_2O_3, it may contain up to 1.0 wt% water), the 45 gallon barrel's contents are vacuum transferred to the 10.2 cubic foot dry powder blender. The vacuum transfer system uses room air for the transport medium. The certified dry powder is also transferred from the barrel to five gallon buckets located at the 5-gallon bucket download station south and east of the barrel download station. These 5-gallon buckets of certified dry powder are then taken to the powder additive hood were measured quantities of Gd_2O_3 and zinc stearate are added to the powder, and then placed in the mixer addback hood for vacuum transfer into the 10.2 cubic foot dry powder blender to be mixed with the certified dry powder. Aluminum oxide (Al_2O_3) and recycle material such as UO_2 or U_3O_8 (containing Gd_2O_3) are vacuum transferred to the blender from the add-back hood. The powder is then blended prior to transfer to the hammermill, where it is milled and gravity-fed to the roll compactor and granulator. The powder eventually falls through the transfer chutes into 5-gallon buckets. The buckets are stored in five tier bucket storage rack until pressing. Additional storage for 5-gallon buckets containing Gd is available in the mezzanine bucket storage.

The powder press equipment presses UO_x/Gd_2O_3 powder into "green" pellets which are conveyed from the press table to the stacker where they are loaded into molybdenum ("moly") sintering boats.

Boats of green pellets are transferred from the boat load mechanism in Room 174 to the green boat storage racks and their associated conveyors in Room 180. The boats may also be transferred directly to the sintering furnaces. The boats are transferred from the storage racks or from a cart to a conveyor leading to the sintering furnace. A single line of boats is transferred through the furnace which heats the pellets in a reducing atmosphere.

The boats of sintered pellets from the furnace are transferred either to the boat storage racks and associated conveyors or directly to the grinder area via a system of conveyors and/or carts.

15.2.2.1 Criticality Safety

The equipment in Room 174 has been analyzed to minimize reliance on Gd poison to make operations in NAF as similar as possible to those in the UO_2 building. In addition, the material control of Gd was analyzed to provide redundant double contingency control based on Gd poison. Consequently, operations downstream of the blender have the added assurance of Gd poison.

PART II - SAFETY DEMONSTRATION REV.

The process flow is controlled to assure that the powder contains ≥ 1 wt% Gd_2O_3. Urania powder, certified is contain less than 1.0 wt.% moisture, is downloaded to 5-gallon buckets. A measured amount of Gd_2O_3 is added to these buckets which are then uploaded to the blender. As a minimum the following controls are implemented in SOPs to assure that the resulting powder can be certified to contain ≥ 1 wt% Gd_2O_3:

- Measured amount of Gd_2O_3 added to blender will be ≥ 1 wt%
- After blending the Gd_2O_3 into the powder in the blender, enough powder will be recycled through powder prep equipment back to the blender to assure that no hold up of non-Gd_2O_3 powder exists.
- Blend recycled material in blender.
- Drop Gd_2O_3 containing powder to color coded buckets which are used only for powder containing ≥ 1 wt% Gd_2O_3.
- Analyze the first three, the last three and every third bucket for Gd_2O_3 wt% before further processing.

Moderation and enrichment controls are used for the powder portion of the system including the blender, powder preparation equipment and the feed to the pellet press. Slab geometry control as well as the neutron absorption characteristics of the moly boats are used from the pellet press stacker to the grinder line. Once the pellets are stacked on pellet trays, criticality safety relies on the geometry and the `carbon steel in the pellet tray.

- NAF Powder Preparation System: the 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood, and vacuum transfer intermediate hood

Criticality safety for the NAF blender and powder preparation equipment is dependent upon restricting the amount of moderator inside the equipment. The only parameters controlled to prevent criticality in the blender and portions of the powder preparation equipment are moderation and enrichment until Gd_2O_3 is added. Geometry control is not practical for the blending portion of the operation due to the need to blend large volumes of material. With the controls on moderation required herein, criticality safety is maintained on a double contingency basis without requiring favorable geometry. Moderation control is also required in the NAF scrap oxidation hood and the certified dry powder storage locations.

Criticality safety in the blender is predicated on maintaining the moisture content of the powder to ≤1 wt.%. The total amount of moderator in the blender is also limited to a maximum of 9.5 kg moisture equivalent until Gd_2O_3 is added.

Criticality safety in the powder preparation equipment is predicated upon limiting moderation in the UO_x to a maximum of 1 wt.% water equivalent of moisture and approved additive.

Summary of Accident Conditions

There are two general accident scenarios involving moderator intrusion with respect to the blenders: one is getting moderator into the vicinity of the blender and the second involves actually getting moderator into the blender itself.

During accident conditions, three methods exist for moderator intrusion into the vicinity of the blender and vacuum transfer lines. There are 1) liquid spray, 2) liquid floods, and 3) liquid carried in the air.

- Liquid spray can be caused by cracked or broken piping, or by leaks from the roof or the roof drains. Distance covered by a spray leak is a function of hole size, hole shape and location, and fluid pressure. For purposes of this evaluation, the assumption is made that the powder preparation equipment enclosures can be wetted by a leaking roof. Therefore, these enclosures must be capable of deflecting sprays and preventing significant amounts of liquid from getting inside enclosure.

- Floods can result from sprays, if they last long enough, or can result from a major liquid supply line break. The vacuum transfer system of powder to the NAF blender is accomplished by manually operating a vacuum wand. This arrangement allows operator intervention to stop transfers in the event of a flood.

- Moderator content in the air, to the extent that water would be added to the UO_x powder via condensation, can be caused by supersaturating the air from a steam leak and then having moist air drawn into the powder preparation system via the Vac-U-Max™ pneumatic powder transport system. There are no steam sources in room 174.

Metal framed, Lexan™ paneled hoods enclose the hammermill, roll compactor and granulator. Barrels of powder emptied to the blender, or buckets filled below the granulator are also enclosed in hoods during filling and emptying. The hoods' primary purpose is to contain loose UO_x powder and keep airborne uranium concentrations as low as reasonably achievable. However, these enclosures also provide protection against water wetting the powder preparation equipment

enclosed within the hoods. Not all of the doors and penetrations into the hoods are sealed. Nonetheless, selective use of spray shields combined with the equipment enclosures is an effective barrier if a water spray were directed at the hoods. If the floor were to flood, the hoods would provide a barrier to slow the rate of water entry. If water were allowed to continue flooding, it would, however, eventually reach a high enough depth to enter the hoods through the unsealed penetration openings and through some of the doors and could seep into the enclosure where it is attached to the floor pad.

Room 174, where the blender is located, has no water sources in the south portion of the room, thus decreasing the possibility of liquid sprays. Use of water for fire fighting is prohibited in this area and is so identified. Water sources are available in the north portion of Room 174 so flooding into the room is possible. Liquid water detectors on the floor of Room 174 are interlocked to shut down the vacuum transfer system if water is present.

The blender is fabricated from steel but is not totally enclosed in a secondary housing such as a hood. Sample ports, inspection/maintenance ports and Vac-U-Max™ filter ports exist on the blender. Inspection/maintenance ports are opened only when the blender is empty. During operation, all ports are normally closed both to prevent air from leaking into the blender (which could lead to powder oxidation) and to keep UO_x powder from leaking out of the blender (which would lead to high airborne uranium concentrations).

The type of accident that has the greatest impact on criticality safety is getting moderation inside the equipment.

The two limiting conditions involving the blender are: (1) approximately 4.0 wt.% moisture uniformly distributed through a full blender of 4.0 g/cc UO_x powder; and (2) approximately 19 kg of water that is optimally interspersed in a 36 cm diameter sphere of UO_x that is reflected by dry UO_x powder. There are three potential pathways in Room 174 for moderator to get into the blender. The three pathways, which do not include breaching the wall of the blender or deliberate opening of inspection/maintenance ports, are:

1) Vacuum transfer lines into the blender.
2) Vacuum exhaust line.
3) Blender drive system lubricant.

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<u>Moderator Entry Via Vacuum Transfer Lines</u>

Excess moderator can get into the blender by transferring powder with a high moderator content and by transferring moderator with the air used to transport the powder. The following defenses are in place to prevent such transfers.

- The powder in the 45-gallon poisoned barrels or 5-gallon buckets has been sampled and confirmed by analysis to contain less than 1.0 wt.% water. Additionally, no more than a total of 9.5 kg of water is allowed in the blender with the UO_2 powder until it contains at least 1.0 wt% Gd_2O_3.

- Uranium powders that have moderating pressing additives are not allowed in the blender, or in hoods that have vacuum lines connected to the blender, without permission from Criticality Safety.

- Drums of UO_x with additives have special controls on labeling and allowable storage locations.

- Normal amounts of additive allowed result in much less than 1.0 wt.% moisture equivalent at normal powder moisture.

- Each transfer line to the blender is equipped with a locking valve which is locked at all times except for during a transfer of confirmed dry powder.

In addition, the following defenses are in place to preclude excess moisture in the vacuum transfer system:

- The two vacuum transfer lines into the blender are moveable vacuum wands that are attended by an operator during transfer;

- The vacuum is interlocked to shut down if the operator leaves his work station.

- No water sources are present in the portion of Room 174 which contains the certified dry powder;

- Water for fire fighting is prohibited in this room.

- Vacuum is interlocked to shut down when fire alarm sounds.

Moderator entry via the vacuum relief line is not credible because the pressure relief device on the blender relieves at about 3.0 psi and it is unlikely that this device will be activated. It is not credible to get water into the blender via this route in part because this route is only open if the blender is at a higher pressure than the room.

Moderator Entry Via the Room 174 Exhaust System

The vacuum exhaust lines from Room 174 discharge to the K-6 exhaust system. The K-6 exhaust system has a significant elevation rise before entering any moderation control areas which prevents intrusion of liquid moderators.

Moderator Entry via the Blender-Drive System Lubricant

The blender drive system contains halocarbon oils and grease. Small amounts of lubricant leaking into the blender are anticipated. However, a 19 Kg leak of lubricant in a short time is not credible given the volume of lubricant used in the system. There are several defenses that prevent large amounts of hydrogenous lubricant from entering the blender.

- ECO inspections will detect significant leaks of lubricant.
- Only trained and authorized maintenance personnel are allowed to service the blender.
- The PM procedure clearly specifies and the blender is clearly posted that only halocarbon lubricants may be used in the blender drive mechanism.
- The lubricant used in the blender has a controlled release to ensure it is not mixed with other lubricants.

• Mezzanine Bucket Storage, Bucket Lift, Bucket Lift Storage Rack, Five Tier Bucket Storage Rack, Bucket Storage Racks for the Powder Preparation Hoods and Bucket Tumblers

Criticality safety in the storage areas depends upon moderation control, enrichment control, mass control and maintenance of adequate spacing. Vertical arrays of 5-gallon buckets are limited to 1 deep by 5 high. Horizontal arrays of 5-gallon buckets are limited to 2 deep by 2 high. Batch size is limited to 45% of minimum critical mass per bucket.

Summary of Accident Conditions

This analysis of the 5-gallon bucket storage racks in Room 174 considers combined upset conditions of double batching powder allowed in each bucket, double batching moderator in the powder and spacing violations. With these three accident conditions and abnormally high interstitial moderation, the arrays are adequately subcritical (k_{eff} <0.95).

- Pellet Press, Pellet Boat Conveyors and NAF Pellet Boat Transfer Cart

The powder portion of the pellet press area is dependent on enrichment and moderation controls to assure criticality safety. It has been demonstrated that all systems are safe with the maximum credible powder density and at least 8 wt.% moisture in the powder (four times the allowed moisture). Criticality safety in the press area is dependent upon moderation control, geometry control (slab thickness), and the presence of neutron absorbers (in the molybdenum pellet boats) and at least 1 wt% Gd in the pellets.

Summary of Accident Conditions

A powder spill in the UO_2 pellet press hood, about 450 to 500 kg of UO_2 at 4.0 gU/cc and 8 wt.% water is safe in a reflected spherical geometry. Since 300 kg is a conservative upper limit for the powder mass in a drum and since the drum contains not more than 2 wt.% of moisture equivalent, the maximum credible powder spill in the UO_2 press hood has a large safety margin. Because the NAF pellet press is fed by 5-gallon drums rather than 45-gallon barrels, the safety margin is significantly greater in most areas of the NAF process.

The pellet boats rely on geometry control (slab depth) and the neutron absorbing characteristics of the moly boats for criticality safety. Moderation control and Gd_2O_3 neutron absorption are also used for maintaining criticality safety. The pellet boat storage rack and NAF pellet transport cart rely on slab geometry of the pellet boats and the designed vertical spacing. The NAF pellet transport carts maintain moderation and geometry (slab depth) controls if the pellets being transported contain < 1 wt% Gd.

For pellets containing ≥ 1 wt% Gd_2O_3, process control is maintained such that non-Gd containing pellets are not accidentally loaded on the cart in greater than safe batch quantities.

- Sintering Furnace (including the Dust Collector) and Pellet Boat Storage

Criticality safety in the sintering furnace depends upon moderation and geometry (slab depth) controls. Criticality safety in the sintering furnace dust collector depends upon mass control in the collection bucket (which is alarmed to indicate when it is full), moderation control, and process control which results in very small amounts of U-bearing dust being released up the stack.

Criticality safety in pellet boat storage depends upon the presence of neutron absorbers (the molybdenum in the boats), geometry control (slab depth), moderation control and spacing control.

Summary of Accident Conditions

The sintering furnace is modeled as a row of end-to-end pellet boats on a conveyor. Pellets of 100% theoretical density in boats overloaded by 0.5 inch on a square pitch, fully flooded, with close ceramic reflection, were considered. Under these accident conditions, k_{eff} was slightly greater than 0.95. No credible set of conditions exists which would produce an unacceptable k_{eff} in the sintering furnace dust collector.

Analysis of loaded pellet boats in storage racks and on conveyors resulted in the conclusion that all of the following conditions would have to occur simultaneously for an unacceptable k_{eff} to be generated.

- Full loading of all racks and all conveyors (normal).
- Flooding of all boats (abnormal).
- Spacing of the pellets in all boats to produce a V_w/V_f in the region 2.0 to 3.0 (incredible-random pellet spacing will result in a $V_w/V_f < 1.0$).
- Close-fitted full water reflection at all sides and above and below rack plus the equivalent of about 5-10 volume % water between tiers (incredible).
- Overloading of all boats by about 0.5" with moderated pellets (abnormal).
- No spacing between modules of the racks (abnormal).

This set of conditions is judged not to be credible, but the sintered boat storage racks would still be substantially subcritical.

- Grinder Line, NAF Open Face Pellet Storage Rack, Bucket-Pellet Storage Rack, QA Inspection Room, Centrifuge and Centrifuge Reservoir Tank

Criticality safety in these areas relies on geometry control (slab thickness), spacing, moderation control, mass control, and neutron absorption.

Summary of Accident Conditions

Even with optimum moderation and full water reflection, the maximum k_{eff} for normal operating conditions (ten trays per stack and stacks arranged end-to-end) is 0.74. No single error will produce a condition that is inadequately subcritical in the storage racks. The highest k_{eff} generated during the sensitivity studies (ten trays per stack, stacks arranged side-by-side) was 0.90. These calculations account for he poison effect and spacing control provided by the stainless steel pellet outgas trays.

The grinder line is designed such that the only areas where a significant accumulation of material which could potentially exceed a slab geometry are the feeder bowl and pellet hopper. One boat at a time is manually placed in the boat dumper. This boat is then lifted and tipped so the pallets flow into a sloping feed tray. The pellets are vibrated into the feeder bowl (18 inch diameter by 4 inches high) when a sensor detects that the pellets are running low. Since the system does not automatically dump boats, an operator would have to load and dump boats to exceed the slab height in the feed bowl and the sensor would have to fail. The depth of pellets with significant moderation would have to exceed 5.9 inches before k_{eff} becomes unacceptable. The equipment is enclosed in a hood which facilitates moderation control.

Filling the centrifuge reservoir with > 8 inches of UO_2 slurry was identified as a potential accident condition. The centrifuge removes most of the UO_2. In addition, an overflow which limits the depth of liquid to ≤ 8 inches is a required design feature to preclude overfilling.

The QC inspection room handles small individual samples under slab control and no conditions which could produce an unacceptable k_{eff} are credible.

- Scrap Recovery - Bowl Cleaning Hood, Oven, Moderated Storage Grids and Burnback Hood

The burnback hood relies on moderation control and is bounded by the analysis on the powder preparation equipment. The moderated storage grids rely on spacing and mass control and are documented in the analysis on the pellet press.

Summary of Accident Conditions

The hoods where miscellaneous material processes are performed maintain criticality safety through either moderation, geometry or mass/volume control. The centrifuge bowls have been analyzed in specific geometries combined with materials of construction.

Analyses for the centrifuge bowl demonstrate that limiting the number of centrifuge bowls in the drying hood to a maximum of two assures that $k_{eff} \leq 0.97$.

The moderated bucket grids with one foot spacing meet the accident conditions requirement of $k_{eff} \leq 0.97$.

15.2.2.2 Radiation Protection

The NAF fabrication activities are performed in a limited access radiation controlled area. Personnel are required to wear protective clothing and eye protection while in the area. This area is operated at a pressure slightly below atmospheric to preclude egress of airborne contamination, and extensive use is made of enclosures around process equipment which contains readily dispersible uranium oxide and surface contamination. The air is sampled for radioactivity and evaluated on a frequency determined by historical experience.

15.2.2.3 Fire Protection

The SF building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the NAF fabrication areas. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

All flammable and combustible liquids of greater than one pint in volume used in the process are stored in fire rated containers.

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15.2.2.4 Environmental Safety

Materials processed in the NAF fabrication areas are confined within containers, closed cones/transfer chutes, or ventilation hoods until they have been pressed into pellets. The concrete floors are sealed to be liquid tight and contain no floor drains. The areas are serviced by a "once-through" HVAC system that is continuously monitored for radioactive contamination. The exhaust systems for the area are double HEPA filtered and have deluge systems to protect the final filters from fire.

15.2.2 Neutron Absorber Fuel Fabrication

Neutron absorber fuel (NAF) fabrication takes place in Rooms 174 and 180 of the Specialty Fuels Building. The process begins with powder preparation and ends with scrap recycle. The major pieces of equipment used in this process include:

1) The NAF powder preparation system; i.e., a 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood and vacuum transfer intermediate hood;

2) Mezzanine bucket storage, bucket lift, bucket lift storage rack, five tier bucket storage rack, and bucket storage racks for the powder preparation hoods and bucket tumblers;

3) The pellet press, pellet boat conveyors and NAF pellet boat transport cart;

4) The grinder line, NAF open face pellet storage rack, bucket-pellet storage rack and QA inspection room;

5) The scrap recovery systems; i.e., a bowl cleaning hood, oven, die lube green scrap hood, burnback hood and moderated storage grid.

6) Sintering boats;

7) Sintering boat storage racks;

8) Sintering furnace; and

9) The sintering furnace dust collector.

The equipment described in 1) - 5) above is located in Room 174. The equipment described in 6) - 9) is located in Room 180.

NAF pellets consist of a mixture of uranium dioxide (UO_2) and gadolinium oxide (Gd_2O_3) pressed and sintered basically the same as the standard UO_2 fuel pellets. Gadolinium oxide is mixed with UO_2 powder to provide the feed for the NAF pelletizing operation.

The function of the NAF powder preparation system is to blend, mill, compact and granulate the mixture of UO_x/Gd_2O_3 powder and special additives in preparation for

pellet pressing. After Operations has determined the total batch of powder to be placed in the blender will contain less than 9.5 kgs of moisture (or, if the powder contains at least 1.0 wt% Gd_2O_3, it may contain up to 1.0 wt% water), the 45 gallon barrel's contents are vacuum transferred to the 10.2 cubic foot dry powder blender. The vacuum transfer system uses room air for the transport medium. The certified dry powder is also transferred from the barrel to five gallon buckets located at the 5-gallon bucket download station south and east of the barrel download station. These 5-gallon buckets of certified dry powder are then taken to the powder additive hood were measured quantities of Gd_2O_3 and zinc stearate are added to the powder, and then placed in the mixer addback hood for vacuum transfer into the 10.2 cubic foot dry powder blender to be mixed with the certified dry powder. Aluminum oxide (Al_2O_3) and recycle material such as UO_2 or U_3O_8 (containing Gd_2O_3) are vacuum transferred to the blender from the add-back hood. The powder is then blended prior to transfer to the hammermill, where it is milled and gravity-fed to the roll compactor and granulator. The powder eventually falls through the transfer chutes into 5-gallon buckets. The buckets are stored in five tier bucket storage rack until pressing. Additional storage for 5-gallon buckets containing Gd is available in the mezzanine bucket storage.

The powder press equipment presses UO_x/Gd_2O_3 powder into "green" pellets which are conveyed from the press table to the stacker where they are loaded into molybdenum ("moly") sintering boats.

Boats of green pellets are transferred from the boat load mechanism in Room 174 to the green boat storage racks and their associated conveyors in Room 180. The boats may also be transferred directly to the sintering furnaces. The boats are transferred from the storage racks or from a cart to a conveyor leading to the sintering furnace. A single line of boats is transferred through the furnace which heats the pellets in a reducing atmosphere.

The boats of sintered pellets from the furnace are transferred either to the boat storage racks and associated conveyors or directly to the grinder area via a system of conveyors and/or carts.

15.2.2.1 Criticality Safety

The equipment in Room 174 has been analyzed to minimize reliance on Gd poison to make operations in NAF as similar as possible to those in the UO_2 building. In addition, the material control of Gd was analyzed to provide redundant double contingency control based on Gd poison. Consequently, operations downstream of the blender have the added assurance of Gd poison.

The process flow is controlled to assure that the powder contains ≥ 1 wt% Gd_2O_3. Urania powder, certified is contain less than 1.0 wt.% moisture, is downloaded to 5-gallon buckets. A measured amount of Gd_2O_3 is added to these buckets which are then uploaded to the blender. As a minimum the following controls are implemented in SOPs to assure that the resulting powder can be certified to contain ≥ 1 wt% Gd_2O_3:

- Measured amount of Gd_2O_3 added to blender will be ≥ 1 wt%
- After blending the Gd_2O_3 into the powder in the blender, enough powder will be recycled through powder prep equipment back to the blender to assure that no hold up of non-Gd_2O_3 powder exists.
- Blend recycled material in blender.
- Drop Gd_2O_3 containing powder to color coded buckets which are used only for powder containing ≥ 1 wt% Gd_2O_3.
- Analyze the first three, the last three and every third bucket for Gd_2O_3 wt% before further processing.

Moderation and enrichment controls are used for the powder portion of the system including the blender, powder preparation equipment and the feed to the pellet press. Slab geometry control as well as the neutron absorption characteristics of the moly boats are used from the pellet press stacker to the grinder line. Once the pellets are stacked on pellet trays, criticality safety relies on the geometry and the carbon steel in the pellet tray.

- NAF Powder Preparation System: the 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood, and vacuum transfer intermediate hood

Criticality safety for the NAF blender and powder preparation equipment is dependent upon restricting the amount of moderator inside the equipment. The only parameters controlled to prevent criticality in the blender and portions of the powder preparation equipment are moderation and enrichment until Gd_2O_3 is added. Geometry control is not practical for the blending portion of the operation due to the need to blend large volumes of material. With the controls on moderation required herein, criticality safety is maintained on a double contingency basis without requiring favorable geometry. Moderation control is also required in the NAF scrap oxidation hood and the certified dry powder storage locations.

Criticality safety in the blender is predicated on maintaining the moisture content of the powder to ≤1 wt.%. The total amount of moderator in the blender is also limited to a maximum of 9.5 kg moisture equivalent until Gd_2O_3 is added.

Criticality safety in the powder preparation equipment is predicated upon limiting moderation in the UO_x to a maximum of 1 wt.% water equivalent of moisture and approved additive.

Summary of Accident Conditions

There are two general accident scenarios involving moderator intrusion with respect to the blenders: one is getting moderator into the vicinity of the blender and the second involves actually getting moderator into the blender itself.

During accident conditions, three methods exist for moderator intrusion into the vicinity of the blender and vacuum transfer lines. There are 1) liquid spray, 2) liquid floods, and 3) liquid carried in the air.

- Liquid spray can be caused by cracked or broken piping, or by leaks from the roof or the roof drains. Distance covered by a spray leak is a function of hole size, hole shape and location, and fluid pressure. For purposes of this evaluation, the assumption is made that the powder preparation equipment enclosures can be wetted by a leaking roof. Therefore, these enclosures must be capable of deflecting sprays and preventing significant amounts of liquid from getting inside enclosure.

- Floods can result from sprays, if they last long enough, or can result from a major liquid supply line break. The vacuum transfer system of powder to the NAF blender is accomplished by manually operating a vacuum wand. This arrangement allows operator intervention to stop transfers in the event of a flood.

- Moderator content in the air, to the extent that water would be added to the UO_x powder via condensation, can be caused by supersaturating the air from a steam leak and then having moist air drawn into the powder preparation system via the Vac-U-Max™ pneumatic powder transport system. There are no steam sources in room 174.

Metal framed, Lexan™ paneled hoods enclose the hammermill, roll compactor and granulator. Barrels of powder emptied to the blender, or buckets filled below the granulator are also enclosed in hoods during filling and emptying. The hoods' primary purpose is to contain loose UO_x powder and keep airborne uranium concentrations as low as reasonably achievable. However, these enclosures also provide protection against water wetting the powder preparation equipment

enclosed within the hoods. Not all of the doors and penetrations into the hoods are sealed. Nonetheless, selective use of spray shields combined with the equipment enclosures is an effective barrier if a water spray were directed at the hoods. If the floor were to flood, the hoods would provide a barrier to slow the rate of water entry. If water were allowed to continue flooding, it would, however, eventually reach a high enough depth to enter the hoods through the unsealed penetration openings and through some of the doors and could seep into the enclosure where it is attached to the floor pad.

Room 174, where the blender is located, has no water sources in the south portion of the room, thus decreasing the possibility of liquid sprays. Use of water for fire fighting is prohibited in this area and is so identified. Water sources are available in the north portion of Room 174 so flooding into the room is possible. Liquid water detectors on the floor of Room 174 are interlocked to shut down the vacuum transfer system if water is present.

The blender is fabricated from steel but is not totally enclosed in a secondary housing such as a hood. Sample ports, inspection/maintenance ports and Vac-U-Max™ filter ports exist on the blender. Inspection/maintenance ports are opened only when the blender is empty. During operation, all ports are normally closed both to prevent air from leaking into the blender (which could lead to powder oxidation) and to keep UO_x powder from leaking out of the blender (which would lead to high airborne uranium concentrations).

The type of accident that has the greatest impact on criticality safety is getting moderation inside the equipment.

The two limiting conditions involving the blender are: (1) approximately 4.0 wt.% moisture uniformly distributed through a full blender of 4.0 g/cc UO_x powder; and (2) approximately 19 kg of water that is optimally interspersed in a 36 cm diameter sphere of UO_x that is reflected by dry UO_x powder. There are three potential pathways in Room 174 for moderator to get into the blender. The three pathways, which do not include breaching the wall of the blender or deliberate opening of inspection/maintenance ports, are:

1) Vacuum transfer lines into the blender.
2) Vacuum exhaust line.
3) Blender drive system lubricant.

Moderator Entry Via Vacuum Transfer Lines

Excess moderator can get into the blender by transferring powder with a high moderator content and by transferring moderator with the air used to transport the powder. The following defenses are in place to prevent such transfers.

- The powder in the 45-gallon poisoned barrels or 5-gallon buckets has been sampled and confirmed by analysis to contain less than 1.0 wt.% water. Additionally, no more than a total of 9.5 kg of water is allowed in the blender with the UO_2 powder until it contains at least 1.0 wt% Gd_2O_3.
- Uranium powders that have moderating pressing additives are not allowed in the blender, or in hoods that have vacuum lines connected to the blender, without permission from Criticality Safety.
- Drums of UO_x with additives have special controls on labeling and allowable storage locations.
- Normal amounts of additive allowed result in much less than 1.0 wt.% moisture equivalent at normal powder moisture.
- Each transfer line to the blender is equipped with a locking valve which is locked at all times except for during a transfer of confirmed dry powder.

In addition, the following defenses are in place to preclude excess moisture in the vacuum transfer system:

- The two vacuum transfer lines into the blender are moveable vacuum wands that are attended by an operator during transfer;
- The vacuum is interlocked to shut down if the operator leaves his work station.
- No water sources are present in the portion of Room 174 which contains the certified dry powder;
- Water for fire fighting is prohibited in this room.
- Vacuum is interlocked to shut down when fire alarm sounds.

Moderator entry via the vacuum relief line is not credible because the pressure relief device on the blender relieves at about 3.0 psi and it is unlikely that this device will be activated. It is not credible to get water into the blender via this route in part because this route is only open if the blender is at a higher pressure than the room.

Moderator Entry Via the Room 174 Exhaust System

The vacuum exhaust lines from Room 174 discharge to the K-6 exhaust system. The K-6 exhaust system has a significant elevation rise before entering any moderation control areas which prevents intrusion of liquid moderators.

Moderator Entry via the Blender-Drive System Lubricant

The blender drive system contains halocarbon oils and grease. Small amounts of lubricant leaking into the blender are anticipated. However, a 19 Kg leak of lubricant in a short time is not credible given the volume of lubricant used in the system. There are several defenses that prevent large amounts of hydrogenous lubricant from entering the blender.

- ECO inspections will detect significant leaks of lubricant.
- Only trained and authorized maintenance personnel are allowed to service the blender.
- The PM procedure clearly specifies and the blender is clearly posted that only halocarbon lubricants may be used in the blender drive mechanism.
- The lubricant used in the blender has a controlled release to ensure it is not mixed with other lubricants.

• Mezzanine Bucket Storage, Bucket Lift, Bucket Lift Storage Rack, Five Tier Bucket Storage Rack, Bucket Storage Racks for the Powder Preparation Hoods and Bucket Tumblers

Criticality safety in the storage areas depends upon moderation control, enrichment control, mass control and maintenance of adequate spacing. Vertical arrays of 5-gallon buckets are limited to 1 deep by 5 high. Horizontal arrays of 5-gallon buckets are limited to 2 deep by 2 high. Batch size is limited to 45% of minimum critical mass per bucket.

Summary of Accident Conditions

This analysis of the 5-gallon bucket storage racks in Room 174 considers combined upset conditions of double batching powder allowed in each bucket, double batching moderator in the powder and spacing violations. With these three accident conditions and abnormally high interstitial moderation, the arrays are adequately subcritical ($k_{eff} < 0.95$).

- Pellet Press, Pellet Boat Conveyors and NAF Pellet Boat Transfer Cart

The powder portion of the pellet press area is dependent on enrichment and moderation controls to assure criticality safety. It has been demonstrated that all systems are safe with the maximum credible powder density and at least 8 wt.% moisture in the powder (four times the allowed moisture). Criticality safety in the press area is dependent upon moderation control, geometry control (slab thickness), and the presence of neutron absorbers (in the molybdenum pellet boats) and at least 1 wt% Gd in the pellets.

Summary of Accident Conditions

A powder spill in the UO_2 pellet press hood, about 450 to 500 kg of UO_2 at 4.0 gU/cc and 8 wt.% water is safe in a reflected spherical geometry. Since 300 kg is a conservative upper limit for the powder mass in a drum and since the drum contains not more than 2 wt.% of moisture equivalent, the maximum credible powder spill in the UO_2 press hood has a large safety margin. Because the NAF pellet press is fed by 5-gallon drums rather than 45-gallon barrels, the safety margin is significantly greater in most areas of the NAF process.

The pellet boats rely on geometry control (slab depth) and the neutron absorbing characteristics of the moly boats for criticality safety. Moderation control and Gd_2O_3 neutron absorption are also used for maintaining criticality safety. The pellet boat storage rack and NAF pellet transport cart rely on slab geometry of the pellet boats and the designed vertical spacing. The NAF pellet transport carts maintain moderation and geometry (slab depth) controls if the pellets being transported contain < 1 wt% Gd.

For pellets containing ≥ 1 wt% Gd_2O_3, process control is maintained such that non-Gd containing pellets are not accidentally loaded on the cart in greater than safe batch quantities.

- Sintering Furnace (including the Dust Collector) and Pellet Boat Storage

Criticality safety in the sintering furnace depends upon moderation and geometry (slab depth) controls. Criticality safety in the sintering furnace dust collector depends upon mass control in the collection bucket (which is alarmed to indicate when it is full), moderation control, and process control which results in very small amounts of U-bearing dust being released up the stack.

Criticality safety in pellet boat storage depends upon the presence of neutron absorbers (the molybdenum in the boats), geometry control (slab depth), moderation control and spacing control.

Summary of Accident Conditions

The sintering furnace is modeled as a row of end-to-end pellet boats on a conveyor. Pellets of 100% theoretical density in boats overloaded by 0.5 inch on a square pitch, fully flooded, with close ceramic reflection, were considered. Under these accident conditions, k_{eff} was slightly greater than 0.95. No credible set of conditions exists which would produce an unacceptable k_{eff} in the sintering furnace dust collector.

Analysis of loaded pellet boats in storage racks and on conveyors resulted in the conclusion that all of the following conditions would have to occur simultaneously for an unacceptable k_{eff} to be generated.

- Full loading of all racks and all conveyors (normal).
- Flooding of all boats (abnormal).
- Spacing of the pellets in all boats to produce a V_w/V_f in the region 2.0 to 3.0 (incredible-random pellet spacing will result in a $V_w/V_f < 1.0$).
- Close-fitted full water reflection at all sides and above and below rack plus the equivalent of about 5-10 volume % water between tiers (incredible).
- Overloading of all boats by about 0.5" with moderated pellets (abnormal).
- No spacing between modules of the racks (abnormal).

This set of conditions is judged not to be credible, but the sintered boat storage racks would still be substantially subcritical.

- Grinder Line, NAF Open Face Pellet Storage Rack, Bucket-Pellet Storage Rack, QA Inspection Room, Centrifuge and Centrifuge Reservoir Tank

Criticality safety in these areas relies on geometry control (slab thickness), spacing, moderation control, mass control, and neutron absorption.

Summary of Accident Conditions

Even with optimum moderation and full water reflection, the maximum k_{eff} for normal operating conditions (ten trays per stack and stacks arranged end-to-end) is 0.74. No single error will produce a condition that is inadequately subcritical in the storage racks. The highest k_{eff} generated during the sensitivity studies (ten trays per stack, stacks arranged side-by-side) was 0.90. These calculations account for he poison effect and spacing control provided by the stainless steel pellet outgas trays.

The grinder line is designed such that the only areas where a significant accumulation of material which could potentially exceed a slab geometry are the feeder bowl and pellet hopper. One boat at a time is manually placed in the boat dumper. This boat is then lifted and tipped so the pellets flow into a sloping feed tray. The pellets are vibrated into the feeder bowl (18 inch diameter by 4 inches high) when a sensor detects that the pellets are running low. Since the system does not automatically dump boats, an operator would have to load and dump boats to exceed the slab height in the feed bowl and the sensor would have to fail. The depth of pellets with significant moderation would have to exceed 5.9 inches before k_{eff} becomes unacceptable. The equipment is enclosed in a hood which facilitates moderation control.

Filling the centrifuge reservoir with > 8 inches of UO_2 slurry was identified as a potential accident condition. The centrifuge removes most of the UO_2. In addition, an overflow which limits the depth of liquid to ≤ 8 inches is a required design feature to preclude overfilling.

The QC inspection room handles small individual samples under slab control and no conditions which could produce an unacceptable k_{eff} are credible.

- Scrap Recovery - Bowl Cleaning Hood, Oven, Moderated Storage Grids and Burnback Hood

The burnback hood relies on moderation control and is bounded by the analysis on the powder preparation equipment. The moderated storage grids rely on spacing and mass control and are documented in the analysis on the pellet press.

Summary of Accident Conditions

The hoods where miscellaneous material processes are performed maintain criticality safety through either moderation, geometry or mass/volume control. The centrifuge bowls have been analyzed in specific geometries combined with materials of construction.

Analyses for the centrifuge bowl demonstrate that limiting the number of centrifuge bowls in the drying hood to a maximum of two assures that $k_{eff} \leq 0.97$.

The moderated bucket grids with one foot spacing meet the accident conditions requirement of $k_{eff} \leq 0.97$.

15.2.2.2 Radiation Protection

The NAF fabrication activities are performed in a limited access radiation controlled area. Personnel are required to wear protective clothing and eye protection while in the area. This area is operated at a pressure slightly below atmospheric to preclude egress of airborne contamination, and extensive use is made of enclosures around process equipment which contains readily dispersible uranium oxide and surface contamination. The air is sampled for radioactivity and evaluated on a frequency determined by historical experience.

15.2.2.3 Fire Protection

The SF building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the NAF fabrication areas. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

All flammable and combustible liquids of greater than one pint in volume used in the process are stored in fire rated containers.

15.2.2.4 Environmental Safety

Materials processed in the NAF fabrication areas are confined within containers, closed cones/transfer chutes, or ventilation hoods until they have been pressed into pellets. The concrete floors are sealed to be liquid tight and contain no floor drains. The areas are serviced by a "once-through" HVAC system that is continuously monitored for radioactive contamination. The exhaust systems for the area are double HEPA filtered and have deluge systems to protect the final filters from fire.

15.2.2 Neutron Absorber Fuel Fabrication

Neutron absorber fuel (NAF) fabrication takes place in Rooms 174 and 180 of the Specialty Fuels Building. The process begins with powder preparation and ends with scrap recycle. The major pieces of equipment used in this process include:

1) The NAF powder preparation system; i.e., a 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood and vacuum transfer intermediate hood;

2) Mezzanine bucket storage, bucket lift, bucket lift storage rack, five tier bucket storage rack, and bucket storage racks for the powder preparation hoods and bucket tumblers;

3) The pellet press, pellet boat conveyors and NAF pellet boat transport cart;

4) The grinder line, NAF open face pellet storage rack, bucket-pellet storage rack and QA inspection room;

5) The scrap recovery systems; i.e., a bowl cleaning hood, oven, die lube green scrap hood, burnback hood and moderated storage grid.

6) Sintering boats;

7) Sintering boat storage racks;

8) Sintering furnace; and

9) The sintering furnace dust collector.

The equipment described in 1) - 5) above is located in Room 174. The equipment described in 6) - 9) is located in Room 180.

NAF pellets consist of a mixture of uranium dioxide (UO_2) and gadolinium oxide (Gd_2O_3) pressed and sintered basically the same as the standard UO_2 fuel pellets. Gadolinium oxide is mixed with UO_2 powder to provide the feed for the NAF pelletizing operation.

The function of the NAF powder preparation system is to blend, mill, compact and granulate the mixture of UO_x/Gd_2O_3 powder and special additives in preparation for

pellet pressing. After Operations has determined the total batch of powder to be placed in the blender will contain less than 9.5 kgs of moisture (or, if the powder contains at least 1.0 wt% Gd_2O_3, it may contain up to 1.0 wt% water), the 45 gallon barrel's contents are vacuum transferred to the 10.2 cubic foot dry powder blender. The vacuum transfer system uses room air for the transport medium. The certified dry powder is also transferred from the barrel to five gallon buckets located at the 5-gallon bucket download station south and east of the barrel download station. These 5-gallon buckets of certified dry powder are then taken to the powder additive hood were measured quantities of Gd_2O_3 and zinc stearate are added to the powder, and then placed in the mixer addback hood for vacuum transfer into the 10.2 cubic foot dry powder blender to be mixed with the certified dry powder. Aluminum oxide (Al_2O_3) and recycle material such as UO_2 or U_3O_8 (containing Gd_2O_3) are vacuum transferred to the blender from the add-back hood. The powder is then blended prior to transfer to the hammermill, where it is milled and gravity-fed to the roll compactor and granulator. The powder eventually falls through the transfer chutes into 5-gallon buckets. The buckets are stored in five tier bucket storage rack until pressing. Additional storage for 5-gallon buckets containing Gd is available in the mezzanine bucket storage.

The powder press equipment presses UO_x/Gd_2O_3 powder into "green" pellets which are conveyed from the press table to the stacker where they are loaded into molybdenum ("moly") sintering boats.

Boats of green pellets are transferred from the boat load mechanism in Room 174 to the green boat storage racks and their associated conveyors in Room 180. The boats may also be transferred directly to the sintering furnaces. The boats are transferred from the storage racks or from a cart to a conveyor leading to the sintering furnace. A single line of boats is transferred through the furnace which heats the pellets in a reducing atmosphere.

The boats of sintered pellets from the furnace are transferred either to the boat storage racks and associated conveyors or directly to the grinder area via a system of conveyors and/or carts.

15.2.2.1 Criticality Safety

The equipment in Room 174 has been analyzed to minimize reliance on Gd poison to make operations in NAF as similar as possible to those in the UO_2 building. In addition, the material control of Gd was analyzed to provide redundant double contingency control based on Gd poison. Consequently, operations downstream of the blender have the added assurance of Gd poison.

PART II - SAFETY DEMONSTRATION

REV.

The process flow is controlled to assure that the powder contains ≥ 1 wt% Gd_2O_3. Urania powder, certified is contain less than 1.0 wt.% moisture, is downloaded to 5-gallon buckets. A measured amount of Gd_2O_3 is added to these buckets which are then uploaded to the blender. As a minimum the following controls are implemented in SOPs to assure that the resulting powder can be certified to contain ≥ 1 wt% Gd_2O_3:

- Measured amount of Gd_2O_3 added to blender will be ≥ 1 wt%
- After blending the Gd_2O_3 into the powder in the blender, enough powder will be recycled through powder prep equipment back to the blender to assure that no hold up of non-Gd_2O_3 powder exists.
- Blend recycled material in blender.
- Drop Gd_2O_3 containing powder to color coded buckets which are used only for powder containing ≥ 1 wt% Gd_2O_3.
- Analyze the first three, the last three and every third bucket for Gd_2O_3 wt% before further processing.

Moderation and enrichment controls are used for the powder portion of the system including the blender, powder preparation equipment and the feed to the pellet press. Slab geometry control as well as the neutron absorption characteristics of the moly boats are used from the pellet press stacker to the grinder line. Once the pellets are stacked on pellet trays, criticality safety relies on the geometry and the carbon steel in the pellet tray.

- <u>NAF Powder Preparation System: the 10.2 cubic foot dry powder blender, hammermill, roll compactor, granulator, NAF mixer vacuum fill hood (5-gallon bucket add-back hood), 45-gallon barrel powder vacuum transfer hood, and vacuum transfer intermediate hood</u>

Criticality safety for the NAF blender and powder preparation equipment is dependent upon restricting the amount of moderator inside the equipment. The only parameters controlled to prevent criticality in the blender and portions of the powder preparation equipment are moderation and enrichment until Gd_2O_3 is added. Geometry control is not practical for the blending portion of the operation due to the need to blend large volumes of material. With the controls on moderation required herein, criticality safety is maintained on a double contingency basis without requiring favorable geometry. Moderation control is also required in the NAF scrap oxidation hood and the certified dry powder storage locations.

Criticality safety in the blender is predicated on maintaining the moisture content of the powder to ≤1 wt.%. The total amount of moderator in the blender is also limited to a maximum of 9.5 kg moisture equivalent until Gd_2O_3 is added.

Criticality safety in the powder preparation equipment is predicated upon limiting moderation in the UO_x to a maximum of 1 wt.% water equivalent of moisture and approved additive.

Summary of Accident Conditions

There are two general accident scenarios involving moderator intrusion with respect to the blenders: one is getting moderator into the vicinity of the blender and the second involves actually getting moderator into the blender itself.

During accident conditions, three methods exist for moderator intrusion into the vicinity of the blender and vacuum transfer lines. There are 1) liquid spray, 2) liquid floods, and 3) liquid carried in the air.

- Liquid spray can be caused by cracked or broken piping, or by leaks from the roof or the roof drains. Distance covered by a spray leak is a function of hole size, hole shape and location, and fluid pressure. For purposes of this evaluation, the assumption is made that the powder preparation equipment enclosures can be wetted by a leaking roof. Therefore, these enclosures must be capable of deflecting sprays and preventing significant amounts of liquid from getting inside enclosure.

- Floods can result from sprays, if they last long enough, or can result from a major liquid supply line break. The vacuum transfer system of powder to the NAF blender is accomplished by manually operating a vacuum wand. This arrangement allows operator intervention to stop transfers in the event of a flood.

- Moderator content in the air, to the extent that water would be added to the UO_x powder via condensation, can be caused by supersaturating the air from a steam leak and then having moist air drawn into the powder preparation system via the Vac-U-Max™ pneumatic powder transport system. There are no steam sources in room 174.

Metal framed, Lexan™ paneled hoods enclose the hammermill, roll compactor and granulator. Barrels of powder emptied to the blender, or buckets filled below the granulator are also enclosed in hoods during filling and emptying. The hoods' primary purpose is to contain loose UO_x powder and keep airborne uranium concentrations as low as reasonably achievable. However, these enclosures also provide protection against water wetting the powder preparation equipment

enclosed within the hoods. Not all of the doors and penetrations into the hoods are sealed. Nonetheless, selective use of spray shields combined with the equipment enclosures is an effective barrier if a water spray were directed at the hoods. If the floor were to flood, the hoods would provide a barrier to slow the rate of water entry. If water were allowed to continue flooding, it would, however, eventually reach a high enough depth to enter the hoods through the unsealed penetration openings and through some of the doors and could seep into the enclosure where it is attached to the floor pad.

Room 174, where the blender is located, has no water sources in the south portion of the room, thus decreasing the possibility of liquid sprays. Use of water for fire fighting is prohibited in this area and is so identified. Water sources are available in the north portion of Room 174 so flooding into the room is possible. Liquid water detectors on the floor of Room 174 are interlocked to shut down the vacuum transfer system if water is present.

The blender is fabricated from steel but is not totally enclosed in a secondary housing such as a hood. Sample ports, inspection/maintenance ports and Vac-U-Max™ filter ports exist on the blender. Inspection/maintenance ports are opened only when the blender is empty. During operation, all ports are normally closed both to prevent air from leaking into the blender (which could lead to powder oxidation) and to keep UO_x powder from leaking out of the blender (which would lead to high airborne uranium concentrations).

The type of accident that has the greatest impact on criticality safety is getting moderation inside the equipment.

The two limiting conditions involving the blender are: (1) approximately 4.0 wt.% moisture uniformly distributed through a full blender of 4.0 g/cc UO_x powder; and (2) approximately 19 kg of water that is optimally interspersed in a 36 cm diameter sphere of UO_x that is reflected by dry UO_x powder. There are three potential pathways in Room 174 for moderator to get into the blender. The three pathways, which do not include breaching the wall of the blender or deliberate opening of inspection/maintenance ports, are:

1) Vacuum transfer lines into the blender.
2) Vacuum exhaust line.
3) Blender drive system lubricant.

Moderator Entry Via Vacuum Transfer Lines

Excess moderator can get into the blender by transferring powder with a high moderator content and by transferring moderator with the air used to transport the powder. The following defenses are in place to prevent such transfers.

- The powder in the 45-gallon poisoned barrels or 5-gallon buckets has been sampled and confirmed by analysis to contain less than 1.0 wt.% water. Additionally, no more than a total of 9.5 kg of water is allowed in the blender with the UO_2 powder until it contains at least 1.0 wt% Gd_2O_3.
- Uranium powders that have moderating pressing additives are not allowed in the blender, or in hoods that have vacuum lines connected to the blender, without permission from Criticality Safety.
- Drums of UO_x with additives have special controls on labeling and allowable storage locations.
- Normal amounts of additive allowed result in much less than 1.0 wt.% moisture equivalent at normal powder moisture.
- Each transfer line to the blender is equipped with a locking valve which is locked at all times except for during a transfer of confirmed dry powder.

In addition, the following defenses are in place to preclude excess moisture in the vacuum transfer system:

- The two vacuum transfer lines into the blender are moveable vacuum wands that are attended by an operator during transfer;
- The vacuum is interlocked to shut down if the operator leaves his work station.
- No water sources are present in the portion of Room 174 which contains the certified dry powder;
- Water for fire fighting is prohibited in this room.
- Vacuum is interlocked to shut down when fire alarm sounds.

Moderator entry via the vacuum relief line is not credible because the pressure relief device on the blender relieves at about 3.0 psi and it is unlikely that this device will be activated. It is not credible to get water into the blender via this route in part because this route is only open if the blender is at a higher pressure than the room.

Moderator Entry Via the Room 174 Exhaust System

The vacuum exhaust lines from Room 174 discharge to the K-6 exhaust system. The K-6 exhaust system has a significant elevation rise before entering any moderation control areas which prevents intrusion of liquid moderators.

Moderator Entry via the Blender-Drive System Lubricant

The blender drive system contains halocarbon oils and grease. Small amounts of lubricant leaking into the blender are anticipated. However, a 19 Kg leak of lubricant in a short time is not credible given the volume of lubricant used in the system. There are several defenses that prevent large amounts of hydrogenous lubricant from entering the blender.

- ECO inspections will detect significant leaks of lubricant.
- Only trained and authorized maintenance personnel are allowed to service the blender.
- The PM procedure clearly specifies and the blender is clearly posted that only halocarbon lubricants may be used in the blender drive mechanism.
- The lubricant used in the blender has a controlled release to ensure it is not mixed with other lubricants.

• Mezzanine Bucket Storage, Bucket Lift, Bucket Lift Storage Rack, Five Tier Bucket Storage Rack, Bucket Storage Racks for the Powder Preparation Hoods and Bucket Tumblers

Criticality safety in the storage areas depends upon moderation control, enrichment control, mass control and maintenance of adequate spacing. Vertical arrays of 5-gallon buckets are limited to 1 deep by 5 high. Horizontal arrays of 5-gallon buckets are limited to 2 deep by 2 high. Batch size is limited to 45% of minimum critical mass per bucket.

Summary of Accident Conditions

This analysis of the 5-gallon bucket storage racks in Room 174 considers combined upset conditions of double batching powder allowed in each bucket, double batching moderator in the powder and spacing violations. With these three accident conditions and abnormally high interstitial moderation, the arrays are adequately subcritical (k_{eff} <0.95).

- Pellet Press, Pellet Boat Conveyors and NAF Pellet Boat Transfer Cart

The powder portion of the pellet press area is dependent on enrichment and moderation controls to assure criticality safety. It has been demonstrated that all systems are safe with the maximum credible powder density and at least 8 wt.% moisture in the powder (four times the allowed moisture). Criticality safety in the press area is dependent upon moderation control, geometry control (slab thickness), and the presence of neutron absorbers (in the molybdenum pellet boats) and at least 1 wt% Gd in the pellets.

Summary of Accident Conditions

A powder spill in the UO_2 pellet press hood, about 450 to 500 kg of UO_2 at 4.0 gU/cc and 8 wt.% water is safe in a reflected spherical geometry. Since 300 kg is a conservative upper limit for the powder mass in a drum and since the drum contains not more than 2 wt.% of moisture equivalent, the maximum credible powder spill in the UO_2 press hood has a large safety margin. Because the NAF pellet press is fed by 5-gallon drums rather than 45-gallon barrels, the safety margin is significantly greater in most areas of the NAF process.

The pellet boats rely on geometry control (slab depth) and the neutron absorbing characteristics of the moly boats for criticality safety. Moderation control and Gd_2O_3 neutron absorption are also used for maintaining criticality safety. The pellet boat storage rack and NAF pellet transport cart rely on slab geometry of the pellet boats and the designed vertical spacing. The NAF pellet transport carts maintain moderation and geometry (slab depth) controls if the pellets being transported contain < 1 wt% Gd.

For pellets containing ≥ 1 wt% Gd_2O_3, process control is maintained such that non-Gd containing pellets are not accidentally loaded on the cart in greater than safe batch quantities.

- Sintering Furnace (including the Dust Collector) and Pellet Boat Storage

Criticality safety in the sintering furnace depends upon moderation and geometry (slab depth) controls. Criticality safety in the sintering furnace dust collector depends upon mass control in the collection bucket (which is alarmed to indicate when it is full), moderation control, and process control which results in very small amounts of U-bearing dust being released up the stack.

Criticality safety in pellet boat storage depends upon the presence of neutron absorbers (the molybdenum in the boats), geometry control (slab depth), moderation control and spacing control.

Summary of Accident Conditions

The sintering furnace is modeled as a row of end-to-end pellet boats on a conveyor. Pellets of 100% theoretical density in boats overloaded by 0.5 inch on a square pitch, fully flooded, with close ceramic reflection were considered. Under these accident conditions, k_{eff} was slightly greater than 0.95. No credible set of conditions exists which would produce an unacceptable k_{eff} in the sintering furnace dust collector.

Analysis of loaded pellet boats in storage racks and on conveyors resulted in the conclusion that all of the following conditions would have to occur simultaneously for an unacceptable k_{eff} to be generated.

- Full loading of all racks and all conveyors (normal).
- Flooding of all boats (abnormal).
- Spacing of the pellets in all boats to produce a V_w/V_f in the region 2.0 to 3.0 (incredible-random pellet spacing will result in a $V_w/V_f < 1.0$).
- Close-fitted full water reflection at all sides and above and below rack plus the equivalent of about 5-10 volume % water between tiers (incredible).
- Overloading of all boats by about 0.5" with moderated pellets (abnormal).
- No spacing between modules of the racks (abnormal).

This set of conditions is judged not to be credible, but the sintered boat storage racks would still be substantially subcritical.

- Grinder Line, NAF Open Face Pellet Storage Rack, Bucket-Pellet Storage Rack, QA Inspection Room, Centrifuge and Centrifuge Reservoir Tank

Criticality safety in these areas relies on geometry control (slab thickness), spacing, moderation control, mass control, and neutron absorption.

Summary of Accident Conditions

Even with optimum moderation and full water reflection, the maximum k_{eff} for normal operating conditions (ten trays per stack and stacks arranged end-to-end) is 0.74. No single error will produce a condition that is inadequately subcritical in the storage racks. The highest k_{eff} generated during the sensitivity studies (ten trays per stack, stacks arranged side-by-side) was 0.90. These calculations account for he poison effect and spacing control provided by the stainless steel pellet outgas trays.

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Filling the centrifuge reservoir with > 8 inches of UO_2 slurry was identified as a potential accident condition. The centrifuge removes most of the UO_2. In addition, an overflow which limits the depth of liquid to ≤ 8 inches is a required design feature to preclude overfilling.

The QC inspection room handles small individual samples under slab control and no conditions which could produce an unacceptable k_{eff} are credible.

- Scrap Recovery - Bowl Cleaning Hood, Oven, Moderated Storage Grids and Burnback Hood

The burnback hood relies on moderation control and is bounded by the analysis on the powder preparation equipment. The moderated storage grids rely on spacing and mass control and are documented in the analysis on the pellet press.

Summary of Accident Conditions

The hoods where miscellaneous material processes are performed maintain criticality safety through either moderation, geometry or mass/volume control. The centrifuge bowls have been analyzed in specific geometries combined with materials of construction.

Analyses for the centrifuge bowl demonstrate that limiting the number of centrifuge bowls in the drying hood to a maximum of two assures that $k_{eff} \leq 0.97$.

The moderated bucket grids with one foot spacing meet the accident conditions requirement of $k_{eff} \leq 0.97$.

15.2.2.2 Radiation Protection

The NAF fabrication activities are performed in a limited access radiation controlled area. Personnel are required to wear protective clothing and eye protection while in the area. This area is operated at a pressure slightly below atmospheric to preclude egress of airborne contamination, and extensive use is made of enclosures around process equipment which contains readily dispersible uranium oxide and surface contamination. The air is sampled for radioactivity and evaluated on a frequency determined by historical experience.

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The SF building is rated as noncombustible. Fire loading is kept to a minimum through monthly inspections. Fire extinguishers (dry chemical or CO_2), alarm pull boxes, and heat detectors are strategically placed throughout the NAF fabrication areas. Where moderation control is in place, high expansion foam, dry chemical or CO_2 are required to be used to combat a fire.

All flammable and combustible liquids of greater than one pint in volume used in the process are stored in fire rated containers.

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Materials processed in the NAF fabrication areas are confined within containers, closed cones/transfer chutes, or ventilation hoods until they have been pressed into pellets. The concrete floors are sealed to be liquid tight and contain no floor drains. The areas are serviced by a "once-through" HVAC system that is continuously monitored for radioactive contamination. The exhaust systems for the area are double HEPA filtered and have deluge systems to protect the final filters from fire.

15.3.2 Gadolinia Scrap Recovery

The Gadolinium Scrap Uranium Recovery facility (GSUR) is located in the basement of the ELO Building. The function of GSUR is to purify off-specification uranium streams (solids and liquids), including streams containing gadolinium oxide (gadolinia). Purification is achieved by solvent extraction (SX). The product from solvent extraction is a low uranium concentration uranyl nitrate (UNH) solution in 55 gallon drums that is suitable for addition into the nuclear fuel fabrication process.

The main components of the GSUR process are the:

1) Dissolver tank and hood;
2) Various 9.5 inch ID tanks and filters and MOP sinks
3) Mixer/settlers, carbonate wash tank, and drip pans
4) UNH product barrels
5) Moderated five gallon storage
6) Raffinate storage tanks
7) The facility scrubber system

These components are located in Rooms 51 and 53 of the ELO Building.

15.3.2.1 Criticality Safety

Criticality safety of the equipment included in this process is provided by controlling the uranium mass allowed in the dissolver tank, the geometry of the cylindrical tanks and slab mixer/settlers, the uranium concentrations in scrubber solutions and product drums, and by controlling the reflectors around the process.

- Dissolver Tank and Hood

The batch controlled powder dissolver is located in Room 53 and is the starting point of the operation. UO_x powder is placed in the dissolver where nitric acid is added. Usually, any available UNH that requires purification is blended with the dissolved uranium oxide at this step. The powder dissolver can also be used to produce uranyl nitrate with a controlled free nitrate concentration by combining UNH and nitric acid.

Criticality safety in the dissolver (and hood) is maintained by controlling the mass of the batch operation to 20 kg UO_2 (17.6 kg U) and by limiting the material forms to UO_x and UNH. An inventory sheet is maintained at the hood. The only uranium-bearing feed streams to this process are (1) hand addition of UO_x powder and (2)

low concentration (≤ 140 gU/l) UNH from a five gallon tank. The dissolver itself is an 18 inch tall by 12 inch OD stainless steel tank.

Summary of Accident Conditions

The dissolver hood is controlled for criticality safety purposes to 20 kgs of U. The process is limited to approximately 8 kg per dissolver batch for process reasons. Abnormal conditions include double batching. Double batches (40 kgs - which is about 5 times the process limit) of 5 wt.% enriched UO_2 powder in the dissolver tank, fully reflected, will result in a k_{eff} less than 0.95.

Sensitivity studies show that adding more than 50 kgs of powder with a density near 1.5 g/cc to the dissolver, fully reflected, is needed before unacceptable k_{eff} values are reached in the dissolver. This is a very large margin considering that a normal process batch is about 8 kg and that, because of the dissolver offgas (DOG) system design (including over-flows and drains to other favorable geometry tanks), fissile solutions cannot be transferred to this tank through the DOG header.

- 9.5 Inch ID Tanks; Filters and MOP Sinks in Room 53

The cylindrical tanks used in the solvent extraction (SX) process, which include the SX tanks and the supply and metering tanks, are fabricated from 1/8 inch thick stainless steel. The tank inside diameter is 9½ inches. The lengths of these tanks are either 3'3" or 5'6" depending on where they are located. The bottoms of the tanks are six inches above the floor.

Three types of UNH recycle filters are used in the process: a sock filter that is 9½ inches in diameter by 34 inches long; a basket filter that is about six inches in diameter and 12 inches long; and several cartridge filters which are two inches in diameter and 20 inches long.

A mop sink (filter pan), located in the northeast corner of Room 53, is a four inch deep by 12 inch diameter open topped cylinder welded to a 14 inch long funnel, and is used to filter solids from mop and other waste water. A filter sits inside the top portion of the sink. The overall length is less than 16 inches with a one inch diameter overflow line at the top of the funnel.

Criticality safety in this equipment is maintained by the safe geometry of the vessels and by controlling the enrichment to 5% maximum.

Summary of Accident Condition

System geometry precludes a criticality accident in any of the tanks, filters, or mop sinks discussed in this section. The potential accident interfaces with the DOG scrubber are prevented by overflows installed on each vessel that will routinely contain fissile material and by drain lines on the vessel vent lines to the scrubber. Even if solutions were to get into the scrubber, the concentration will be less than 140 g U/l and would be quickly diluted by the scrubber solution.

- Mixer Settlers, Carbonate Wash Tank, and Drip Pans

The mixer settlers, carbonate wash tank and drip pans are all slab geometry. The carbonate wash slab tank also has a poly-mass that floats on the carbonate to facilitate separation of the organic and carbonate. The mixer settler and carbonate wash tanks are 6.25 inch thick horizontal slab tanks with 0.5 inch overflow holes centered 4.25 inches above the bottom of the tank. The drip pan under the dissolver is ≤ 1 inch deep. All other drip pans are ≤ 4.0 inches deep.

Criticality safety in these vessels is maintained by the safe slab thickness for the uranium forms allowed. Enrichment is also controlled to 5% maximum.

Summary of Accident Conditions

No conditions leading to unacceptable k_{eff} values in these vessels were identified.

- UNH Product Barrel Filling and Storage

After verifying that UNH concentration is less than 140 g U/l, it is pumped to 55-gallon barrels and placed in storage. Criticality safety is maintained by controlling enrichment to 5% maximum and by controlling the uranium concentration in the UNH to a maximum of 140 g U/l (50% of the minimum critical concentration).

Summary of Accident Conditions

The 55-gallon product barrel is an unfavorable geometry. The conditions that could lead to a criticality accident are:

1) Exceeding 289 g U/l in multiple drums stored edge-to-edge;
2) Exceeding 450 g U/l UNH in a single drum; and
3) Exceeding 300 g U/l UO_2-H_2O in a single drum.

The defenses against these accidents include:

- Before UNH can go critical in a 55-gallon drum (23 inch diameter), the U concentration must exceed 450 g U/l. (Minimum critical diameter for 450 g U/l UNH solution is over 25 inches).

- The target solvent extraction feed concentration from the powder dissolver is 200 g U/l.

- The maximum theoretical loading using 100% tri-butyl phosphate (TBP) as the organic is about 435 g U/l.

- The maximum theoretical loading using SPC's Criticality Safety-approved mixture of 30 volume % TBP and 70 volume % dodecane organic is nominally 130 g U/l. The process make up of TBP-dodecane typically will never extract more than 95 g U/l. If organic in the process is loaded to 130 g U/l, the solvent extraction process will not work and this will be detected by the operator.

- The specific gravity of the UNH is measured and confirmed to be within established limits before the UNH is transferred to the drum.

- Moderated 5-gallon Container Storage and Volume Controlled Organic Separator

Five gall n containers are used to store moderated compounds from the GSUR process. Criticality safety depends upon controlling the enrichment to 5% maximum; controlling the mass to one safe batch per container; and maintaining a minimum 12 inch spacing between containers.

Summary of Accident Conditions

Overbatching, flooding (between containers), and spacing violations were considered. Should overbatching occur, k_{eff} is 0.94 for an infinite array of 4 containers on a 23 inch square pitch with a double batched container added in the center. Overbatching is prevented by requiring an inventory label with net wt. and enrichment be affixed to each container. Criticality safety limit cards giving safe batch weights by enrichment are posted at each storage location. Spacing violations are prevented by metal floor grids into which the containers are set. If an array is flooded, the moderator between containers isolates containers from each other, resulting in k_{eff} being that of the individual container; i.e., 0.698 for a single batched container and 0.925 for a double batched container.

- Raffinate Storage Tanks

The raffinate storage tanks in Room 51 are 10-inch Sch. 80 polypropylene pipe with a length of approximately 15 feet. The ID of these tanks is 9.56 inches. The tank wall is ½ inch thick polypropylene reinforced with resin rich fiberglass. The tanks consist of two banks of four tanks each. These tanks are used to store raffinate until the U concentration of the raffinate is verified to meet the limits imposed on Lagoon 3 (1000 ppm) to which the raffinate is discharged.

The raffinate storage tanks are favorable geometry for UNH with concentration up to 1200 g U/l and enrichments up to 6% ^{235}U.

Summary of Accident Conditions

The normal concentration of the raffinate is about 150-250 ppm U. Concentrations of up to 5 g U/l would be the result of a major process upset. Hypothetical upset conditions such as flooding due to a flow reversal can cause the feed to go to the product state with little extraction.

Product can also be discharged to the raffinate tank instead of the product tanks if the organic flow to the solvent extraction process is stopped. The raffinate is transferred to interim receiver tanks where the contents are checked prior to being transferred to the raffinate storage tanks. All of these tanks are favorable geometry tanks. No identified process upset could cause the raffinate storage tank contents to approach the 1200 g U/l modeled.

- ELO Facility Scrubber System

The scrubber system used in the ELO Facility in Room 51 consists of the following components:

1) Dissolver offgas (DOG) scrubber/stripper tanks;
2) Makeup tank;
3) Mystaire scrubber; and
4) Mystaire scrubber surge tank

The DOG receives offgas from the powder dissolver, pellet dissolver, and in the near future a MOP powder dissolver. This offgas is routed to two favorable geometry packed column scrubbers which scrub NO_x from the offgas stream.

A water makeup tank is utilized to maintain the proper amount of water makeup to the system. A continuous bleedoff of scrubbed solution is discharged to the ELO drain system which automatically discharges to Lagoon 3.

The offgas that exits the DOG scrubbers is routed to the POG portion of the system and enters upstream of the Mystaire scrubber. At this point exhaust from the SX slab tanks and product loadout drums is combined with the DOG exhaust and enters the POG scrubber portion of the system. The combined exhaust then passes through a Mystaire scrubber to remove any residual chemical fumes.

Summary of Accident Condition

Large quantities of UO_x in the scrubber pads and sump or filling the Mystaire scrubber with concentrated UNH solution will both result in unacceptable conditions. The only method of getting UO_x into the scrubber is for it to be entrained in the scrubber offgas. The scrubber design ensures that all offgases that have the potential for entrained UO_x powder must be processed through the DOG system before it gets to the POG. It is not credible for significant amounts of UO_x to enter the ELO Mystaire scrubber via this route. Also, the pH of the UNH facility Mystaire scrubber solution is typically less than 3-4. Similar operating conditions in the ELO scrubber prevent solid buildup in the ELO Mystaire scrubber. In addition, the Mystaire scrubber operates with minimal liquid hold up in the sump by design. Multiple overflows provide control of liquid depth in the sump to safe levels.

15.3.2.2 Radiation Protection

Gadolinia scrap recovery is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.2.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the process areas.

15.3.2.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes may be disposed of in special containers distributed throughout the process area. These wastes are treated as hazardous mixed waste as appropriate and periodically transferred to a secured storage area for future disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.2 Gadolinia Scrap Recovery

The Gadolinium Scrap Uranium Recovery facility (GSUR) is located in the basement of the ELO Building. The function of GSUR is to purify off-specification uranium streams (solids and liquids), including streams containing gadolinium oxide (gadolinia). Purification is achieved by solvent extraction (SX). The product from solvent extraction is a low uranium concentration uranyl nitrate (UNH) solution in 55 gallon drums that is suitable for addition into the nuclear fuel fabrication process.

The main components of the GSUR process are the:

1) Dissolver tank and hood;
2) Various 9.5 inch ID tanks and filters and MOP sinks
3) Mixer/settlers, carbonate wash tank, and drip pans
4) UNH product barrels
5) Moderated five gallon storage
6) Raffinate storage tanks
7) The facility scrubber system

These components are located in Rooms 51 and 53 of the ELO Building.

15.3.2.1 Criticality Safety

Criticality safety of the equipment included in this process is provided by controlling the uranium mass allowed in the dissolver tank, the geometry of the cylindrical tanks and slab mixer/settlers, the uranium concentrations in scrubber solutions and product drums, and by controlling the reflectors around the process.

- Dissolver Tank and Hood

The batch controlled powder dissolver is located in Room 53 and is the starting point of the operation. UO_x powder is placed in the dissolver where nitric acid is added. Usually, any available UNH that requires purification is blended with the dissolved uranium oxide at this step. The powder dissolver can also be used to produce uranyl nitrate with a controlled free nitrate concentration by combining UNH and nitric acid.

Criticality safety in the dissolver (and hood) is maintained by controlling the mass of the batch operation to 20 kg UO_2 (17.6 kg U) and by limiting the material forms to UO_x and UNH. An inventory sheet is maintained at the hood. The only uranium-bearing feed streams to this process are (1) hand addition of UO_x powder and (2)

low concentration (≤ 140 gU/l) UNH from a five gallon tank. The dissolver itself is an 18 inch tall by 12 inch OD stainless steel tank.

Summary of Accident Conditions

The dissolver hood is controlled for criticality safety purposes to 20 kgs of U. The process is limited to approximately 8 kg per dissolver batch for process reasons. Abnormal conditions include double batching. Double batches (40 kgs - which is about 5 times the process limit) of 5 wt.% enriched UO_2 powder in the dissolver tank, fully reflected, will result in a k_{eff} less than 0.95.

Sensitivity studies show that adding more than 50 kgs of powder with a density near 1.5 g/cc to the dissolver, fully reflected, is needed before unacceptable k_{eff} values are reached in the dissolver. This is a very large margin considering that a normal process batch is about 8 kg and that, because of the dissolver offgas (DOG) system design (including over-flows and drains to other favorable geometry tanks), fissile solutions cannot be transferred to this tank through the DOG header.

- 9.5 Inch ID Tanks; Filters and MOP Sinks in Room 53

The cylindrical tanks used in the solvent extraction (SX) process, which include the SX tanks and the supply and metering tanks, are fabricated from 1/8 inch thick stainless steel. The tank inside diameter is 9½ inches. The lengths of these tanks are either 3'3" or 5'6" depending on where they are located. The bottoms of the tanks are six inches above the floor.

Three types of UNH recycle filters are used in the process: a sock filter that is 9½ inches in diameter by 34 inches long; a basket filter that is about six inches in diameter and 12 inches long; and several cartridge filters which are two inches in diameter and 20 inches long.

A mop sink (filter pan), located in the northeast corner of Room 53, is a four inch deep by 12 inch diameter open topped cylinder welded to a 14 inch long funnel, and is used to filter solids from mop and other waste water. A filter sits inside the top portion of the sink. The overall length is less than 16 inches with a one inch diameter overflow line at the top of the funnel.

Criticality safety in this equipment is maintained by the safe geometry of the vessels and by controlling the enrichment to 5% maximum.

Summary of Accident Condition

System geometry precludes a criticality accident in any of the tanks, filters, or mop sinks discussed in this section. The potential accident interfaces with the DOG scrubber are prevented by overflows installed on each vessel that will routinely contain fissile material and by drain lines on the vessel vent lines to the scrubber. Even if solutions were to get into the scrubber, the concentration will be less than 140 g U/l and would be quickly diluted by the scrubber solution.

- Mixer Settlers, Carbonate Wash Tank, and Drip Pans

The mixer settlers, carbonate wash tank and drip pans are all slab geometry. The carbonate wash slab tank also has a poly-mass that floats on the carbonate to facilitate separation of the organic and carbonate. The mixer settler and carbonate wash tanks are 6.25 inch thick horizontal slab tanks with 0.5 inch overflow holes centered 4.25 inches above the bottom of the tank. The drip pan under the dissolver is ≤ 1 inch deep. All other drip pans are ≤ 4.0 inches deep.

Criticality safety in these vessels is maintained by the safe slab thickness for the uranium forms allowed. Enrichment is also controlled to 5% maximum.

Summary of Accident Conditions

No conditions leading to unacceptable k_{eff} values in these vessels were identified.

- UNH Product Barrel Filling and Storage

After verifying that UNH concentration is less than 140 g U/l, it is pumped to 55-gallon barrels and placed in storage. Criticality safety is maintained by controlling enrichment to 5% maximum and by controlling the uranium concentration in the UNH to a maximum of 140 g U/l (50% of the minimum critical concentration).

Summary of Accident Conditions

The 55-gallon product barrel is an unfavorable geometry. The conditions that could lead to a criticality accident are:

1) Exceeding 289 g U/l in multiple drums stored edge-to-edge;
2) Exceeding 450 g U/l UNH in a single drum; and
3) Exceeding 300 g U/l UO_2-H_2O in a single drum.

The defenses against these accidents include:

- Before UNH can go critical in a 55-gallon drum (23 inch diameter), the U concentration must exceed 450 g U/l. (Minimum critical diameter for 450 g U/l UNH solution is over 25 inches).

- The target solvent extraction feed concentration from the powder dissolver is 200 g U/l.

- The maximum theoretical loading using 100% tri-butyl phosphate (TBP) as the organic is about 435 g U/l.

- The maximum theoretical loading using SPC's Criticality Safety-approved mixture of 30 volume % TBP and 70 volume % dodecane organic is nominally 130 g U/l. The process make up of TBP-dodecane typically will never extract more than 95 g U/l. If organic in the process is loaded to 130 g U/l, the solvent extraction process will not work and this will be detected by the operator.

- The specific gravity of the UNH is measured and confirmed to be within established limits before the UNH is transferred to the drum.

• <u>Moderated 5-gallon Container Storage and Volume Controlled Organic Separator</u>

Five gallon containers are used to store moderated compounds from the GSUR process. Criticality safety depends upon controlling the enrichment to 5% maximum; controlling the mass to one safe batch per container; and maintaining a minimum 12 inch spacing between containers.

<u>Summary of Accident Conditions</u>

Overbatching, flooding (between containers), and spacing violations were considered. Should overbatching occur, k_{eff} is 0.94 for an infinite array of 4 containers on a 23 inch square pitch with a double batched container added in the center. Overbatching is prevented by requiring an inventory label with net wt. and enrichment be affixed to each container. Criticality safety limit cards giving safe batch weights by enrichment are posted at each storage location. Spacing violations are prevented by metal floor grids into which the containers are set. If an array is flooded, the moderator between containers isolates containers from each other, resulting in k_{eff} being that of the individual container; i.e., 0.698 for a single batched container and 0.925 for a double batched container.

- Raffinate Storage Tanks

The raffinate storage tanks in Room 51 are 10-inch Sch. 80 polypropylene pipe with a length of approximately 15 feet. The ID of these tanks is 9.56 inches. The tank wall is ½ inch thick polypropylene reinforced with resin rich fiberglass. The tanks consist of two banks of four tanks each. These tanks are used to store raffinate until the U concentration of the raffinate is verified to meet the limits imposed on Lagoon 3 (1000 ppm) to which the raffinate is discharged.

The raffinate storage tanks are favorable geometry for UNH with concentration up to 1200 g U/l and enrichments up to 6% ^{235}U.

Summary of Accident Conditions

The normal concentration of the raffinate is about 150-250 ppm U. Concentrations of up to 5 g U/l would be the result of a major process upset. Hypothetical upset conditions such as flooding due to a flow reversal can cause the feed to go to the product state with little extraction.

Product can also be discharged to the raffinate tank instead of the product tanks if the organic flow to the solvent extraction process is stopped. The raffinate is transferred to interim receiver tanks where the contents are checked prior to being transferred to the raffinate storage tanks. All of these tanks are favorable geometry tanks. No identified process upset could cause the raffinate storage tank contents to approach the 1200 g U/l modeled.

- ELO Facility Scrubber System

The scrubber system used in the ELO Facility in Room 51 consists of the following components:

1) Dissolver offgas (DOG) scrubber/stripper tanks;
2) Makeup tank;
3) Mystaire scrubber; and
4) Mystaire scrubber surge tank

The DOG receives offgas from the powder dissolver, pellet dissolver, and in the near future a MOP powder dissolver. This offgas is routed to two favorable geometry packed column scrubbers which scrub NO_x from the offgas stream.

A water makeup tank is utilized to maintain the proper amount of water makeup to the system. A continuous bleedoff of scrubbed solution is discharged to the ELO drain system which automatically discharges to Lagoon 3.

The offgas that exits the DOG scrubbers is routed to the POG portion of the system and enters upstream of the Mystaire scrubber. At this point exhaust from the SX slab tanks and product loadout drums is combined with the DOG exhaust and enters the POG scrubber portion of the system. The combined exhaust then passes through a Mystaire scrubber to remove any residual chemical fumes.

Summary of Accident Condition

Large quantities of UO_x in the scrubber pads and sump or filling the Mystaire scrubber with concentrated UNH solution will both result in unacceptable conditions. The only method of getting UO_x into the scrubber is for it to be entrained in the scrubber offgas. The scrubber design ensures that all offgases that have the potential for entrained UO_x powder must be processed through the DOG system before it gets to the POG. It is not credible for significant amounts of UO_x to enter the ELO Mystaire scrubber via this route. Also, the pH of the UNH facility Mystaire scrubber solution is typically less than 3-4. Similar operating conditions in the ELO scrubber prevent solid buildup in the ELO Mystaire scrubber. In addition, the Mystaire scrubber operates with minimal liquid hold up in the sump by design. Multiple overflows provide control of liquid depth in the sump to safe levels.

15.3.2.2 Radiation Protection

Gadolinia scrap recovery is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.2.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the process areas.

15.3.2.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes may be disposed of in special containers distributed throughout the process area. These wastes are treated as hazardous mixed waste as appropriate and periodically transferred to a secured storage area for future disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.2 Gadolinia Scrap Recovery

The Gadolinium Scrap Uranium Recovery facility (GSUR) is located in the basement of the ELO Building. The function of GSUR is to purify off-specification uranium streams (solids and liquids), including streams containing gadolinium oxide (gadolinia). Purification is achieved by solvent extraction (SX). The product from solvent extraction is a low uranium concentration uranyl nitrate (UNH) solution in 55 gallon drums that is suitable for addition into the nuclear fuel fabrication process.

The main components of the GSUR process are the:

1) Dissolver tank and hood;
2) Various 9.5 inch ID tanks and filters and MOP sinks
3) Mixer/settlers, carbonate wash tank, and drip pans
4) UNH product barrels
5) Moderated five gallon storage
6) Raffinate storage tanks
7) The facility scrubber system

These components are located in Rooms 51 and 53 of the ELO Building.

15.3.2.1 Criticality Safety

Criticality safety of the equipment included in this process is provided by controlling the uranium mass allowed in the dissolver tank, the geometry of the cylindrical tanks and slab mixer/settlers, the uranium concentrations in scrubber solutions and product drums, and by controlling the reflectors around the process.

- Dissolver Tank and Hood

The batch controlled powder dissolver is located in Room 53 and is the starting point of the operation. UO_x powder is placed in the dissolver where nitric acid is added. Usually, any available UNH that requires purification is blended with the dissolved uranium oxide at this step. The powder dissolver can also be used to produce uranyl nitrate with a controlled free nitrate concentration by combining UNH and nitric acid.

Criticality safety of the dissolver (and hood) is maintained by controlling the mass of the batch operation to 20 kg UO_2 (17.6 kg U) and by limiting the material forms to UO_x and UNH. An inventory sheet is maintained at the hood. The only uranium-bearing feed streams to this process are (1) hand addition of UO_x powder and (2)

low concentration (≤ 140 gU/l) UNH from a five gallon tank. The dissolver itself is an 18 inch tall by 12 inch OD stainless steel tank.

Summary of Accident Conditions

The dissolver hood is controlled for criticality safety purposes to 20 kgs of U. The process is limited to approximately 8 kg per dissolver batch for process reasons. Abnormal conditions include double batching. Double batches (40 kgs - which is about 5 times the process limit) of 5 wt.% enriched UO_2 powder in the dissolver tank, fully reflected, will result in a k_{eff} less than 0.95.

Sensitivity studies show that adding more than 50 kgs of powder with a density near 1.5 g/cc to the dissolver, fully reflected, is needed before unacceptable k_{eff} values are reached in the dissolver. This is a very large margin considering that a normal process batch is about 8 kg and that, because of the dissolver offgas (DOG) system design (including over-flows and drains to other favorable geometry tanks), fissile solutions cannot be transferred to this tank through the DOG header.

- 9.5 Inch ID Tanks; Filters and MOP Sinks in Room 53

The cylindrical tanks used in the solvent extraction (SX) process, which include the SX tanks and the supply and metering tanks, are fabricated from 1/8 inch thick stainless steel. The tank inside diameter is 9½ inches. The lengths of these tanks are either 3'3" or 5'6" depending on where they are located. The bottoms of the tanks are six inches above the floor.

Three types of UNH recycle filters are used in the process: a sock filter that is 9½ inches in diameter by 34 inches long; a basket filter that is about six inches in diameter and 12 inches long; and several cartridge filters which are two inches in diameter and 20 inches long.

A mop sink (filter pan), located in the northeast corner of Room 53, is a four inch deep by 12 inch diameter open topped cylinder welded to a 14 inch long funnel, and is used to filter solids from mop and other waste water. A filter sits inside the top portion of the sink. The overall length is less than 16 inches with a one inch diameter overflow line at the top of the funnel.

Criticality safety in this equipment is maintained by the safe geometry of the vessels and by controlling the enrichment to 5% maximum.

Summary of Accident Condition

System geometry precludes a criticality accident in any of the tanks, filters, or mop sinks discussed in this section. The potential accident interfaces with the DOG scrubber are prevented by overflows installed on each vessel that will routinely contain fissile material and by drain lines on the vessel vent lines to the scrubber. Even if solutions were to get into the scrubber, the concentration will be less than 140 g U/l and would be quickly diluted by the scrubber solution.

- Mixer Settlers, Carbonate Wash Tank, and Drip Pans

The mixer settlers, carbonate wash tank and drip pans are all slab geometry. The carbonate wash slab tank also has a poly-mass that floats on the carbonate to facilitate separation of the organic and carbonate. The mixer settler and carbonate wash tanks are 6.25 inch thick horizontal slab tanks with 0.5 inch overflow holes centered 4.25 inches above the bottom of the tank. The drip pan under the dissolver is ≤ 1 inch deep. All other drip pans are ≤ 4.0 inches deep.

Criticality safety in these vessels is maintained by the safe slab thickness for the uranium forms allowed. Enrichment is also controlled to 5% maximum.

Summary of Accident Conditions

No conditions leading to unacceptable k_{eff} values in these vessels were identified.

- UNH Product Barrel Filling and Storage

After verifying that UNH concentration is less than 140 g U/l, it is pumped to 55-gallon barrels and placed in storage. Criticality safety is maintained by controlling enrichment to 5% maximum and by controlling the uranium concentration in the UNH to a maximum of 140 g U/l (50% of the minimum critical concentration).

Summary of Accident Conditions

The 55-gallon product barrel is an unfavorable geometry. The conditions that could lead to a criticality accident are:

1) Exceeding 289 g U/l in multiple drums stored edge-to-edge;
2) Exceeding 450 g U/l UNH in a single drum; and
3) Exceeding 300 g U/l UO_2-H_2O in a single drum.

The defenses against these accidents include:

- Before UNH can go critical in a 55-gallon drum (23 inch diameter), the U concentration must exceed 450 g U/l. (Minimum critical diameter for 450 g U/l UNH solution is over 25 inches).

- The target solvent extraction feed concentration from the powder dissolver is 200 g U/l.

- The maximum theoretical loading using 100% tri-butyl phosphate (TBP) as the organic is about 435 g U/l.

- The maximum theoretical loading using SPC's Criticality Safety-approved mixture of 30 volume % TBP and 70 volume % dodecane organic is nominally 130 g U/l. The process make up of TBP-dodecane typically will never extract more than 95 g U/l. If organic in the process is loaded to 130 g U/l, the solvent extraction process will not work and this will be detected by the operator.

- The specific gravity of the UNH is measured and confirmed to be within established limits before the UNH is transferred to the drum.

- <u>Moderated 5-gallon Container Storage and Volume Controlled Organic Separator</u>

Five gallon containers are used to store moderated compounds from the GSUR process. Criticality safety depends upon controlling the enrichment to 5% maximum; controlling the mass to one safe batch per container; and maintaining a minimum 12 inch spacing between containers.

<u>Summary of Accident Conditions</u>

Overbatching, flooding (between containers), and spacing violations were considered. Should overbatching occur, k_{eff} is 0.94 for an infinite array of 4 containers on a 23 inch square pitch with a double batched container added in the center. Overbatching is prevented by requiring an inventory label with net wt. and enrichment be affixed to each container. Criticality safety limit cards giving safe batch weights by enrichment are posted at each storage location. Spacing violations are prevented by metal floor grids into which the containers are set. If an array is flooded, the moderator between containers isolates containers from each other, resulting in k_{eff} being that of the individual container; i.e., 0.698 for a single batched container and 0.925 for a double batched container.

- Raffinate Storage Tanks

The raffinate storage tanks in Room 51 are 10-inch Sch. 80 polypropylene pipe with a length of approximately 15 feet. The ID of these tanks is 9.56 inches. The tank wall is ½ inch thick polypropylene reinforced with resin rich fiberglass. The tanks consist of two banks of four tanks each. These tanks are used to store raffinate until the U concentration of the raffinate is verified to meet the limits imposed on Lagoon 3 (1000 ppm) to which the raffinate is discharged.

The raffinate storage tanks are favorable geometry for UNH with concentration up to 1200 g U/l and enrichments up to 6% ^{235}U.

Summary of Accident Conditions

The normal concentration of the raffinate is about 150-250 ppm U. Concentrations of up to 5 g U/l would be the result of a major process upset. Hypothetical upset conditions such as flooding due to a flow reversal can cause the feed to go to the product state with little extraction.

Product can also be discharged to the raffinate tank instead of the product tanks if the organic flow to the solvent extraction process is stopped. The raffinate is transferred to interim receiver tanks where the contents are checked prior to being transferred to the raffinate storage tanks. All of these tanks are favorable geometry tanks. No identified process upset could cause the raffinate storage tank contents to approach the 1200 g U/l modeled.

- ELO Facility Scrubber System

The scrubber system used in the ELO Facility in Room 51 consists of the following components:

1) Dissolver offgas (DOG) scrubber/stripper tanks;
2) Makeup tank;
3) Mystaire scrubber; and
4) Mystaire scrubber surge tank

The DOG receives offgas from the powder dissolver, pellet dissolver, and in the near future a MOP powder dissolver. This offgas is routed to two favorable geometry packed column scrubbers which scrub NO_x from the offgas stream.

A water makeup tank is utilized to maintain the proper amount of water makeup to the system. A continuous bleedoff of scrubbed solution is discharged to the ELO drain system which automatically discharges to Lagoon 3.

The offgas that exits the DOG scrubbers is routed to the POG portion of the system and enters upstream of the Mystaire scrubber. At this point exhaust from the SX slab tanks and product loadout drums is combined with the DOG exhaust and enters the POG scrubber portion of the system. The combined exhaust then passes through a Mystaire scrubber to remove any residual chemical fumes.

Summary of Accident Condition

Large quantities of UO_x in the scrubber pads and sump or filling the Mystaire scrubber with concentrated UNH solution will both result in unacceptable conditions. The only method of getting UO_x into the scrubber is for it to be entrained in the scrubber offgas. The scrubber design ensures that all offgases that have the potential for entrained UO_x powder must be processed through the DOG system before it gets to the POG. It is not credible for significant amounts of UO_x to enter the ELO Mystaire scrubber via this route. Also, the pH of the UNH facility Mystaire scrubber solution is typically less than 3-4. Similar operating conditions in the ELO scrubber prevent solid buildup in the ELO Mystaire scrubber. In addition, the Mystaire scrubber operates with minimal liquid hold up in the sump by design. Multiple overflows provide control of liquid depth in the sump to safe levels.

15.3.2.2 Radiation Protection

Gadolinia scrap recovery is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.2.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the process areas.

15.3.2.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes may be disposed of in special containers distributed throughout the process area. These wastes are treated as hazardous mixed waste as appropriate and periodically transferred to a secured storage area for future disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.2 Gadolinia Scrap Recovery

The Gadolinium Scrap Uranium Recovery facility (GSUR) is located in the basement of the ELO Building. The function of GSUR is to purify off-specification uranium streams (solids and liquids), including streams containing gadolinium oxide (gadolinia). Purification is achieved by solvent extraction (SX). The product from solvent extraction is a low uranium concentration uranyl nitrate (UNH) solution in 55 gallon drums that is suitable for addition into the nuclear fuel fabrication process.

The main components of the GSUR process are the:

1) Dissolver tank and hood;
2) Various 9.5 inch ID tanks and filters and MOP sinks
3) Mixer/settlers, carbonate wash tank, and drip pans
4) UNH product barrels
5) Moderated five gallon storage
6) Raffinate storage tanks
7) The facility scrubber system

These components are located in Rooms 51 and 53 of the ELO Building.

15.3.2.1 Criticality Safety

Criticality safety of the equipment included in this process is provided by controlling the uranium mass allowed in the dissolver tank, the geometry of the cylindrical tanks and slab mixer/settlers, the uranium concentrations in scrubber solutions and product drums, and by controlling the reflectors around the process.

- Dissolver Tank and Hood

The batch controlled powder dissolver is located in Room 53 and is the starting point of the operation. UO_x powder is placed in the dissolver where nitric acid is added. Usually, any available UNH that requires purification is blended with the dissolved uranium oxide at this step. The powder dissolver can also be used to produce uranyl nitrate with a controlled free nitrate concentration by combining UNH and nitric acid.

Criticality safety in the dissolver (and hood) is maintained by controlling the mass of the batch operation to 20 kg UO_2 (17.6 kg U) and by limiting the material forms to UO_x and UNH. An inventory sheet is maintained at the hood. The only uranium-bearing feed streams to this process are (1) hand addition of UO_x powder and (2)

low concentration (≤ 140 gU/l) UNH from a five gallon tank. The dissolver itself is an 18 inch tall by 12 inch OD stainless steel tank.

Summary of Accident Conditions

The dissolver hood is controlled for criticality safety purposes to 20 kgs of U. The process is limited to approximately 8 kg per dissolver batch for process reasons. Abnormal conditions include double batching. Double batches (40 kgs - which is about 5 times the process limit) of 5 wt.% enriched UO_2 powder in the dissolver tank, fully reflected, will result in a k_{eff} less than 0.95.

Sensitivity studies show that adding more than 50 kgs of powder with a density near 1.5 g/cc to the dissolver, fully reflected, is needed before unacceptable k_{eff} values are reached in the dissolver. This is a very large margin considering that a normal process batch is about 8 kg and that, because of the dissolver offgas (DOG) system design (including over-flows and drains to other favorable geometry tanks), fissile solutions cannot be transferred to this tank through the DOG header.

- 9.5 Inch ID Tanks; Filters and MOP Sinks in Room 53

The cylindrical tanks used in the solvent extraction (SX) process, which include the SX tanks and the supply and metering tanks, are fabricated from 1/8 inch thick stainless steel. The tank inside diameter is 9½ inches. The lengths of these tanks are either 3'3" or 5'6" depending on where they are located. The bottoms of the tanks are six inches above the floor.

Three types of UNH recycle filters are used in the process: a sock filter that is 9½ inches in diameter by 34 inches long; a basket filter that is about six inches in diameter and 12 inches long; and several cartridge filters which are two inches in diameter and 20 inches long.

A mop sink (filter pan), located in the northeast corner of Room 53, is a four inch deep by 12 inch diameter open topped cylinder welded to a 14 inch long funnel, and is used to filter solids from mop and other waste water. A filter sits inside the top portion of the sink. The overall length is less than 16 inches with a one inch diameter overflow line at the top of the funnel.

Criticality safety in this equipment is maintained by the safe geometry of the vessels and by controlling the enrichment to 5% maximum.

Summary of Accident Condition

System geometry precludes a criticality accident in any of the tanks, filters, or mop sinks discussed in this section. The potential accident interfaces with the DOG scrubber are prevented by overflows installed on each vessel that will routinely contain fissile material and by drain lines on the vessel vent lines to the scrubber. Even if solutions were to get into the scrubber, the concentration will be less than 140 g U/l and would be quickly diluted by the scrubber solution.

- Mixer Settlers, Carbonate Wash Tank, and Drip Pans

The mixer settlers, carbonate wash tank and drip pans are all slab geometry. The carbonate wash slab tank also has a poly-mass that floats on the carbonate to facilitate separation of the organic and carbonate. The mixer settler and carbonate wash tanks are 6.25 inch thick horizontal slab tanks with 0.5 inch overflow holes centered 4.25 inches above the bottom of the tank. The drip pan under the dissolver is ≤ 1 inch deep. All other drip pans are ≤ 4.0 inches deep.

Criticality safety in these vessels is maintained by the safe slab thickness for the uranium forms allowed. Enrichment is also controlled to 5% maximum.

Summary of Accident Conditions

No conditions leading to unacceptable k_{eff} values in these vessels were identified.

- UNH Product Barrel Filling and Storage

After verifying that UNH concentration is less than 140 g U/l, it is pumped to 55-gallon barrels and placed in storage. Criticality safety is maintained by controlling enrichment to 5% maximum and by controlling the uranium concentration in the UNH to a maximum of 140 g U/l (50% of the minimum critical concentration).

Summary of Accident Conditions

The 55-gallon product barrel is an unfavorable geometry. The conditions that could lead to a criticality accident are:

1) Exceeding 289 g U/l in multiple drums stored edge-to-edge;
2) Exceeding 450 g U/l UNH in a single drum; and
3) Exceeding 300 g U/l UO_2-H_2O in a single drum.

The defenses against these accidents include:

- Before UNH can go critical in a 55-gallon drum (23 inch diameter), the U concentration must exceed 450 g U/l. (Minimum critical diameter for 450 g U/l UNH solution is over 25 inches).

- The target solvent extraction feed concentration from the powder dissolver is 200 g U/l.

- The maximum theoretical loading using 100% tri-butyl phosphate (TBP) as the organic is about 435 g U/l.

- The maximum theoretical loading using SPC's Criticality Safety-approved mixture of 30 volume % TBP and 70 volume % dodecane organic is nominally 130 g U/l. The process make up of TBP-dodecane typically will never extract more than 95 g U/l. If organic in the process is loaded to 130 g U/l, the solvent extraction process will not work and this will be detected by the operator.

- The specific gravity of the UNH is measured and confirmed to be within established limits before the UNH is transferred to the drum.

- <u>Moderated 5-gallon Container Storage and Volume Controlled Organic Separator</u>

Five gallon containers are used to store moderated compounds from the GSUR process. Criticality safety depends upon controlling the enrichment to 5% maximum; controlling the mass to one safe batch per container; and maintaining a minimum 12 inch spacing between containers.

<u>Summary of Accident Conditions</u>

Overbatching, flooding (between containers), and spacing violations were considered. Should overbatching occur, k_{eff} is 0.94 for an infinite array of 4 containers on a 23 inch square pitch with a double batched container added in the center. Overbatching is prevented by requiring an inventory label with net wt. and enrichment be affixed to each container. Criticality safety limit cards giving safe batch weights by enrichment are posted at each storage location. Spacing violations are prevented by metal floor grids into which the containers are set. If an array is flooded, the moderator between containers isolates containers from each other, resulting in k_{eff} being that of the individual container; i.e., 0.698 for a single batched container and 0.925 for a double batched container.

- Raffinate Storage Tanks

The raffinate storage tanks in Room 51 are 10-inch Sch. 80 polypropylene pipe with a length of approximately 15 feet. The ID of these tanks is 9.56 inches. The tank wall is ½ inch thick polypropylene reinforced with resin rich fiberglass. The tanks consist of two banks of four tanks each. These tanks are used to store raffinate until the U concentration of the raffinate is verified to meet the limits imposed on Lagoon 3 (1000 ppm) to which the raffinate is discharged.

The raffinate storage tanks are favorable geometry for UNH with concentration up to 1200 g U/l and enrichments up to 6% ^{235}U.

Summary of Accident Conditions

The normal concentration of the raffinate is about 150-250 ppm U. Concentrations of up to 5 g U/l would be the result of a major process upset. Hypothetical upset conditions such as flooding due to a flow reversal can cause the feed to go to the product state with little extraction.

Product can also be discharged to the raffinate tank instead of the product tanks if the organic flow to the solvent extraction process is stopped. The raffinate is transferred to interim receiver tanks where the contents are checked prior to being transferred to the raffinate storage tanks. All of these tanks are favorable geometry tanks. No identified process upset could cause the raffinate storage tank contents to approach the 1200 g U/l modeled.

- ELO Facility Scrubber System

The scrubber system used in the ELO Facility in Room 51 consists of the following components:

1) Dissolver offgas (DOG) scrubber/stripper tanks;
2) Makeup tank;
3) Mystaire scrubber; and
4) Mystaire scrubber surge tank

The DOG receives offgas from the powder dissolver, pellet dissolver, and in the near future a MOP powder dissolver. This offgas is routed to two favorable geometry packed column scrubbers which scrub NO_x from the offgas stream.

A water makeup tank is utilized to maintain the proper amount of water makeup to the system. A continuous bleedoff of scrubbed solution is discharged to the ELO drain system which automatically discharges to Lagoon 3.

The offgas that exits the DOG scrubbers is routed to the POG portion of the system and enters upstream of the Mystaire scrubber. At this point exhaust from the SX slab tanks and product loadout drums is combined with the DOG exhaust and enters the POG scrubber portion of the system. The combined exhaust then passes through a Mystaire scrubber to remove any residual chemical fumes.

Summary of Accident Condition

Large quantities of UO_x in the scrubber pads and sump or filling the Mystaire scrubber with concentrated UNH solution will both result in unacceptable conditions. The only method of getting UO_x into the scrubber is for it to be entrained in the scrubber offgas. The scrubber design ensures that all offgases that have the potential for entrained UO_x powder must be processed through the DOG system before it gets to the POG. It is not credible for significant amounts of UO_x to enter the ELO Mystaire scrubber via this route. Also, the pH of the UNH facility Mystaire scrubber solution is typically less than 3-4. Similar operating conditions in the ELO scrubber prevent solid buildup in the ELO Mystaire scrubber. In addition, the Mystaire scrubber operates with minimal liquid hold up in the sump by design. Multiple overflows provide control of liquid depth in the sump to safe levels.

15.3.2.2 Radiation Protection

Gadolinia scrap recovery is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.2.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the process areas.

15.3.2.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes may be disposed of in special containers distributed throughout the process area. These wastes are treated as hazardous mixed waste as appropriate and periodically transferred to a secured storage area for future disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.2 Gadolinia Scrap Recovery

The Gadolinium Scrap Uranium Recovery facility (GSUR) is located in the basement of the ELO Building. The function of GSUR is to purify off-specification uranium streams (solids and liquids), including streams containing gadolinium oxide (gadolinia). Purification is achieved by solvent extraction (SX). The product from solvent extraction is a low uranium concentration uranyl nitrate (UNH) solution in 55 gallon drums that is suitable for addition into the nuclear fuel fabrication process.

The main components of the GSUR process are the:

1) Dissolver tank and hood;
2) Various 9.5 inch ID tanks and filters and MOP sinks
3) Mixer/settlers, carbonate wash tank, and drip pans
4) UNH product barrels
5) Moderated five gallon storage
6) Raffinate storage tanks
7) The facility scrubber system

These components are located in Rooms 51 and 53 of the ELO Building.

15.3.2.1 Criticality Safety

Criticality safety of the equipment included in this process is provided by controlling the uranium mass allowed in the dissolver tank, the geometry of the cylindrical tanks and slab mixer/settlers, the uranium concentrations in scrubber solutions and product drums, and by controlling the reflectors around the process.

- Dissolver Tank and Hood

The batch controlled powder dissolver is located in Room 53 and is the starting point of the operation. UO_x powder is placed in the dissolver where nitric acid is added. Usually, any available UNH that requires purification is blended with the dissolved uranium oxide at this step. The powder dissolver can also be used to produce uranyl nitrate with a controlled free nitrate concentration by combining UNH and nitric acid.

Criticality safety in the dissolver (and hood) is maintained by controlling the mass of the batch operation to 20 kg UO_2 (17.6 kg U) and by limiting the material forms to UO_x and UNH. An inventory sheet is maintained at the hood. The only uranium-bearing feed streams to this process are (1) hand addition of UO_x powder and (2)

low concentration (≤ 140 gU/l) UNH from a five gallon tank. The dissolver itself is an 18 inch tall by 12 inch OD stainless steel tank.

Summary of Accident Conditions

The dissolver hood is controlled for criticality safety purposes to 20 kgs of U. The process is limited to approximately 8 kg per dissolver batch for process reasons. Abnormal conditions include double batching. Double batches (40 kgs - which is about 5 times the process limit) of 5 wt.% enriched UO_2 powder in the dissolver tank, fully reflected, will result in a k_{eff} less than 0.95.

Sensitivity studies show that adding more than 50 kgs of powder with a density near 1.5 g/cc to the dissolver, fully reflected, is needed before unacceptable k_{eff} values are reached in the dissolver. This is a very large margin considering that a normal process batch is about 8 kg and that, because of the dissolver offgas (DOG) system design (including over-flows and drains to other favorable geometry tanks), fissile solutions cannot be transferred to this tank through the DOG header.

- 9.5 Inch ID Tanks; Filters and MOP Sinks in Room 53

The cylindrical tanks used in the solvent extraction (SX) process, which include the SX tanks and the supply and metering tanks, are fabricated from 1/8 inch thick stainless steel. The tank inside diameter is 9½ inches. The lengths of these tanks are either 3'3" or 5'6" depending on where they are located. The bottoms of the tanks are six inches above the floor.

Three types of UNH recycle filters are used in the process: a sock filter that is 9½ inches in diameter by 34 inches long; a basket filter that is about six inches in diameter and 12 inches long; and several cartridge filters which are two inches in diameter and 20 inches long.

A mop sink (filter pan), located in the northeast corner of Room 53, is a four inch deep by 12 inch diameter open topped cylinder welded to a 14 inch long funnel, and is used to filter solids from mop and other waste water. A filter sits inside the top portion of the sink. The overall length is less than 16 inches with a one inch diameter overflow line at the top of the funnel.

Criticality safety in this equipment is maintained by the safe geometry of the vessels and by controlling the enrichment to 5% maximum.

Summary of Accident Condition

System geometry precludes a criticality accident in any of the tanks, filters, or mop sinks discussed in this section. The potential accident interfaces with the DOG scrubber are prevented by overflows installed on each vessel that will routinely contain fissile material and by drain lines on the vessel vent lines to the scrubber. Even if solutions were to get into the scrubber, the concentration will be less than 140 g U/l and would be quickly diluted by the scrubber solution.

- Mixer Settlers, Carbonate Wash Tank, and Drip Pans

The mixer settlers, carbonate wash tank and drip pans are all slab geometry. The carbonate wash slab tank also has a poly-mass that floats on the carbonate to facilitate separation of the organic and carbonate. The mixer settler and carbonate wash tanks are 6.25 inch thick horizontal slab tanks with 0.5 inch overflow holes centered 4.25 inches above the bottom of the tank. The drip pan under the dissolver is ≤ 1 inch deep. All other drip pans are ≤ 4.0 inches deep.

Criticality safety in these vessels is maintained by the safe slab thickness for the uranium forms allowed. Enrichment is also controlled to 5% maximum.

Summary of Accident Conditions

No conditions leading to unacceptable k_{eff} values in these vessels were identified.

- UNH Product Barrel Filling and Storage

After verifying that UNH concentration is less than 140 g U/l, it is pumped to 55-gallon barrels and placed in storage. Criticality safety is maintained by controlling enrichment to 5% maximum and by controlling the uranium concentration in the UNH to a maximum of 140 g U/l (50% of the minimum critical concentration).

Summary of Accident Conditions

The 55-gallon product barrel is an unfavorable geometry. The conditions that could lead to a criticality accident are:

1) Exceeding 289 g U/l in multiple drums stored edge-to-edge;
2) Exceeding 450 g U/l UNH in a single drum; and
3) Exceeding 300 g U/l UO_2-H_2O in a single drum.

The defenses against these accidents include:

- Before UNH can go critical in a 55-gallon drum (23 inch diameter), the U concentration must exceed 450 g U/l. (Minimum critical diameter for 450 g U/l UNH solution is over 25 inches).

- The target solvent extraction feed concentration from the powder dissolver is 200 g U/l.

- The maximum theoretical loading using 100% tri-butyl phosphate (TBP) as the organic is about 435 g U/l.

- The maximum theoretical loading using SPC's Criticality Safety-approved mixture of 30 volume % TBP and 70 volume % dodecane organic is nominally 130 g U/l. The process make up of TBP-dodecane typically will never extract more than 95 g U/l. If organic in the process is loaded to 130 g U/l, the solvent extraction process will not work and this will be detected by the operator.

- The specific gravity of the UNH is measured and confirmed to be within established limits before the UNH is transferred to the drum.

- Moderated 5-gallon Container Storage and Volume Controlled Organic Separator

Five gallon containers are used to store moderated compounds from the GSUR process. Criticality safety depends upon controlling the enrichment to 5% maximum; controlling the mass to one safe batch per container; and maintaining a minimum 12 inch spacing between containers.

Summary of Accident Conditions

Overbatching, flooding (between containers), and spacing violations were considered. Should overbatching occur, k_{eff} is 0.94 for an infinite array of 4 containers on a 23 inch square pitch with a double batched container added in the center. Overbatching is prevented by requiring an inventory label with net wt. and enrichment be affixed to each container. Criticality safety limit cards giving safe batch weights by enrichment are posted at each storage location. Spacing violations are prevented by metal floor grids into which the containers are set. If an array is flooded, the moderator between containers isolates containers from each other, resulting in k_{eff} being that of the individual container; i.e., 0.698 for a single batched container and 0.925 for a double batched container.

- Raffinate Storage Tanks

The raffinate storage tanks in Room 51 are 10-inch Sch. 80 polypropylene pipe with a length of approximately 15 feet. The ID of these tanks is 9.56 inches. The tank wall is ½ inch thick polypropylene reinforced with resin rich fiberglass. The tanks consist of two banks of four tanks each. These tanks are used to store raffinate until the U concentration of the raffinate is verified to meet the limits imposed on Lagoon 3 (1000 ppm) to which the raffinate is discharged.

The raffinate storage tanks are favorable geometry for UNH with concentration up to 1200 g U/l and enrichments up to 6% ^{235}U.

Summary of Accident Conditions

The normal concentration of the raffinate is about 150-250 ppm U. Concentrations of up to 5 g U/l would be the result of a major process upset. Hypothetical upset conditions such as flooding due to a flow reversal can cause the feed to go to the product state with little extraction.

Product can also be discharged to the raffinate tank instead of the product tanks if the organic flow to the solvent extraction process is stopped. The raffinate is transferred to interim receiver tanks where the contents are checked prior to being transferred to the raffinate storage tanks. All of these tanks are favorable geometry tanks. No identified process upset could cause the raffinate storage tank contents to approach the 1200 g U/l modeled.

- ELO Facility Scrubber System

The scrubber system used in the ELO Facility in Room 51 consists of the following components:

1) Dissolver offgas (DOG) scrubber/stripper tanks;
2) Makeup tank;
3) Mystaire scrubber; and
4) Mystaire scrubber surge tank

The DOG receives offgas from the powder dissolver, pellet dissolver, and in the near future a MOP powder dissolver. This offgas is routed to two favorable geometry packed column scrubbers which scrub NO_x from the offgas stream.

A water makeup tank is utilized to maintain the proper amount of water makeup to the system. A continuous bleedoff of scrubbed solution is discharged to the ELO drain system which automatically discharges to Lagoon 3.

The offgas that exits the DOG scrubbers is routed to the POG portion of the system and enters upstream of the Mystaire scrubber. At this point exhaust from the SX slab tanks and product loadout drums is combined with the DOG exhaust and enters the POG scrubber portion of the system. The combined exhaust then passes through a Mystaire scrubber to remove any residual chemical fumes.

Summary of Accident Condition

Large quantities of UO_x in the scrubber pads and sump or filling the Mystaire scrubber with concentrated UNH solution will both result in unacceptable conditions. The only method of getting UO_x into the scrubber is for it to be entrained in the scrubber offgas. The scrubber design ensures that all offgases that have the potential for entrained UO_x powder must be processed through the DOG system before it gets to the POG. It is not credible for significant amounts of UO_x to enter the ELO Mystaire scrubber via this route. Also, the pH of the UNH facility Mystaire scrubber solution is typically less than 3-4. Similar operating conditions in the ELO scrubber prevent solid buildup in the ELO Mystaire scrubber. In addition, the Mystaire scrubber operates with minimal liquid hold up in the sump by design. Multiple overflows provide control of liquid depth in the sump to safe levels.

15.3.2.2 Radiation Protection

Gadolinia scrap recovery is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.2.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the process areas.

15.3.2.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes may be disposed of in special containers distributed throughout the process area. These wastes are treated as hazardous mixed waste as appropriate and periodically transferred to a secured storage area for future disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

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The Gadolinium Scrap Uranium Recovery facility (GSUR) is located in the basement of the ELO Building. The function of GSUR is to purify off-specification uranium streams (solids and liquids), including streams containing gadolinium oxide (gadolinia). Purification is achieved by solvent extraction (SX). The product from solvent extraction is a low uranium concentration uranyl nitrate (UNH) solution in 55 gallon drums that is suitable for addition into the nuclear fuel fabrication process.

The main components of the GSUR process are the:

1) Dissolver tank and hood;
2) Various 9.5 inch ID tanks and filters and MOP sinks
3) Mixer/settlers, carbonate wash tank, and drip pans
4) UNH product barrels
5) Moderated five gallon storage
6) Raffinate storage tanks
7) The facility scrubber system

These components are located in Rooms 51 and 53 of the ELO Building.

15.3.2.1 Criticality Safety

Criticality safety of the equipment included in this process is provided by controlling the uranium mass allowed in the dissolver tank, the geometry of the cylindrical tanks and slab mixer/settlers, the uranium concentrations in scrubber solutions and product drums, and by controlling the reflectors around the process.

- Dissolver Tank and Hood

The batch controlled powder dissolver is located in Room 53 and is the starting point of the operation. UO_x powder is placed in the dissolver where nitric acid is added. Usually, any available UNH that requires purification is blended with the dissolved uranium oxide at this step. The powder dissolver can also be used to produce uranyl nitrate with a controlled free nitrate concentration by combining UNH and nitric acid.

Criticality safety in the dissolver (and hood) is maintained by controlling the mass of the batch operation to 20 kg UO_2 (17.6 kg U) and by limiting the material forms to UO_x and UNH. An inventory sheet is maintained at the hood. The only uranium-bearing feed streams to this process are (1) hand addition of UO_x powder and (2)

low concentration (≤ 140 gU/l) UNH from a five gallon tank. The dissolver itself is an 18 inch tall by 12 inch OD stainless steel tank.

Summary of Accident Conditions

The dissolver hood is controlled for criticality safety purposes to 20 kgs of U. The process is limited to approximately 8 kg per dissolver batch for process reasons. Abnormal conditions include double batching. Double batches (40 kgs - which is about 5 times the process limit) of 5 wt.% enriched UO_2 powder in the dissolver tank, fully reflected, will result in a k_{eff} less than 0.95.

Sensitivity studies show that adding more than 50 kgs of powder with a density near 1.5 g/cc to the dissolver, fully reflected, is needed before unacceptable k_{eff} values are reached in the dissolver. This is a very large margin considering that a normal process batch is about 8 kg and that, because of the dissolver offgas (DOG) system design (including over-flows and drains to other favorable geometry tanks), fissile solutions cannot be transferred to this tank through the DOG header.

- 9.5 Inch ID Tanks; Filters and MOP Sinks in Room 53

The cylindrical tanks used in the solvent extraction (SX) process, which include the SX tanks and the supply and metering tanks, are fabricated from 1/8 inch thick stainless steel. The tank inside diameter is 9½ inches. The lengths of these tanks are either 3'3" or 5'6" depending on where they are located. The bottoms of the tanks are six inches above the floor.

Three types of UNH recycle filters are used in the process: a sock filter that is 9½ inches in diameter by 34 inches long; a basket filter that is about six inches in diameter and 12 inches long; and several cartridge filters which are two inches in diameter and 20 inches long.

A mop sink (filter pan), located in the northeast corner of Room 53, is a four inch deep by 12 inch diameter open topped cylinder welded to a 14 inch long funnel, and is used to filter solids from mop and other waste water. A filter sits inside the top portion of the sink. The overall length is less than 16 inches with a one inch diameter overflow line at the top of the funnel.

Criticality safety in this equipment is maintained by the safe geometry of the vessels and by controlling the enrichment to 5% maximum.

Summary of Accident Condition

System geometry precludes a criticality accident in any of the tanks, filters, or mop sinks discussed in this section. The potential accident interfaces with the DOG scrubber are prevented by overflows installed on each vessel that will routinely contain fissile material and by drain lines on the vessel vent lines to the scrubber. Even if solutions were to get into the scrubber, the concentration will be less than 140 g U/l and would be quickly diluted by the scrubber solution.

- Mixer Settlers, Carbonate Wash Tank, and Drip Pans

The mixer settlers, carbonate wash tank and drip pans are all slab geometry. The carbonate wash slab tank also has a poly-mass that floats on the carbonate to facilitate separation of the organic and carbonate. The mixer settler and carbonate wash tanks are 6.25 inch thick horizontal slab tanks with 0.5 inch overflow holes centered 4.25 inches above the bottom of the tank. The drip pan under the dissolver is ≤ 1 inch deep. All other drip pans are ≤ 4.0 inches deep.

Criticality safety in these vessels is maintained by the safe slab thickness for the uranium forms allowed. Enrichment is also controlled to 5% maximum.

Summary of Accident Conditions

No conditions leading to unacceptable k_{eff} values in these vessels were identified.

- UNH Product Barrel Filling and Storage

After verifying that UNH concentration is less than 140 g U/l, it is pumped to 55-gallon barrels and placed in storage. Criticality safety is maintained by controlling enrichment to 5% maximum and by controlling the uranium concentration in the UNH to a maximum of 140 g U/l (50% of the minimum critical concentration).

Summary of Accident Conditions

The 55-gallon product barrel is an unfavorable geometry. The conditions that could lead to a criticality accident are:

1) Exceeding 289 g U/l in multiple drums stored edge-to-edge;
2) Exceeding 450 g U/l UNH in a single drum; and
3) Exceeding 300 g U/l UO_2-H_2O in a single drum.

The defenses against these accidents include:

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- Before UNH can go critical in a 55-gallon drum (23 inch diameter), the U concentration must exceed 450 g U/l. (Minimum critical diameter for 450 g U/l UNH solution is over 25 inches).

- The target solvent extraction feed concentration from the powder dissolver is 200 g U/l.

- The maximum theoretical loading using 100% tri-butyl phosphate (TBP) as the organic is about 435 g U/l.

- The maximum theoretical loading using SPC's Criticality Safety-approved mixture of 30 volume % TBP and 70 volume % dodecane organic is nominally 130 g U/l. The process make up of TBP-dodecane typically will never extract more than 95 g U/l. If organic in the process is loaded to 130 g U/l, the solvent extraction process will not work and this will be detected by the operator.

- The specific gravity of the UNH is measured and confirmed to be within established limits before the UNH is transferred to the drum.

• <u>Moderated 5-gallon Container Storage and Volume Controlled Organic Separator</u>

Five gallon containers are used to store moderated compounds from the GSUR process. Criticality safety depends upon controlling the enrichment to 5% maximum; controlling the mass to one safe batch per container; and maintaining a minimum 12 inch spacing between containers.

<u>Summary of Accident Conditions</u>

Overbatching, flooding (between containers), and spacing violations were considered. Should overbatching occur, k_{eff} is 0.94 for an infinite array of 4 containers on a 23 inch square pitch with a double batched container added in the center. Overbatching is prevented by requiring an inventory label with net wt. and enrichment be affixed to each container. Criticality safety limit cards giving safe batch weights by enrichment are posted at each storage location. Spacing violations are prevented by metal floor grids into which the containers are set. If an array is flooded, the moderator between containers isolates containers from each other, resulting in k_{eff} being that of the individual container; i.e., 0.698 for a single batched container and 0.925 for a double batched container.

- Raffinate Storage Tanks

The raffinate storage tanks in Room 51 are 10-inch Sch. 80 polypropylene pipe with a length of approximately 15 feet. The ID of these tanks is 9.56 inches. The tank wall is ½ inch thick polypropylene reinforced with resin rich fiberglass. The tanks consist of two banks of four tanks each. These tanks are used to store raffinate until the U concentration of the raffinate is verified to meet the limits imposed on Lagoon 3 (1000 ppm) to which the raffinate is discharged.

The raffinate storage tanks are favorable geometry for UNH with concentration up to 1200 g U/l and enrichments up to 6%^{235}U.

Summary of Accident Conditions

The normal concentration of the raffinate is about 150-250 ppm U. Concentrations of up to 5 g U/l would be the result of a major process upset. Hypothetical upset conditions such as flooding due to a flow reversal can cause the feed to go to the product state with little extraction

Product can also be discharged to the [illegible]nate tank instead of the product tanks if the organic flow to the solvent extraction process is stopped. The raffinate is transferred to interim receiver tanks where the contents are checked prior to being transferred to the raffinate storage tanks. All of these tanks are favorable geometry tanks. No identified process upset could cause the raffinate storage tank contents to approach the 1200 g U/l modeled.

- ELO Facility Scrubber System

The scrubber system used in the ELO Facility in Room 51 consists of the following components:

1) Dissolver offgas (DOG) scrubber/stripper tanks;
2) Makeup tank;
3) Mystaire scrubber; and
4) Mystaire scrubber surge tank

The DOG receives offgas from the powder dissolver, pellet dissolver, and in the near future a MOP powder dissolver. This offgas is routed to two favorable geometry packed column scrubbers which scrub NO_x from the offgas stream.

A water makeup tank is utilized to maintain the proper amount of water makeup to the system. A continuous bleedoff of scrubbed solution is discharged to the ELO drain system which automatically discharges to Lagoon 3.

The offgas that exits the DOG scrubbers is routed to the POG portion of the system and enters upstream of the Mystaire scrubber. At this point exhaust from the SX slab tanks and product loadout drums is combined with the DOG exhaust and enters the POG scrubber portion of the system. The combined exhaust then passes through a Mystaire scrubber to remove any residual chemical fumes.

Summary of Accident Condition

Large quantities of UO_x in the scrubber pads and sump or filling the Mystaire scrubber with concentrated UNH solution will both result in unacceptable conditions. The only method of getting UO_x into the scrubber is for it to be entrained in the scrubber offgas. The scrubber design ensures that all offgases that have the potential for entrained UO_x powder must be processed through the DOG system before it gets to the POG. It is not credible for significant amounts of UO_x to enter the ELO Mystaire scrubber via this route. Also, the pH of the UNH facility Mystaire scrubber solution is typically less than 3-4. Similar operating conditions in the ELO scrubber prevent solid buildup in the ELO Mystaire scrubber. In addition, the Mystaire scrubber operates with minimal liquid hold up in the sump by design. Multiple overflows provide control of liquid depth in the sump to safe levels.

15.3.2.2 Radiation Protection

Gadolinia scrap recovery is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by extensive use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.2.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the process areas.

15.3.2.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes may be disposed of in special containers distributed throughout the process area. These wastes are treated as hazardous mixed waste as appropriate and periodically transferred to a secured storage area for future disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.4 Mop Powder Dissolution

Mop water produced on plant is dumped into mop sinks where, after being screened for large objects such as pellets, etc., it is sent to the Miscellaneous Uranium Recovery System (MURS) in the UO_2 Building where the uranium-bearing solids are precipitated, centrifuged, collected and placed into an oven for drying. The resulting powder is then milled and stored in containers in the building.

Dissolution of the mop powder produced at MURS takes place in the basement of the ELO Building. Nitric acid solution is added to the powder in a dissolver tank in the dissolution hood. Water is added to the tank to adjust the uranium concentration to about 200 grams per liter. The tank is then moved to a settling area in Room 56 for the "red mud" solids to settle. After the solids have settled in the tank, the tank is moved to a decant station where the clear UNH is withdrawn from the tank and pumped to the solvent extraction system for processing. The red mud slurry left over is then pumped into an 18-liter carboy. The red mud will either undergo uranium precipitation or it will be burned-back in the MURS oven. Alternatively, it may be pumped back into a dissolver tank for additional settling and decanting.

The equipment is located in Room 58 in the ELO Building and consists of:

1. Dissolver tanks
2. Dissolution hood
3. 18-liter carboys for storage and on-plant transport of red mud heels

15.3.4.1 Criticality Safety

The mop powder dissolution process is acceptably subcritical for normal operations and for all credible abnormal conditions. The dissolver tanks and carboys are of favorable geometry for homogeneous uranium compounds. The dissolver tanks are designed such that the base and the cart to which they are attached provide the required spacing between them. Due to the possibility of a spill, the contents of the dissolver are limited to 20 kilograms of uranium compounds.

All Equipment

The dissolver tanks are nine inch OD by 48 inch high vertical cylinders welded to a 23 inch diameter base which is permanently attached to a cart with a minimum width of 32 inches. The bases are designed to preclude overlapping. The tanks are critically safe for 5% enriched uranium compounds and are also limited to less than a minimum critical mass (20 kg).

Carboys, which hold approximately eighteen liters, are to be used only for red mud. They are handled according to the requirements for plastic five-gallon buckets (enrichment and spacing limits) with the exception that they are exempt from any mass limit because the process removes all but trace amounts of uranium.

Summary of Accident Conditions

The only scenario in which a criticality is possible is if the contents of a more than a double-batched dissolver tank spills and the contents form a fully reflected, optimally moderated sphere with a mass of uranium compounds greater than 40 kilograms. This condition is prevented by placing a limit on the quantity of uranium that may be placed into the dissolver tanks. The operational limit is 10 kilograms. Therefore, to exceed 40 kilograms would require more than twice the criticality safety limits and approximately four times the operational limit of uranium in the tank. The second control is the fact that the tanks are mounted onto a special cart so spilling a tank is unlikely. Also, the tank lid is required to be in-place with the vent and decant ports plugged during transit. If a tank is tipped over, an operator can right the tank before a significant quantity of liquid can spill out. Finally, the possibility of the spilled liquid content assuming a spherical shape and being fully reflected is very small.

15.3.4.2 Radiation Protection

Mop powder dissolution is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by use of closed containers and by the use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.4.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the mop powder dissolver area and the rest of the ELO Building.

15.3.4.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes such as solvent contaminated rags from the controlled areas are disposed of in special containers distributed throughout the processing areas. The rags are treated as hazardous mixed hazardous waste as appropriate and periodically transferred to a secured storage area for future processing/disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.4 Mop Powder Dissolution

Mop water produced on plant is dumped into mop sinks where, after being screened for large objects such as pellets, etc., it is sent to the Miscellaneous Uranium Recovery System (MURS) in the UO_2 Building where the uranium-bearing solids are precipitated, centrifuged, collected and placed into an oven for drying. The resulting powder is then milled and stored in containers in the building.

Dissolution of the mop powder produced at MURS takes place in the basement of the ELO Building. Nitric acid solution is added to the powder in a dissolver tank in the dissolution hood. Water is added to the tank to adjust the uranium concentration to about 200 grams per liter. The tank is then moved to a settling area in Room 56 for the "red mud" solids to settle. After the solids have settled in the tank, the tank is moved to a decant station where the clear UNH is withdrawn from the tank and pumped to the solvent extraction system for processing. The red mud slurry left over is then pumped into an 18-liter carboy. The red mud will either undergo uranium precipitation or it will be burned-back in the MURS oven. Alternatively, it may be pumped back into a dissolver tank for additional settling and decanting.

The equipment is located in Room 58 in the ELO Building and consists of:

1. Dissolver tanks
2. Dissolution hood
3. 18-liter carboys for storage and on-plant transport of red mud heels

15.3.4.1 Criticality Safety

The mop powder dissolution process is acceptably subcritical for normal operations and for all credible abnormal conditions. The dissolver tanks and carboys are of favorable geometry for homogeneous uranium compounds. The dissolver tanks are designed such that the base and the cart to which they are attached provide the required spacing between them. Due to the possibility of a spill, the contents of the dissolver are limited to 20 kilograms of uranium compounds.

All Equipment

The dissolver tanks are nine inch OD by 48 inch high vertical cylinders welded to a 23 inch diameter base which is permanently attached to a cart with a minimum width of 32 inches. The bases are designed to preclude overlapping. The tanks are critically safe for 5% enriched uranium compounds and are also limited to less than a minimum critical mass (20 kg).

Carboys, which hold approximately eighteen liters, are to be used only for red mud. They are handled according to the requirements for plastic five-gallon buckets (enrichment and spacing limits) with the exception that they are exempt from any mass limit because the process removes all but trace amounts of uranium.

Summary of Accident Conditions

The only scenario in which a criticality is possible is if the contents of a more than a double-batched dissolver tank spills and the contents form a fully reflected, optimally moderated sphere with a mass of uranium compounds greater than 40 kilograms. This condition is prevented by placing a limit on the quantity of uranium that may be placed into the dissolver tanks. The operational limit is 10 kilograms. Therefore, to exceed 40 kilograms would require more than twice the criticality safety limits and approximately four times the operational limit of uranium in the tank. The second control is the fact that the tanks are mounted onto a special cart so spilling a tank is unlikely. Also, the tank lid is required to be in-place with the vent and decant ports plugged during transit. If a tank is tipped over, an operator can right the tank before a significant quantity of liquid can spill out. Finally, the possibility of the spilled liquid content assuming a spherical shape and being fully reflected is very small.

15.3.4.2 Radiation Protection

Mop powder dissolution is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by use of closed containers and by the use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.4.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the mop powder dissolver area and the rest of the ELO Building.

15.3.4.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes such as solvent contaminated rags from the controlled areas are disposed of in special containers distributed throughout the processing areas. The rags are treated as hazardous mixed hazardous waste as appropriate and periodically transferred to a secured storage area for future processing/disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.4 Mop Powder Dissolution

Mop water produced on plant is dumped into mop sinks where, after being screened for large objects such as pellets, etc., it is sent to the Miscellaneous Uranium Recovery System (MURS) in the UO_2 Building where the uranium-bearing solids are precipitated, centrifuged, collected and placed into an oven for drying. The resulting powder is then milled and stored in containers in the building.

Dissolution of the mop powder produced at MURS takes place in the basement of the ELO Building. Nitric acid solution is added to the powder in a dissolver tank in the dissolution hood. Water is added to the tank to adjust the uranium concentration to about 200 grams per liter. The tank is then moved to a settling area in Room 56 for the "red mud" solids to settle. After the solids have settled in the tank, the tank is moved to a decant station where the clear UNH is withdrawn from the tank and pumped to the solvent extraction system for processing. The red mud slurry left over is then pumped into an 18-liter carboy. The red mud will either undergo uranium precipitation or it will be burned-back in the MURS oven. Alternatively, it may be pumped back into a dissolver tank for additional settling and decanting.

The equipment is located in Room 58 in the ELO Building and consists of:

1. Dissolver tanks
2. Dissolution hood
3. 18-liter carboys for storage and on-plant transport of red mud heels

15.3.4.1 Criticality Safety

The mop powder dissolution process is acceptably subcritical for normal operations and for all credible abnormal conditions. The dissolver tanks and carboys are of favorable geometry for homogeneous uranium compounds. The dissolver tanks are designed such that the base and the cart to which they are attached provide the required spacing between them. Due to the possibility of a spill, the contents of the dissolver are limited to 20 kilograms of uranium compounds.

All Equipment

The dissolver tanks are nine inch OD by 48 inch high vertical cylinders welded to a 23 inch diameter base which is permanently attached to a cart with a minimum width of 32 inches. The bases are designed to preclude overlapping. The tanks are critically safe for 5% enriched uranium compounds and are also limited to less than a minimum critical mass (20 kg).

Carboys, which hold approximately eighteen liters, are to be used only for red mud. They are handled according to the requirements for plastic five-gallon buckets (enrichment and spacing limits) with the exception that they are exempt from any mass limit because the process removes all but trace amounts of uranium.

Summary of Accident Conditions

The only scenario in which a criticality is possible is if the contents of a more than a double-batched dissolver tank spills and the contents form a fully reflected, optimally moderated sphere with a mass of uranium compounds greater than 40 kilograms. This condition is prevented by placing a limit on the quantity of uranium that may be placed into the dissolver tanks. The operational limit is 10 kilograms. Therefore, to exceed 40 kilograms would require more than twice the criticality safety limits and approximately four times the operational limit of uranium in the tank. The second control is the fact that the tanks are mounted onto a special cart so spilling a tank is unlikely. Also, the tank lid is required to be in-place with the vent and decant ports plugged during transit. If a tank is tipped over, an operator can right the tank before a significant quantity of liquid can spill out. Finally, the possibility of the spilled liquid content assuming a spherical shape and being fully reflected is very small.

15.3.4.2 Radiation Protection

Mop powder dissolution is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by use of closed containers and by the use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.4.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the mop powder dissolver area and the rest of the ELO Building.

15.3.4.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes such as solvent contaminated rags from the controlled areas are disposed of in special containers distributed throughout the processing areas. The rags are treated as hazardous mixed hazardous waste as appropriate and periodically transferred to a secured storage area for future processing/disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.4 Mop Powder Dissolution

Mop water produced on plant is dumped into mop sinks where, after being screened for large objects such as pellets, etc., it is sent to the Miscellaneous Uranium Recovery System (MURS) in the UO_2 Building where the uranium-bearing solids are precipitated, centrifuged, collected and placed into an oven for drying. The resulting powder is then milled and stored in containers in the building.

Dissolution of the mop powder produced at MURS takes place in the basement of the ELO Building. Nitric acid solution is added to the powder in a dissolver tank in the dissolution hood. Water is added to the tank to adjust the uranium concentration to about 200 grams per liter. The tank is then moved to a settling area in Room 56 for the "red mud" solids to settle. After the solids have settled in the tank, the tank is moved to a decant station where the clear UNH is withdrawn from the tank and pumped to the solvent extraction system for processing. The red mud slurry left over is then pumped into an 18-liter carboy. The red mud will either undergo uranium precipitation or it will be burned-back in the MURS oven. Alternatively, it may be pumped back into a dissolver tank for additional settling and decanting.

The equipment is located in Room 58 in the ELO Building and consists of:

1. Dissolver tanks
2. Dissolution hood
3. 18-liter carboys for storage and on-plant transport of red mud heels

15.3.4.1 Criticality Safety

The mop powder dissolution process is acceptably subcritical for normal operations and for all credible abnormal conditions. The dissolver tanks and carboys are of favorable geometry for homogeneous uranium compounds. The dissolver tanks are designed such that the base and the cart to which they are attached provide the required spacing between them. Due to the possibility of a spill, the contents of the dissolver are limited to 20 kilograms of uranium compounds.

All Equipment

The dissolver tanks are nine inch OD by 48 inch high vertical cylinders welded to a 23 inch diameter base which is permanently attached to a cart with a minimum width of 32 inches. The bases are designed to preclude overlapping. The tanks are critically safe for 5% enriched uranium compounds and are also limited to less than a minimum critical mass (20 kg).

Carboys, which hold approximately eighteen liters, are to be used only for red mud. They are handled according to the requirements for plastic five-gallon buckets (enrichment and spacing limits) with the exception that they are exempt from any mass limit because the process removes all but trace amounts of uranium.

Summary of Accident Conditions

The only scenario in which a criticality is possible is if the contents of a more than a double-batched dissolver tank spills and the contents form a fully reflected, optimally moderated sphere with a mass of uranium compounds greater than 40 kilograms. This condition is prevented by placing a limit on the quantity of uranium that may be placed into the dissolver tanks. The operational limit is 10 kilograms. Therefore, to exceed 40 kilograms would require more than twice the criticality safety limits and approximately four times the operational limit of uranium in the tank. The second control is the fact that the tanks are mounted onto a special cart so spilling a tank is unlikely. Also, the tank lid is required to be in-place with the vent and decant ports plugged during transit. If a tank is tipped over, an operator can right the tank before a significant quantity of liquid can spill out. Finally, the possibility of the spilled liquid content assuming a spherical shape and being fully reflected is very small.

15.3.4.2 Radiation Protection

Mop powder dissolution is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by use of closed containers and by the use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.4.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the mop powder dissolver area and the rest of the ELO Building.

15.3.4.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes such as solvent contaminated rags from the controlled areas are disposed of in special containers distributed throughout the processing areas. The rags are treated as hazardous mixed hazardous waste as appropriate and periodically transferred to a secured storage area for future processing/disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.4 Mop Powder Dissolution

Mop water produced on plant is dumped into mop sinks where, after being screened for large objects such as pellets, etc., it is sent to the Miscellaneous Uranium Recovery System (MURS) in the UO_2 Building where the uranium-bearing solids are precipitated, centrifuged, collected and placed into an oven for drying. The resulting powder is then milled and stored in containers in the building.

Dissolution of the mop powder produced at MURS takes place in the basement of the ELO Building. Nitric acid solution is added to the powder in a dissolver tank in the dissolution hood. Water is added to the tank to adjust the uranium concentration to about 200 grams per liter. The tank is then moved to a settling area in Room 56 for the "red mud" solids to settle. After the solids have settled in the tank, the tank is moved to a decant station where the clear UNH is withdrawn from the tank and pumped to the solvent extraction system for processing. The red mud slurry left over is then pumped into an 18-liter carboy. The red mud will either undergo uranium precipitation or it will be burned-back in the MURS oven. Alternatively, it may be pumped back into a dissolver tank for additional settling and decanting.

The equipment is located in Room 58 in the ELO Building and consists of:

1. Dissolver tanks
2. Dissolution hood
3. 18-liter carboys for storage and on-plant transport of red mud heels

15.3.4.1 Criticality Safety

The mop powder dissolution process is acceptably subcritical for normal operations and for all credible abnormal conditions. The dissolver tanks and carboys are of favorable geometry for homogeneous uranium compounds. The dissolver tanks are designed such that the base and the cart to which they are attached provide the required spacing between them. Due to the possibility of a spill, the contents of the dissolver are limited to 20 kilograms of uranium compounds.

All Equipment

The dissolver tanks are nine inch OD by 48 inch high vertical cylinders welded to a 23 inch diameter base which is permanently attached to a cart with a minimum width of 32 inches. The bases are designed to preclude overlapping. The tanks are critically safe for 5% enriched uranium compounds and are also limited to less than a minimum critical mass (20 kg).

Carboys, which hold approximately eighteen liters, are to be used only for red mud. They are handled according to the requirements for plastic five-gallon buckets (enrichment and spacing limits) with the exception that they are exempt from any mass limit because the process removes all but trace amounts of uranium.

Summary of Accident Conditions

The only scenario in which a criticality is possible is if the contents of a more than a double-batched dissolver tank spills and the contents form a fully reflected, optimally moderated sphere with a mass of uranium compounds greater than 40 kilograms. This condition is prevented by placing a limit on the quantity of uranium that may be placed into the dissolver tanks. The operational limit is 10 kilograms. Therefore, to exceed 40 kilograms would require more than twice the criticality safety limits and approximately four times the operational limit of uranium in the tank. The second control is the fact that the tanks are mounted onto a special cart so spilling a tank is unlikely. Also, the tank lid is required to be in-place with the vent and decant ports plugged during transit. If a tank is tipped over, an operator can right the tank before a significant quantity of liquid can spill out. Finally, the possibility of the spilled liquid content assuming a spherical shape and being fully reflected is very small.

15.3.4.2 Radiation Protection

Mop powder dissolution is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by use of closed containers and by the use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.4.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the mop powder dissolver area and the rest of the ELO Building.

15.3.4.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes such as solvent contaminated rags from the controlled areas are disposed of in special containers distributed throughout the processing areas. The rags are treated as hazardous mixed hazardous waste as appropriate and periodically transferred to a secured storage area for future processing/disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.4 Mop Powder Dissolution

Mop water produced on plant is dumped into mop sinks where, after being screened for large objects such as pellets, etc., it is sent to the Miscellaneous Uranium Recovery System (MURS) in the UO_2 Building where the uranium-bearing solids are precipitated, centrifuged, collected and placed into an oven for drying. The resulting powder is then milled and stored in containers in the building.

Dissolution of the mop powder produced at MURS takes place in the basement of the ELO Building. Nitric acid solution is added to the powder in a dissolver tank in the dissolution hood. Water is added to the tank to adjust the uranium concentration to about 200 grams per liter. The tank is then moved to a settling area in Room 56 for the "red mud" solids to settle. After the solids have settled in the tank, the tank is moved to a decant station where the clear UNH is withdrawn from the tank and pumped to the solvent extraction system for processing. The red mud slurry left over is then pumped into an 18-liter carboy. The red mud will either undergo uranium precipitation or it will be burned-back in the MURS oven. Alternatively, it may be pumped back into a dissolver tank for additional settling and decanting.

The equipment is located in Room 58 in the ELO Building and consists of:

1. Dissolver tanks
2. Dissolution hood
3. 18-liter carboys for storage and on-plant transport of red mud heels

15.3.4.1 Criticality Safety

The mop powder dissolution process is acceptably subcritical for normal operations and for all credible abnormal conditions. The dissolver tanks and carboys are of favorable geometry for homogeneous uranium compounds. The dissolver tanks are designed such that the base and the cart to which they are attached provide the required spacing between them. Due to the possibility of a spill, the contents of the dissolver are limited to 20 kilograms of uranium compounds.

All Equipment

The dissolver tanks are nine inch OD by 48 inch high vertical cylinders welded to a 23 inch diameter base which is permanently attached to a cart with a minimum width of 32 inches. The bases are designed to preclude overlapping. The tanks are critically safe for 5% enriched uranium compounds and are also limited to less than a minimum critical mass (20 kg).

Carboys, which hold approximately eighteen liters, are to be used only for red mud. They are handled according to the requirements for plastic five-gallon buckets (enrichment and spacing limits) with the exception that they are exempt from any mass limit because the process removes all but trace amounts of uranium.

Summary of Accident Conditions

The only scenario in which a criticality is possible is if the contents of a more than a double-batched dissolver tank spills and the contents form a fully reflected, optimally moderated sphere with a mass of uranium compounds greater than 40 kilograms. This condition is prevented by placing a limit on the quantity of uranium that may be placed into the dissolver tanks. The operational limit is 10 kilograms. Therefore, to exceed 40 kilograms would require more than twice the criticality safety limits and approximately four times the operational limit of uranium in the tank. The second control is the fact that the tanks are mounted onto a special cart so spilling a tank is unlikely. Also, the tank lid is required to be in-place with the vent and decant ports plugged during transit. If a tank is tipped over, an operator can right the tank before a significant quantity of liquid can spill out. Finally, the possibility of the spilled liquid content assuming a spherical shape and being fully reflected is very small.

15.3.4.2 Radiation Protection

Mop powder dissolution is performed in a limited access radiation controlled area. Personnel entering the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

Airborne uranium contamination is controlled by use of closed containers and by the use of hoods which are maintained at negative pressure and ventilated to the POG or DOG system. An example of such a hood location is a dissolver tank hood.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.4.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the mop powder dissolver area and the rest of the ELO Building.

15.3.4.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines or by hoods. Hoods are maintained at a negative pressure and vented to the POG or DOG system. Floors are sealed and have no drains.

The POG and DOG systems treat and remove fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes such as solvent contaminated rags from the controlled areas are disposed of in special containers distributed throughout the processing areas. The rags are treated as hazardous mixed hazardous waste as appropriate and periodically transferred to a secured storage area for future processing/disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.3.3 ELO Drain System

The ELO drain system collects various liquid waste streams which are generated in the ELO Building. Some of these sources originate in rooms that are safe batch workstations. These sources normally do not contain significant quantities of uranium compounds; however, they have the potential to contain up to a safe batch of uranium. Liquid waste streams received by the ELO drain system are then discharged to Lagoon 3 which is an unfavorable geometry system. The system is operated such that all liquid waste discharges must contain ≤ 1000 ppm U.

The main system components are:

1) The sump tanks in Rooms 51 and 53
2) The drain tank in Room 58
3) The pumps and associated piping
4) The Lagoon 3 discharge line

15.3.3.1 Criticality Safety

- All Equipment

Criticality safety of the ELO drain system equipment is provided by geometry (safe slab or safe volume) of the tanks. In addition, the processes discharging to the ELO drain system operate under either safe batch control or concentration control (≤1000 ppm U), thereby limiting the amount material introduced to the system.

Summary of Accident Conditions

The ELO drain system is normally operated such that limited quantities (≤ safe batch) of U compounds are available for introduction. All accident scenarios would require that an abnormal quantity of U compounds would have to accumulate or be introduced. In addition the material would have to migrate to an unfavorable geometry. The following three potential accident/upset geometries were evaluated.

- Plugging of discharge line from sump tanks in Rooms 51 and 53, causing backflow up to lab sinks and hoods.

  The pumps that discharge the tanks in Rooms 51 and 53 do so through a one inch line. These lines connect to the two inch diameter sink drain lines. The two inch line is less likely to plug than the one inch line. The solution concentration/fissile mass is insufficient to cause criticality.

- Higher than expected mass of U.

  All sources to the Room 58 drain tank are limited in quantity or concentration. Periodic verification of tank volume or thickness is required. An acid wash of the tank to minimize accumulation of material is required.

- Loss of safe slab geometry for drain tank in room 58.

  The tank is stainless steel and is placed inside a carbon steel lined concrete containment. This configuration provides double containment within a geometry which is less than the minimum critical slab required for UO_2. No single short term accident can cause a loss of the drain tank's favorable geometry. A periodic check of tank thickness and containment integrity to prevent degradation of system geometry is required.

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Airborne uranium contamination is controlled by use of closed containers which are maintained at negative pressure and ventilated to the POG system.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

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The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the ELO Building.

15.3.3.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines. Floors are sealed and have no drains.

The POG system treats and removes fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

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The main system components are:

1) The sump tanks in Rooms 51 and 53
2) The drain tank in Room 58
3) The pumps and associated piping
4) The Lagoon 3 discharge line

15.3.3.1 Criticality Safety

- All Equipment

Criticality safety of the ELO drain system equipment is provided by geometry (safe slab or safe volume) of the tanks. In addition, the processes discharging to the ELO drain system operate under either safe batch control or concentration control (≤1000 ppm U), thereby limiting the amount material introduced to the system.

Summary of Accident Conditions

The ELO drain system is normally operated such that limited quantities (≤ safe batch) of U compounds are available for introduction. All accident scenarios would require that an abnormal quantity of U compounds would have to accumulate or be introduced. In addition the material would have to migrate to an unfavorable geometry. The following three potential accident/upset geometries were evaluated.

- Plugging of discharge line from sump tanks in Rooms 51 and 53, causing backflow up to lab sinks and hoods.

  The pumps that discharge the tanks in Rooms 51 and 53 do so through a one inch line. These lines connect to the two inch diameter sink drain lines. The two inch line is less likely to plug than the one inch line. The solution concentration/fissile mass is insufficient to cause criticality.

- Higher than expected mass of U.

  All sources to the Room 58 drain tank are limited in quantity or concentration. Periodic verification of tank volume or thickness is required. An acid wash of the tank to minimize accumulation of material is required.

- Loss of safe slab geometry for drain tank in room 58.

  The tank is stainless steel and is placed inside a carbon steel lined concrete containment. This configuration provides double containment within a geometry which is less than the minimum critical slab required for UO_2. No single short term accident can cause a loss of the drain tank's favorable geometry. A periodic check of tank thickness and containment integrity to prevent degradation of system geometry is required.

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Airborne uranium contamination is controlled by use of closed containers which are maintained at negative pressure and ventilated to the POG system.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

Urine sample analyses and lung counts are periodically performed for personnel who work in the controlled access area. The frequencies of such testing are described in Chapter 3.

15.3.3.3 Fire Protection

The ELO Building is rated as noncombustible. Monthly inspections confirm that fire loading is kept to a minimum. Fire extinguishers, alarm pull boxes, and heat detectors are strategically placed throughout the ELO Building.

15.3.3.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines. Floors are sealed and have no drains.

The POG system treats and removes fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

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The main system components are:

1) The sump tanks in Rooms 51 and 53
2) The drain tank in Room 58
3) The pumps and associated piping
4) The Lagoon 3 discharge line

15.3.3.1 Criticality Safety

- All Equipment

Criticality safety of the ELO drain system equipment is provided by geometry (safe slab or safe volume) of the tanks. In addition, the processes discharging to the ELO drain system operate under either safe batch control or concentration control (≤1000 ppm U), thereby limiting the amount material introduced to the system.

Summary of Accident Conditions

The ELO drain system is normally operated such that limited quantities (≤ safe batch) of U compounds are available for introduction. All accident scenarios would require that an abnormal quantity of U compounds would have to accumulate or be introduced. In addition the material would have to migrate to an unfavorable geometry. The following three potential accident/upset geometries were evaluated.

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  The pumps that discharge the tanks in Rooms 51 and 53 do so through a one inch line. These lines connect to the two inch diameter sink drain lines. The two inch line is less likely to plug than the one inch line. The solution concentration/fissile mass is insufficient to cause criticality.

- Higher than expected mass of U.

  All sources to the Room 58 drain tank are limited in quantity or concentration. Periodic verification of tank volume or thickness is required. An acid wash of the tank to minimize accumulation of material is required.

- Loss of safe slab geometry for drain tank in room 58.

  The tank is stainless steel and is placed inside a carbon steel lined concrete containment. This configuration provides double containment within a geometry which is less than the minimum critical slab required for UO_2. No single short term accident can cause a loss of the drain tank's favorable geometry. A periodic check of tank thickness and containment integrity to prevent degradation of system geometry is required.

15.3.3.2 Radiation Protection

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Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines. Floors are sealed and have no drains.

The POG system treats and removes fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

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The main system components are:

1) The sump tanks in Rooms 51 and 53
2) The drain tank in Room 58
3) The pumps and associated piping
4) The Lagoon 3 discharge line

15.3.3.1 Criticality Safety

- All Equipment

Criticality safety of the ELO drain system equipment is provided by geometry (safe slab or safe volume) of the tanks. In addition, the processes discharging to the ELO drain system operate under either safe batch control or concentration control (≤1000 ppm U), thereby limiting the amount material introduced to the system.

Summary of Accident Conditions

The ELO drain system is normally operated such that limited quantities (≤ safe batch) of U compounds are available for introduction. All accident scenarios would require that an abnormal quantity of U compounds would have to accumulate or be introduced. In addition the material would have to migrate to an unfavorable geometry. The following three potential accident/upset geometries were evaluated.

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- Higher than expected mass of U.

  All sources to the Room 58 drain tank are limited in quantity or concentration. Periodic verification of tank volume or thickness is required. An acid wash of the tank to minimize accumulation of material is required.

- Loss of safe slab geometry for drain tank in room 58.

  The tank is stainless steel and is placed inside a carbon steel lined concrete containment. This configuration provides double containment within a geometry which is less than the minimum critical slab required for UO_2. No single short term accident can cause a loss of the drain tank's favorable geometry. A periodic check of tank thickness and containment integrity to prevent degradation of system geometry is required.

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Airborne uranium contamination is controlled by use of closed containers which are maintained at negative pressure and ventilated to the POG system.

Routine surveys are performed and housekeeping practices are enforced to minimize surface and airborne contamination in the processing areas. Air is continuously sampled and periodically analyzed to detect any airborne contamination.

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15.3.3.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines. Floors are sealed and have no drains.

The POG system treats and removes fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

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The main system components are:

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15.3.3.1 Criticality Safety

- All Equipment

Criticality safety of the ELO drain system equipment is provided by geometry (safe slab or safe volume) of the tanks. In addition, the processes discharging to the ELO drain system operate under either safe batch control or concentration control (≤1000 ppm U), thereby limiting the amount material introduced to the system.

Summary of Accident Conditions

The ELO drain system is normally operated such that limited quantities (≤ safe batch) of U compounds are available for introduction. All accident scenarios would require that an abnormal quantity of U compounds would have to accumulate or be introduced. In addition the material would have to migrate to an unfavorable geometry. The following three potential accident/upset geometries were evaluated.

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- Higher than expected mass of U.

  All sources to the Room 58 drain tank are limited in quantity or concentration. Periodic verification of tank volume or thickness is required. An acid wash of the tank to minimize accumulation of material is required.

- Loss of safe slab geometry for drain tank in room 58.

  The tank is stainless steel and is placed inside a carbon steel lined concrete containment. This configuration provides double containment within a geometry which is less than the minimum critical slab required for UO_2. No single short term accident can cause a loss of the drain tank's favorable geometry. A periodic check of tank thickness and containment integrity to prevent degradation of system geometry is required.

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15.3.3.4 <u>Environmental Safety</u>

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15.3.3.1 Criticality Safety

- All Equipment

Criticality safety of the ELO drain system equipment is provided by geometry (safe slab or safe volume) of the tanks. In addition, the processes discharging to the ELO drain system operate under either safe batch control or concentration control (≤1000 ppm U), thereby limiting the amount material introduced to the system.

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  All sources to the Room 58 drain tank are limited in quantity or concentration. Periodic verification of tank volume or thickness is required. An acid wash of the tank to minimize accumulation of material is required.

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15.3.3.4 Environmental Safety

Hazardous materials are contained to prevent their introduction into the environment. All unit operations are served by POG vent lines. Floors are sealed and have no drains.

The POG system treats and removes fumes and particulates from the exhaust air using scrubbers, dryers and two stages of high efficiency particulate filtration (HEPA).

All room and building air is processed through the heating, ventilation, and air conditioning system and then HEPA filtered to remove particulates.

Certain chemically hazardous solid wastes such as solvent contaminated rags from the controlled areas are disposed of in special containers distributed throughout the processing areas. The rags are treated as hazardous mixed hazardous waste as appropriate and periodically transferred to a secured storage area for future processing/disposal. Liquid chemical wastes are typically routed to the surface impoundment system which is appropriately designed, constructed, and operated to provide safe and effective storage/treatment of these effluents.

15.4.3 Lagoons

Lagoons used at SPC serve two different purposes. The first is to collect and store solutions that cannot be discharged to the municipal sewer system without additional processing because of uranium or chemical content. The lagoons used for this purpose are Lagoons 1, 2, 3, 4, and 5B. Of these, Lagoon 3 is used to store uranium solutions with the highest uranium concentrations. Uranium concentrations in the 200 to 1,000 parts per million (ppm) range are typical of the solutions transferred to Lagoon 3. Lagoon 3 solutions are further processed for uranium recovery.

The second purpose is to serve as a "surge tank" for solutions with a low uranium content (approximately 1 ppm or less) and chemical constituent concentrations that are suitable for discharge to the municipal sewer. The lagoon used for this purpose is Lagoon 5A. Lagoon 5A solutions are normally processed through the Discharged Waste Uranium Reduction (DWUR) equipment before being discharged to the municipal sewer. Solution discharges are controlled so that the quantities of chemicals discharged are within the limits of SPC's State Waste Discharge Permit.

The Lagoon system consists of the following components:

1) Lagoons 1 and 2 (high pH lagoons);
2) Lagoons 3, 4, and 5B (lagoons with pH controlled to $\leq$ 8.0); and
3) Lagoon 5A (sewering lagoon); Discharged Waste Uranium Reduction (DWUR) equipment (Lagoon 5A IX and associated sand filters); and the IX regeneration metal wash system.

The lagoon system is located east and south of the UO_2 Building. Lagoons 1, 2, 3, and 4 are located side-by-side at the same elevation with approximately three feet of soil separating them. Lagoons 5A and 5B are located about 20 feet above and to the east of Lagoons 1 and 2, and are separated from these lagoons by about 60 feet and from each other by about 20 feet of soil.

Lagoon 1 is constructed from two liners and a cover made from High Density Polyethylene (HDPE). The lagoon is 245 feet wide by 219 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 2 is constructed with two Hypalon liners, overlain with a HDPE liner and cover. The lagoon is 245 feet wide by 119 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 3 is constructed with two Hypalon liners. The lagoon is 243 feet wide by 382.5 feet long by an average of 7 feet deep. Lagoon 4 is constructed from two Hypalon liners overlain by a HDPE liner. The lagoon is 240.5 feet wide by 287.5 feet long by an average of 7 feet deep. Lagoons 5A and 5B are constructed from two Hypalon liners. The lagoons are 240 feet wide by 175 feet long by an average of 7.5 feet deep.

All the lagoons have an inter-liner leak detection/leachate collection system consisting of an inter-liner layer of sand (Lagoons 2-5B) or Geonet spacer fabric (Lagoon 1), along with associated collection tubing.

15.4.3.1 Criticality Safety

The uranium concentrations in the lagoon solutions range from less than one ppm to hundreds of ppm. Since the minimum critical concentration for 5.0% enriched UO_2-water is about 280 g U/l (about 280,000 ppm uranium by weight), a large safety factor exists for the liquid phase at normal conditions. Although the uranium concentration is low, the total quantity of uranium in the lagoon is large; therefore, uranium precipitation which results in a slab (or other geometry) of solids at the lagoon bottom with a uranium concentration near 280 g U/l approaches conditions where a criticality accident is possible.

Because the lagoons are unfavorable geometry vessels, criticality safety is provided by maintaining uranium concentration control such that any variations in concentration or sampling errors will not result in exceeding the general plant safe concentration limit of 140 g U/l. In addition the enrichment is controlled to 5%, maximum.

- Lagoons 1 and 2

Lagoons 1 and 2 receive aqueous solutions from the UF_6/UNH to UO_2 conversion and Miscellaneous Uranium Recovery System (MURS) processes. These streams consist of ammonium hydroxide, ammonium nitrate, and ammonium fluoride solutions that also contain a few ppm uranium. These lagoons, which are essentially large bladder tanks as they are covered to prevent the escape of ammonia and to minimize evaporation, provide feed solutions to the Ammonia Recovery Facility (ARF). Lagoons 1 and 2 contain high pH solutions and therefore, to minimize the potential for uranium precipitation, uranium concentration in the feed streams to these two lagoons is closely monitored and controlled to very low concentrations to minimize the need to routinely monitor for sludge build-up and sample for uranium content.

Criticality safety is maintained for Lagoons 1 and 2 by concentration control. By limiting the input to trace quantities of uranium compounds (1.5 ppm, maximum), no surveillance for buildup of uranium compounds is required. Concentrations at or below 1.5 ppm are not considered significant since the uranium will remain in solution. The criticality safety analysis for these lagoons analyzed the potential pathways which would result in feed streams exceeding an average input of 1.5 ppm uranium.

Summary of Accident Conditions

The main criticality safety concern involving Lagoons 1 and 2 is the possible addition of high uranium concentration solutions into the lagoons resulting in the possibility of localized precipitation. Lagoons 1 and 2 receive aqueous solution from the UF_6/UNH to UO_2 conversion and the MURS processes. The feed streams to Lagoons 1 and 2 are:

- ARF bottoms recycle stream;
- Ammonia vaporizer blowdown sump;
- UO_2 Line 1 proportional sampler from Line 1 IX column;
- UO_2 Line 2 proportional sampler from Line 2 IX column;
- UO_2 proportional sampler from MURS IX columns and Dry Conversion;
- Inter-lagoon transfer system; and
- Tank farm sump.

A brief discussion of how each of the above pathways is limited to low concentrations of U is provided below.

The ARF bottoms recycle stream contains the same uranium concentration that is in Lagoon 2. Dilution of the Lagoon 4 feed stream to ARF (typically 10-15 ppm uranium), required by process to prevent plugging, results in its having a uranium concentration approximately the same as Lagoon 1 and 2 limits (1.5 ppm).

The ammonia vaporizer blowdown sump does not contain uranium-bearing materials.

The UO_2 Line 1 and Line 2 IX columns are controlled to ensure that all effluent goes through two IX columns in series before being discharged through a uranium monitor and a proportional sampler which verify that only low concentrations of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and interlocked to minimize their probability of occurrence.

Waste streams from the MURS IX columns and dry conversion both discharge through uranium monitoring equipment and a proportional sampler which verify only low amounts of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and alarmed to minimize their probability of occurrence.

The inter-lagoon transfer system has the capability to transfer material among lagoons. The transfer capability from Lagoons 3, 4, 5A and 5B to Lagoons 1 or 2 is unusable because the piping is disconnected and the pump is locked out of service to prevent uncontrolled transfer from the high uranium concentration lagoons to low uranium concentration lagoons.

The tank farm sump does not contain uranium bearing materials.

- Lagoons 3,4, and 5B

Lagoons 3, 4 and 5B contain soluble uranium in the form of UNH and UO_2F_2. Both the uranium concentration (the control limit is 1000 ppm) and the pH are controlled in these lagoons. These solutions also contain high concentrations of ammonium fluoride, sulfate and nitrate. The solutions are well buffered against large pH changes. Feed streams containing significant quantities of uranium are routed to Lagoon 3 for uranium recovery.

Summary of Accident Conditions

The lagoons would have to exceed the minimum critical concentration of 280 g U/l before a criticality would be possible. All feed streams to Lagoons 3, 4 and 5B are controlled such that they contain much less than the critical concentration and such that the pH is less than 8.0, to minimize uranium precipitation.

Uranium precipitation, potentially caused by the following conditions, has been evaluated:

- Concentration due to evaporation densification (uniform precipitation);

- Reduced solubility during cold weather (uniform precipitation);

- Addition of solutions/slurries with a uranium concentration greater than the solubility limit in the lagoon (local precipitation unless very large volumes are present);

- Raising the lagoon pH via addition of large volumes of a base such as NaOH or NH_4OH (local precipitation unless very large volumes are present. It is noted that transfers from Lagoons 1, 2 or 5A are equivalent to adding a basic solution); and

- Adding a reagent which reduces the uranium from a soluble valence state to a less soluble valence state (local precipitation unless very large volumes are present)

Uniform precipitation is discussed below.

The uniform precipitation of uranium compounds from solution in Lagoons 3, 4 and 5B which could form a slab with a depth greater than the safe limit (3.6 inches) and having a concentration greater than the safe concentration (140 g U/l) is considered to be an incredible event. Concentrations would have to be 20 times the 1,000 ppm uranium

control limit before the concentration could reach 140 g U/l as a result of precipitation. About 280 g U/l is required before criticality is possible. The sludge in Lagoons 3, 4, and 5B is periodically sampled. The results of the analyses of such samples demonstrate that the maximum lagoon uranium sludge concentration historically has been 22 g U/l.

Raising the pH to 8.5-8.7 coupled with low temperatures could result in uranium precipitation. Therefore, the maximum acceptable pH for lagoon solutions was set at 8.0 which will serve to reduce the probability of general precipitation. Laboratory tests have shown that solids that have precipitated from Lagoon 3 solutions have a low U concentration.

Lagoon 3 is the largest lagoon with the highest concentration of U. Based on a 1000 ppm uranium control limit, a uniform precipitation of all the uranium in solution in a layer with a minimum critical density of 280 g U/l would result in a layer about 0.17 inches thick. This layer would be 4.72% of the 3.6 inch safe slab limit. Assuming the uranium precipitated into a layer 3.6 inches deep, the resulting concentration is 13.9 g U/l which is 4.96% of the minimum critical concentration. Therefore, uniform U precipitation forming a uniform slab thickness will be subcritical either by geometry or by concentration.

An additional characteristic of Lagoon 3 sludge is that it contains a minimum of 1.4 g Gd/l. Gd concentrations over about 0.1 wt.% in UO_2 make criticality impossible in a well moderated system. Gd is insoluble in Lagoon 3 and the ELO solvent extraction raffinate discharged to Lagoon 3 provides a source of Gd which is deposited with insoluble uranium compounds that form in the lagoon.

Review of historical lagoon sludge laboratory analytical data indicates that no results above 22 g U/l have been observed. Although criticality safety relies on a concentration limit of 140 g U/l, a control limit of 22 g U/l has been chosen to provide an action point for criticality safety. Exceeding 22 g U/l will initiate a review of the lagoon in question to determine what actions, if any, should be taken. The 22 g U/l limit also provides a large safety factor to help assure that stratification and other nonhomogeneous distributions of uranium will not exceed 140 g U/l before action is taken.

Localized precipitation is discussed below.

Lagoon 3 has the following feed streams:

- ELO liquid wastes;
- UF_6 cylinder wash solutions;
- DWUR eluate; and
- Lagoon transfer system.

The solutions from these sources are controlled to well below the general plant safe concentration limit of 140 g U/l. Also, the Lagoon 3 feed streams are mixed together before entering the lagoon. This feature assures that discharges to the lagoon which exceed 1000 ppm uranium will be diluted before entering the lagoon, thereby minimizing the potential for localized precipitation. Additionally, the large volume of Lagoon 3 would require the addition of significant quantities of material to alter its chemistry because this lagoon is well buffered against large pH changes.

A major constituent of the ELO liquid waste is the raffinate from the Gadolinia Scrap Uranium Recovery (GSUR) system. The raffinate has a low pH, contains less than 1000 ppm uranium, except under special conditions (greater than 1000 ppm, with additional checks and sampling, may be discharged to Lagoon 3), and normally contains a significant amount of Gd. Solutions from the ELO drain system are also discharged to Lagoon 3 and also generally contain less than 1000 ppm U. The ELO proportional sampler confirms that the average discharge to Lagoon 3 is less than 1000 ppm U.

The cylinder wash and the DWUR eluate are generated by batch processes with safe batch limits and are diluted as they enter the lagoon.

Cylinder wash tank UO_2F_2-HF-H_2O solutions from UF_6 cylinder washing are discharged to Lagoon 3. These discharges are limited to 15.9 kg U per day (one safe batch at 5.0% enrichment). These discharges may occasionally have uranium concentrations as high as 20,000 ppm. To preclude problems due to insolubility at these high concentrations, all solutions from cylinder washing are diluted by the waste neutralization system immediately before they enter Lagoon 3.

About once every six months eluate from the DWUR system is discharged to Lagoon 3. The DWUR elution cycle discharges a maximum of about 10 kg uranium each cycle. The concentration of this solution varies between 100 - 500 ppm uranium.

Reagents are used to cause uranium precipitation at LUR. Assuming that some of these reagents then transfer from Lagoon 4 to Lagoon 3 may be equivalent to adding dilute LUR reagent. The reagents used at LUR have slow kinetics which limit the potential for localized precipitation. The reagents typically take several hours to form a precipitate. This allows time for diffusion (dilution) throughout the lagoon.

- <u>Lagoon 5A, Discharged Waste Uranium Reduction (DWUR) Equipment - Lagoon 5A IX and Deep Bed Filters and the Metal Wash System</u>

The solutions which Lagoon 5A receives are destined for discharge to the city sewer.

This lagoon does not have feed streams which could potentially contain large quantities of uranium during normal or abnormal conditions. Lagoon 5A does contain a thin layer of sedimentation which contains up to 3 g U/l in an insoluble form. Much of this sedimentation is from Zr precipitate from when etch waste was sent to the lagoon and from windblown sand.

Prior to being discharged to the municipal sewer, solutions from Lagoon 5A are normally processed through DWUR where they are reduced from about 1-2 ppm U to less than 0.1 - 0.2 ppm U.

The DWUR system consists of two deep bed mixed media filters and an ion exchange column. The first deep bed filter is 30 inches in diameter, 5 feet tall and is about three-quarters filled with filter media. The purpose of this filter is to prevent the discharge of suspended solids into the sewer system. Uranium loading on the filter media is negligible.

The second deep bed filter is 36 inches in diameter and 6.5 feet tall. This filter vessel is also about three-quarters filled with filter media. This second filter has a finer media to remove any remaining small particles that would clog the IX resin bed.

The ion exchange column is 42 inches in diameter, 10 feet high, and is approximately half filled with resin. The resin bed has a volume of approximately 40 cubic feet. The resin used is a commercially available ion exchange resin. The highest average uranium loading observed in this type of resin during bench scale testing was 21 g U/l of resin.

The Metal Wash system is used to remove metals from the IX metal wash cycle. The uranium content of the process feed streams and effluents is less than 1.5 ppm U. The system is operated in batch mode which eliminates any potential significant accumulation of U.

Criticality safety is maintained for the DWUR system by means of safe concentration control. All inputs to the system are limited and monitored to assure that they will not exceed 140 g U/l. The only potential mechanism to concentrate uranium is the resin; however, lab analysis has verified that the resin will not load to greater than 140 g U/l.

Summary of Accident Conditions

Concentration of solids was considered. The filters are to be back-flushed on approximately a monthly basis to prevent a buildup of solids from clogging the filters. Even though it is not credible, if one postulates that for some reason Lagoon 5A solids were able to concentrate by a factor of 100, to about 100 g U/l, without plugging the filter, the resulting uranium concentration would still remain significantly below the safe

concentration of 140 g U/l. Regardless, such a buildup must be detectable, hence a requirement to sample and analyze the filter media for uranium buildup semi-annually.

Misroutings were considered. The backflush line from the secondary sand filter, when valved incorrectly, could be routed through the line that discharges to Lagoon 3. This line is shared by other lines that also discharge to Lagoon 3. Because the IX column and secondary deep bed filter are at a higher elevation than Lagoon 3, no credible mechanism exists to get Lagoon 3 solution back to the IX system. In addition, all the lagoons are limited to a concentration which is significantly below the safe concentration of 140 g U/l.

The only potential misrouting to the secondary deep bed filter involving uranium-bearing solutions, other than those coming from Lagoon 5A or Lagoon 4, would be as a result of misaligned valves and the discharge line shared by other processes becoming plugged, by a closed valve or debris, and for solution normally discharged to Lagoon 3 to back up into the secondary deep bed filter. Although plausible, this occurrence is not likely because: (1) the discharge line is large enough in diameter to make plugging from discharge solution solids or windblown debris unlikely; (2) the line is monitored for plugging due to crystallizing AlF_3; (3) the line between the secondary deep bed filter and the shared discharge line to Lagoon 3 has a backflow preventer; and (4) the backflush line between the outlet of the secondary deep bed filter and discharge line to Lagoon 3 also has two normally closed pneumatically actuated block valves. The consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

The only potential misrouting of uranium-bearing solutions into the IX column other than those coming from Lagoon 5A or Lagoon 4, is for solution normally discharged to Lagoon 3 to back up into the DWUR IX columns as a result of a plugged discharge line. The pump used in the Lagoon 3 neutralization system provides enough pressure to force solution back to the DWUR IX columns. Even so, the consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

A potential backup of eluate into other process systems that discharge into Lagoon 3 is also of no criticality safety consequence since the maximum possible concentration in the eluate is 2.55 g U/l which is much less than a safe concentration of uranium regardless of the system geometry.

Misrouting of the eluate to the metal wash system would result in a higher than normal concentration of uranium in the solution. However, under worst case conditions the mass would be limited to about 24 kgU due to the limited IX column resin capacity.

15.4.3.2 Radiation Protection

The lagoons, which are never allowed to reach a dry state, are within SPC's fenced area. The lagoons themselves are in a controlled access radiation-controlled area and have a separate fence around them. Bird alarms are in use to keep birds away from the lagoons. In the Lagoon 5A IX area the uranium-bearing solutions are in closed containers.

Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

15.4.3.3 Fire Safety

Fire in the lagoons is not credible. The Lagoon 5A IX system buildings contain manual pull alarm stations and fixed/rate-of-rise temperature sensors to alarm a fire and the buildings are rated noncombustible. There are portable fire extinguishers available at the Lagoon 5A IX.

15.4.3.4 Environmental Safety

The lagoons are equipped with multiple liners (minimum of two) with a leak detection system between the liners to detect leaks prior to reaching groundwater. In addition there is an extensive network of groundwater sampling wells associated with the lagoon system (see Chapter 5).

The Lagoon 5A IX system resides in a building addition to the Ammonia Recovery Facility. The addition is built on a sealed concrete floor with curbs which drains to a main sump. All uranium-bearing material is in closed containers or process vessels.

15.4.3 Lagoons

Lagoons used at SPC serve two different purposes. The first is to collect and store solutions that cannot be discharged to the municipal sewer system without additional processing because of uranium or chemical content. The lagoons used for this purpose are Lagoons 1, 2, 3, 4, and 5B. Of these, Lagoon 3 is used to store uranium solutions with the highest uranium concentrations. Uranium concentrations in the 200 to 1,000 parts per million (ppm) range are typical of the solutions transferred to Lagoon 3. Lagoon 3 solutions are further processed for uranium recovery.

The second purpose is to serve as a "surge tank" for solutions with a low uranium content (approximately 1 ppm or less) and chemical constituent concentrations that are suitable for discharge to the municipal sewer. The lagoon used for this purpose is Lagoon 5A. Lagoon 5A solutions are normally processed through the Discharged Waste Uranium Reduction (DWUR) equipment before being discharged to the municipal sewer. Solution discharges are controlled so that the quantities of chemicals discharged are within the limits of SPC's State Waste Discharge Permit.

The Lagoon system consists of the following components:

1) Lagoons 1 and 2 (high pH lagoons);
2) Lagoons 3, 4, and 5B (lagoons with pH controlled to ≤ 8.0); and
3) Lagoon 5A (sewering lagoon); Discharged Waste Uranium Reduction (DWUR) equipment (Lagoon 5A IX and associated sand filters); and the IX regeneration metal wash system.

The lagoon system is located east and south of the UO_2 Building. Lagoons 1, 2, 3, and 4 are located side-by-side at the same elevation with approximately three feet of soil separating them. Lagoons 5A and 5B are located about 20 feet above and to the east of Lagoons 1 and 2, and are separated from these lagoons by about 60 feet and from each other by about 20 feet of soil.

Lagoon 1 is constructed from two liners and a cover made from High Density Polyethylene (HDPE). The lagoon is 245 feet wide by 219 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 2 is constructed with two Hypalon liners, overlain with a HDPE liner and cover. The lagoon is 245 feet wide by 119 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 3 is constructed with two Hypalon liners. The lagoon is 243 feet wide by 382.5 feet long by an average of 7 feet deep. Lagoon 4 is constructed from two Hypalon liners overlain by a HDPE liner. The lagoon is 240.5 feet wide by 287.5 feet long by an average of 7 feet deep. Lagoons 5A and 5B are constructed from two Hypalon liners. The lagoons are 240 feet wide by 175 feet long by an average of 7.5 feet deep.

All the lagoons have an inter-liner leak detection/leachate collection system consisting of an inter-liner layer of sand (Lagoons 2-5B) or Geonet spacer fabric (Lagoon 1), along with associated collection tubing.

15.4.3.1 Criticality Safety

The uranium concentrations in the lagoon solutions range from less than one ppm to hundreds of ppm. Since the minimum critical concentration for 5.0% enriched UO_2-water is about 280 g U/l (about 280,000 ppm uranium by weight), a large safety factor exists for the liquid phase at normal conditions. Although the uranium concentration is low, the total quantity of uranium in the lagoon is large; therefore, uranium precipitation which results in a slab (or other geometry) of solids at the lagoon bottom with a uranium concentration near 280 g U/l approaches conditions where a criticality accident is possible.

Because the lagoons are unfavorable geometry vessels, criticality safety is provided by maintaining uranium concentration control such that any variations in concentration or sampling errors will not result in exceeding the general plant safe concentration limit of 140 g U/l. In addition the enrichment is controlled to 5%, maximum.

- Lagoons 1 and 2

Lagoons 1 and 2 receive aqueous solutions from the UF_6/UNH to UO_2 conversion and Miscellaneous Uranium Recovery System (MURS) processes. These streams consist of ammonium hydroxide, ammonium nitrate, and ammonium fluoride solutions that also contain a few ppm uranium. These lagoons, which are essentially large bladder tanks as they are covered to prevent the escape of ammonia and to minimize evaporation, provide feed solutions to the Ammonia Recovery Facility (ARF). Lagoons 1 and 2 contain high pH solutions and therefore, to minimize the potential for uranium precipitation, uranium concentration in the feed streams to these two lagoons is closely monitored and controlled to very low concentrations to minimize the need to routinely monitor for sludge build-up and sample for uranium content.

Criticality safety is maintained for Lagoons 1 and 2 by concentration control. By limiting the input to trace quantities of uranium compounds (1.5 ppm, maximum), no surveillance for buildup of uranium compounds is required. Concentrations at or below 1.5 ppm are not considered significant since the uranium will remain in solution. The criticality safety analysis for these lagoons analyzed the potential pathways which would result in feed streams exceeding an average input of 1.5 ppm uranium.

Summary of Accident Conditions

The main criticality safety concern involving Lagoons 1 and 2 is the possible addition of high uranium concentration solutions into the lagoons resulting in the possibility of localized precipitation. Lagoons 1 and 2 receive aqueous solution from the UF_6/UNH to UO_2 conversion and the MURS processes. The feed streams to Lagoons 1 and 2 are:

- ARF bottoms recycle stream;
- Ammonia vaporizer blowdown sump;
- UO_2 Line 1 proportional sampler from Line 1 IX column;
- UO_2 Line 2 proportional sampler from Line 2 IX column;
- UO_2 proportional sampler from MURS IX columns and Dry Conversion;
- Inter-lagoon transfer system; and
- Tank farm sump.

A brief discussion of how each of the above pathways is limited to low concentrations of U is provided below.

The ARF bottoms recycle stream contains the same uranium concentration that is in Lagoon 2. Dilution of the Lagoon 4 feed stream to ARF (typically 10-15 ppm uranium), required by process to prevent plugging, results in its having a uranium concentration approximately the same as Lagoon 1 and 2 limits (1.5 ppm).

The ammonia vaporizer blowdown sump does not contain uranium-bearing materials.

The UO_2 Line 1 and Line 2 IX columns are controlled to ensure that all effluent goes through two IX columns in series before being discharged through a uranium monitor and a proportional sampler which verify that only low concentrations of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and interlocked to minimize their probability of occurrence.

Waste streams from the MURS IX columns and dry conversion both discharge through uranium monitoring equipment and a proportional sampler which verify only low amounts of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and alarmed to minimize their probability of occurrence.

The inter-lagoon transfer system has the capability to transfer material among lagoons. The transfer capability from Lagoons 3, 4, 5A and 5B to Lagoons 1 or 2 is unusable because the piping is disconnected and the pump is locked out of service to prevent uncontrolled transfer from the high uranium concentration lagoons to low uranium concentration lagoons.

The tank farm sump does not contain uranium bearing materials.

- Lagoons 3,4, and 5B

Lagoons 3, 4 and 5B contain soluble uranium in the form of UNH and UO_2F_2. Both the uranium concentration (the control limit is 1000 ppm) and the pH are controlled in these lagoons. These solutions also contain high concentrations of ammonium fluoride, sulfate and nitrate. The solutions are well buffered against large pH changes. Feed streams containing significant quantities of uranium are routed to Lagoon 3 for uranium recovery.

Summary of Accident Conditions

The lagoons would have to exceed the minimum critical concentration of 280 g U/l before a criticality would be possible. All feed streams to Lagoons 3, 4 and 5B are controlled such that they contain much less than the critical concentration and such that the pH is less than 8.0, to minimize uranium precipitation.

Uranium precipitation, potentially caused by the following conditions, has been evaluated:

- Concentration due to evaporation densification (uniform precipitation);
- Reduced solubility during cold weather (uniform precipitation);
- Addition of solutions/slurries with a uranium concentration greater than the solubility limit in the lagoon (local precipitation unless very large volumes are present);
- Raising the lagoon pH via addition of large volumes of a base such as NaOH or NH_4OH (local precipitation unless very large volumes are present. It is noted that transfers from Lagoons 1, 2 or 5A are equivalent to adding a basic solution); and
- Adding a reagent which reduces the uranium from a soluble valence state to a less soluble valence state (local precipitation unless very large volumes are present)

Uniform precipitation is discussed below.

The uniform precipitation of uranium compounds from solution in Lagoons 3, 4 and 5B which could form a slab with a depth greater than the safe limit (3.6 inches) and having a concentration greater than the safe concentration (140 g U/l) is considered to be an incredible event. Concentrations would have to be 20 times the 1,000 ppm uranium

control limit before the concentration could reach 140 g U/l as a result of precipitation. About 280 g U/l is required before criticality is possible. The sludge in Lagoons 3, 4, and 5B is periodically sampled. The results of the analyses of such samples demonstrate that the maximum lagoon uranium sludge concentration historically has been 22 g U/l.

Raising the pH to 8.5-8.7 coupled with low temperatures could result in uranium precipitation. Therefore, the maximum acceptable pH for lagoon solutions was set at 8.0 which will serve to reduce the probability of general precipitation. Laboratory tests have shown that solids that have precipitated from Lagoon 3 solutions have a low U concentration.

Lagoon 3 is the largest lagoon with the highest concentration of U. Based on a 1000 ppm uranium control limit, a uniform precipitation of all the uranium in solution in a layer with a minimum critical density of 280 g U/l would result in a layer about 0.17 inches thick. This layer would be 4.72% of the 3.6 inch safe slab limit. Assuming the uranium precipitated into a layer 3.6 inches deep, the resulting concentration is 13.9 g U/l which is 4.96% of the minimum critical concentration. Therefore, uniform U precipitation forming a uniform slab thickness will be subcritical either by geometry or by concentration.

An additional characteristic of Lagoon 3 sludge is that it contains a minimum of 1.4 g Gd/l. Gd concentrations over about 0.1 wt.% in UO_2 make criticality impossible in a well moderated system. Gd is insoluble in Lagoon 3 and the ELO solvent extraction raffinate discharged to Lagoon 3 provides a source of Gd which is deposited with insoluble uranium compounds that form in the lagoon.

Review of historical lagoon sludge laboratory analytical data indicates that no results above 22 g U/l have been observed. Although criticality safety relies on a concentration limit of 140 g U/l, a control limit of 22 g U/l has been chosen to provide an action point for criticality safety. Exceeding 22 g U/l will initiate a review of the lagoon in question to determine what actions, if any, should be taken. The 22 g U/l limit also provides a large safety factor to help assure that stratification and other nonhomogeneous distributions of uranium will not exceed 140 g U/l before action is taken.

Localized precipitation is discussed below.

Lagoon 3 has the following feed streams:

- ELO liquid wastes;
- UF_6 cylinder wash solutions;
- DWUR eluate; and
- Lagoon transfer system.

The solutions from these sources are controlled to well below the general plant safe concentration limit of 140 g U/l. Also the Lagoon 3 feed streams are mixed together before entering the lagoon. This feature assures that discharges to the lagoon which exceed 1000 ppm uranium will be diluted before entering the lagoon, thereby minimizing the potential for localized precipitation. Additionally, the large volume of Lagoon 3 would require the addition of significant quantities of material to alter its chemistry because this lagoon is well buffered against large pH changes.

A major constituent of the ELO liquid waste is the raffinate from the Gadolinia Scrap Uranium Recovery (GSUR) system. The raffinate has a low pH, contains less than 1000 ppm uranium, except under special conditions (greater than 1000 ppm, with additional checks and sampling, may be discharged to Lagoon 3), and normally contains a significant amount of Gd. Solutions from the ELO drain system are also discharged to Lagoon 3 and also generally contain less than 1000 ppm U. The ELO proportional sampler confirms that the average discharge to Lagoon 3 is less than 1000 ppm U.

The cylinder wash and the DWUR eluate are generated by batch processes with safe batch limits and are diluted as they enter the lagoon.

Cylinder wash tank UO_2F_2-HF-H_2O solutions from UF_6 cylinder washing are discharged to Lagoon 3. These discharges are limited to 15.9 kg U per day (one safe batch at 5.0% enrichment). These discharges may occasionally have uranium concentrations as high as 20,000 ppm. To preclude problems due to insolubility at these high concentrations, all solutions from cylinder washing are diluted by the waste neutralization system immediately before they enter Lagoon 3.

About once every six months eluate from the DWUR system is discharged to Lagoon 3. The DWUR elution cycle discharges a maximum of about 10 kg uranium each cycle. The concentration of this solution varies between 100 - 500 ppm uranium.

Reagents are used to cause uranium precipitation at LUR. Assuming that some of these reagents then transfer from Lagoon 4 to Lagoon 3 may be equivalent to adding dilute LUR reagent. The reagents used at LUR have slow kinetics which limit the potential for localized precipitation. The reagents typically take several hours to form a precipitate. This allows time for diffusion (dilution) throughout the lagoon.

- <u>Lagoon 5A, Discharged Waste Uranium Reduction (DWUR) Equipment - Lagoon 5A IX and Deep Bed Filters and the Metal Wash System</u>

The solutions which Lagoon 5A receives are destined for discharge to the city sewer.

This lagoon does not have feed streams which could potentially contain large quantities of uranium during normal or abnormal conditions. Lagoon 5A does contain a thin layer of sedimentation which contains up to 3 g U/l in an insoluble form. Much of this sedimentation is from Zr precipitate from when etch waste was sent to the lagoon and from windblown sand.

Prior to being discharged to the municipal sewer, solutions from Lagoon 5A are normally processed through DWUR where they are reduced from about 1-2 ppm U to less than 0.1 - 0.2 ppm U.

The DWUR system consists of two deep bed mixed media filters and an ion exchange column. The first deep bed filter is 30 inches in diameter, 5 feet tall and is about three-quarters filled with filter media. The purpose of this filter is to prevent the discharge of suspended solids into the sewer system. Uranium loading on the filter media is negligible.

The second deep bed filter is 36 inches in diameter and 6.5 feet tall. This filter vessel is also about three-quarters filled with filter media. This second filter has a finer media to remove any remaining small particles that would clog the IX resin bed.

The ion exchange column is 42 inches in diameter, 10 feet high, and is approximately half filled with resin. The resin bed has a volume of approximately 40 cubic feet. The resin used is a commercially available ion exchange resin. The highest average uranium loading observed in this type of resin during bench scale testing was 21 g U/l of resin.

The Metal Wash system is used to remove metals from the IX metal wash cycle. The uranium content of the process feed streams and effluents is less than 1.5 ppm U. The system is operated in batch mode which eliminates any potential significant accumulation of U.

Criticality safety is maintained for the DWUR system by means of safe concentration control. All inputs to the system are limited and monitored to assure that they will not exceed 140 g U/l. The only potential mechanism to concentrate uranium is the resin; however, lab analysis has verified that the resin will not load to greater than 140 g U/l.

Summary of Accident Conditions

Concentration of solids was considered. The filters are to be back-flushed on approximately a monthly basis to prevent a buildup of solids from clogging the filters. Even though it is not credible, if one postulates that for some reason Lagoon 5A solids were able to concentrate by a factor of 100, to about 100 g U/l, without plugging the filter, the resulting uranium concentration would still remain significantly below the safe

concentration of 140 g U/l. Regardless, such a buildup must be detectable, hence a requirement to sample and analyze the filter media for uranium buildup semi-annually.

Misroutings were considered. The backflush line from the secondary sand filter, when valved incorrectly, could be routed through the line that discharges to Lagoon 3. This line is shared by other lines that also discharge to Lagoon 3. Because the IX column and secondary deep bed filter are at a higher elevation than Lagoon 3, no credible mechanism exists to get Lagoon 3 solution back to the IX system. In addition, all the lagoons are limited to a concentration which is significantly below the safe concentration of 140 g U/l.

The only potential misrouting to the secondary deep bed filter involving uranium-bearing solutions, other than those coming from Lagoon 5A or Lagoon 4, would be as a result of misaligned valves and the discharge line shared by other processes becoming plugged, by a closed valve or debris, and for solution normally discharged to Lagoon 3 to back up into the secondary deep bed filter. Although plausible, this occurrence is not likely because: (1) the discharge line is large enough in diameter to make plugging from discharge solution solids or windblown debris unlikely; (2) the line is monitored for plugging due to crystallizing AlF_3; (3) the line between the secondary deep bed filter and the shared discharge line to Lagoon 3 has a backflow preventer; and (4) the backflush line between the outlet of the secondary deep bed filter and discharge line to Lagoon 3 also has two normally closed pneumatically actuated block valves. The consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

The only potential misrouting of uranium-bearing solutions into the IX column other than those coming from Lagoon 5A or Lagoon 4, is for solution normally discharged to Lagoon 3 to back up into the DWUR IX columns as a result of a plugged discharge line. The pump used in the Lagoon 3 neutralization system provides enough pressure to force solution back to the DWUR IX columns. Even so, the consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

A potential backup of eluate into other process systems that discharge into Lagoon 3 is also of no criticality safety consequence since the maximum possible concentration in the eluate is 2.55 g U/l which is much less than a safe concentration of uranium regardless of the system geometry.

Misrouting of the eluate to the metal wash system would result in a higher than normal concentration of uranium in the solution. However, under worst case conditions the mass would be limited to about 24 kgU due to the limited IX column resin capacity.

15.4.3.2 Radiation Protection

The lagoons, which are never allowed to reach a dry state, are within SPC's fenced area. The lagoons themselves are in a controlled access radiation-controlled area and have a separate fence around them. Bird alarms are in use to keep birds away from the lagoons. In the Lagoon 5A IX area the uranium-bearing solutions are in closed containers.

Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

15.4.3.3 Fire Safety

Fire in the lagoons is not credible. The Lagoon 5A IX system buildings contain manual pull alarm stations and fixed/rate-of-rise temperature sensors to alarm a fire and the buildings are rated noncombustible. There are portable fire extinguishers available at the Lagoon 5A IX.

15.4.3.4 Environmental Safety

The lagoons are equipped with multiple liners (minimum of two) with a leak detection system between the liners to detect leaks prior to reaching groundwater. In addition there is an extensive network of groundwater sampling wells associated with the lagoon system (see Chapter 5).

The Lagoon 5A IX system resides in a building addition to the Ammonia Recovery Facility. The addition is built on a sealed concrete floor with curbs which drains to a main sump. All uranium-bearing material is in closed containers or process vessels.

15.4.3 Lagoons

Lagoons used at SPC serve two different purposes. The first is to collect and store solutions that cannot be discharged to the municipal sewer system without additional processing because of uranium or chemical content. The lagoons used for this purpose are Lagoons 1, 2, 3, 4, and 5B. Of these, Lagoon 3 is used to store uranium solutions with the highest uranium concentrations. Uranium concentrations in the 200 to 1,000 parts per million (ppm) range are typical of the solutions transferred to Lagoon 3. Lagoon 3 solutions are further processed for uranium recovery.

The second purpose is to serve as a "surge tank" for solutions with a low uranium content (approximately 1 ppm or less) and chemical constituent concentrations that are suitable for discharge to the municipal sewer. The lagoon used for this purpose is Lagoon 5A. Lagoon 5A solutions are normally processed through the Discharged Waste Uranium Reduction (DWUR) equipment before being discharged to the municipal sewer. Solution discharges are controlled so that the quantities of chemicals discharged are within the limits of SPC's State Waste Discharge Permit.

The Lagoon system consists of the following components:

1) Lagoons 1 and 2 (high pH lagoons);
2) Lagoons 3, 4, and 5B (lagoons with pH controlled to $\leq$ 8.0); and
3) Lagoon 5A (sewering lagoon); Discharged Waste Uranium Reduction (DWUR) equipment (Lagoon 5A IX and associated sand filters); and the IX regeneration metal wash system.

The lagoon system is located east and south of the UO_2 Building. Lagoons 1, 2, 3, and 4 are located side-by-side at the same elevation with approximately three feet of soil separating them. Lagoons 5A and 5B are located about 20 feet above and to the east of Lagoons 1 and 2, and are separated from these lagoons by about 60 feet and from each other by about 20 feet of soil.

Lagoon 1 is constructed from two liners and a cover made from High Density Polyethylene (HDPE). The lagoon is 245 feet wide by 219 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 2 is constructed with two Hypalon liners, overlain with a HDPE liner and cover. The lagoon is 245 feet wide by 119 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 3 is constructed with two Hypalon liners. The lagoon is 243 feet wide by 382.5 feet long by an average of 7 feet deep. Lagoon 4 is constructed from two Hypalon liners overlain by a HDPE liner. The lagoon is 240.5 feet wide by 287.5 feet long by an average of 7 feet deep. Lagoons 5A and 5B are constructed from two Hypalon liners. The lagoons are 240 feet wide by 175 feet long by an average of 7.5 feet deep.

All the lagoons have an inter-liner leak detection/leachate collection system consisting of an inter-liner layer of sand (Lagoons 2-5B) or Geonet spacer fabric (Lagoon 1), along with associated collection tubing.

15.4.3.1 Criticality Safety

The uranium concentrations in the lagoon solutions range from less than one ppm to hundreds of ppm. Since the minimum critical concentration for 5.0% enriched UO_2-water is about 280 g U/l (about 280,000 ppm uranium by weight), a large safety factor exists for the liquid phase at normal conditions. Although the uranium concentration is low, the total quantity of uranium in the lagoon is large; therefore, uranium precipitation which results in a slab (or other geometry) of solids at the lagoon bottom with a uranium concentration near 280 g U/l approaches conditions where a criticality accident is possible.

Because the lagoons are unfavorable geometry vessels, criticality safety is provided by maintaining uranium concentration control such that any variations in concentration or sampling errors will not result in exceeding the general plant safe concentration limit of 140 g U/l. In addition the enrichment is controlled to 5%, maximum.

- Lagoons 1 and 2

Lagoons 1 and 2 receive aqueous solutions from the UF_6/UNH to UO_2 conversion and Miscellaneous Uranium Recovery System (MURS) processes. These streams consist of ammonium hydroxide, ammonium nitrate, and ammonium fluoride solutions that also contain a few ppm uranium. These lagoons, which are essentially large bladder tanks as they are covered to prevent the escape of ammonia and to minimize evaporation, provide feed solutions to the Ammonia Recovery Facility (ARF). Lagoons 1 and 2 contain high pH solutions and therefore, to minimize the potential for uranium precipitation, uranium concentration in the feed streams to these two lagoons is closely monitored and controlled to very low concentrations to minimize the need to routinely monitor for sludge build-up and sample for uranium content.

Criticality safety is maintained for Lagoons 1 and 2 by concentration control. By limiting the input to trace quantities of uranium compounds (1.5 ppm, maximum), no surveillance for buildup of uranium compounds is required. Concentrations at or below 1.5 ppm are not considered significant since the uranium will remain in solution. The criticality safety analysis for these lagoons analyzed the potential pathways which would result in feed streams exceeding an average input of 1.5 ppm uranium.

Summary of Accident Conditions

The main criticality safety concern involving Lagoons 1 and 2 is the possible addition of high uranium concentration solutions into the lagoons resulting in the possibility of localized precipitation. Lagoons 1 and 2 receive aqueous solution from the UF_6/UNH to UO_2 conversion and the MURS processes. The feed streams to Lagoons 1 and 2 are:

- ARF bottoms recycle stream;
- Ammonia vaporizer blowdown sump;
- UO_2 Line 1 proportional sampler from Line 1 IX column;
- UO_2 Line 2 proportional sampler from Line 2 IX column;
- UO_2 proportional sampler from MURS IX columns and Dry Conversion;
- Inter-lagoon transfer system; and
- Tank farm sump.

A brief discussion of how each of the above pathways is limited to low concentrations of U is provided below.

The ARF bottoms recycle stream contains the same uranium concentration that is in Lagoon 2. Dilution of the Lagoon 4 feed stream to ARF (typically 10-15 ppm uranium), required by process to prevent plugging, results in its having a uranium concentration approximately the same as Lagoon 1 and 2 limits (1.5 ppm).

The ammonia vaporizer blowdown sump does not contain uranium-bearing materials.

The UO_2 Line 1 and Line 2 IX columns are controlled to ensure that all effluent goes through two IX columns in series before being discharged through a uranium monitor and a proportional sampler which verify that only low concentrations of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and interlocked to minimize their probability of occurrence.

Waste streams from the MURS IX columns and dry conversion both discharge through uranium monitoring equipment and a proportional sampler which verify only low amounts of uranium are discharged to the lagoons Conditions causing a high uranium discharge are monitored and alarmed to minimize their probability of occurrence.

The inter-lagoon transfer system has the capability to transfer material among lagoons. The transfer capability from Lagoons 3, 4, 5A and 5B to Lagoons 1 or 2 is unusable because the piping is disconnected and the pump is locked out of service to prevent uncontrolled transfer from the high uranium concentration lagoons to low uranium concentration lagoons.

The tank farm sump does not contain uranium bearing materials.

- Lagoons 3,4, and 5B

Lagoons 3, 4 and 5B contain soluble uranium in the form of UNH and UO_2F_2. Both the uranium concentration (the control limit is 1000 ppm) and the pH are controlled in these lagoons. These solutions also contain high concentrations of ammonium fluoride, sulfate and nitrate. The solutions are well buffered against large pH changes. Feed streams containing significant quantities of uranium are routed to Lagoon 3 for uranium recovery.

Summary of Accident Conditions

The lagoons would have to exceed the minimum critical concentration of 280 g U/l before a criticality would be possible. All feed streams to Lagoons 3, 4 and 5B are controlled such that they contain much less than the critical concentration and such that the pH is less than 8.0, to minimize uranium precipitation.

Uranium precipitation, potentially caused by the following conditions, has been evaluated:

- Concentration due to evaporation densification (uniform precipitation);
- Reduced solubility during cold weather (uniform precipitation);
- Addition of solutions/slurries with a uranium concentration greater than the solubility limit in the lagoon (local precipitation unless very large volumes are present);
- Raising the lagoon pH via addition of large volumes of a base such as NaOH or NH_4OH (local precipitation unless very large volumes are present. It is noted that transfers from Lagoons 1, 2 or 5A are equivalent to adding a basic solution); and
- Adding a reagent which reduces the uranium from a soluble valence state to a less soluble valence state (local precipitation unless very large volumes are present)

Uniform precipitation is discussed below.

The uniform precipitation of uranium compounds from solution in Lagoons 3, 4 and 5B which could form a slab with a depth greater than the safe limit (3.6 inches) and having a concentration greater than the safe concentration (140 g U/l) is considered to be an incredible event. Concentrations would have to be 20 times the 1,000 ppm uranium

control limit before the concentration could reach 140 g U/l as a result of precipitation. About 280 g U/l is required before criticality is possible. The sludge in Lagoons 3, 4, and 5B is periodically sampled. The results of the analyses of such samples demonstrate that the maximum lagoon uranium sludge concentration historically has been 22 g U/l.

Raising the pH to 8.5-8.7 coupled with low temperatures could result in uranium precipitation. Therefore, the maximum acceptable pH for lagoon solutions was set at 8.0 which will serve to reduce the probability of general precipitation. Laboratory tests have shown that solids that have precipitated from Lagoon 3 solutions have a low U concentration.

Lagoon 3 is the largest lagoon with the highest concentration of U. Based on a 1000 ppm uranium control limit, a uniform precipitation of all the uranium in solution in a layer with a minimum critical density of 280 g U/l would result in a layer about 0.17 inches thick. This layer would be 4.72% of the 3.6 inch safe slab limit. Assuming the uranium precipitated into a layer 3.6 inches deep, the resulting concentration is 13.9 g U/l which is 4.96% of the minimum critical concentration. Therefore, uniform U precipitation forming a uniform slab thickness will be subcritical either by geometry or by concentration.

An additional characteristic of Lagoon 3 sludge is that it contains a minimum of 1.4 g Gd/l. Gd concentrations over about 0.1 wt.% in UO_2 make criticality impossible in a well moderated system. Gd is insoluble in Lagoon 3 and the ELO solvent extraction raffinate discharged to Lagoon 3 provides a source of Gd which is deposited with insoluble uranium compounds that form in the lagoon.

Review of historical lagoon sludge laboratory analytical data indicates that no results above 22 g U/l have been observed. Although criticality safety relies on a concentration limit of 140 g U/l, a control limit of 22 g U/l has been chosen to provide an action point for criticality safety. Exceeding 22 g U/l will initiate a review of the lagoon in question to determine what actions, if any, should be taken. The 22 g U/l limit also provides a large safety factor to help assure that stratification and other nonhomogeneous distributions of uranium will not exceed 140 g U/l before action is taken.

Localized precipitation is discussed below.

Lagoon 3 has the following feed streams:

- ELO liquid wastes;
- UF_6 cylinder wash solutions;
- DWUR eluate; and
- Lagoon transfer system.

The solutions from these sources are controlled to well below the general plant safe concentration limit of 140 g U/l. Also, the Lagoon 3 feed streams are mixed together before entering the lagoon. This feature assures that discharges to the lagoon which exceed 1000 ppm uranium will be diluted before entering the lagoon, thereby minimizing the potential for localized precipitation. Additionally, the large volume of Lagoon 3 would require the addition of significant quantities of material to alter its chemistry because this lagoon is well buffered against large pH changes.

A major constituent of the ELO liquid waste is the raffinate from the Gadolinia Scrap Uranium Recovery (GSUR) system. The raffinate has a low pH, contains less than 1000 ppm uranium, except under special conditions (greater than 1000 ppm, with additional checks and sampling, may be discharged to Lagoon 3), and normally contains a significant amount of Gd. Solutions from the ELO drain system are also discharged to Lagoon 3 and also generally contain less than 1000 ppm U. The ELO proportional sampler confirms that the average discharge to Lagoon 3 is less than 1000 ppm U.

The cylinder wash and the DWUR eluate are generated by batch processes with safe batch limits and are diluted as they enter the lagoon.

Cylinder wash tank UO_2F_2-HF-H_2O solutions from UF_6 cylinder washing are discharged to Lagoon 3. These discharges are limited to 15.9 kg U per day (one safe batch at 5.0% enrichment). These discharges may occasionally have uranium concentrations as high as 20,000 ppm. To preclude problems due to insolubility at these high concentrations, all solutions from cylinder washing are diluted by the waste neutralization system immediately before they enter Lagoon 3.

About once every six months eluate from the DWUR system is discharged to Lagoon 3. The DWUR elution cycle discharges a maximum of about 10 kg uranium each cycle. The concentration of this solution varies between 100 - 500 ppm uranium.

Reagents are used to cause uranium precipitation at LUR. Assuming that some of these reagents then transfer from Lagoon 4 to Lagoon 3 may be equivalent to adding dilute LUR reagent. The reagents used at LUR have slow kinetics which limit the potential for localized precipitation. The reagents typically take several hours to form a precipitate. This allows time for diffusion (dilution) throughout the lagoon.

- Lagoon 5A, Discharged Waste Uranium Reduction (DWUR) Equipment - Lagoon 5A IX and Deep Bed Filters and the Metal Wash System

The solutions which Lagoon 5A receives are destined for discharge to the city sewer.

This lagoon does not have feed streams which could potentially contain large quantities of uranium during normal or abnormal conditions. Lagoon 5A does contain a thin layer of sedimentation which contains up to 3 g U/l in an insoluble form. Much of this sedimentation is from Zr precipitate from when etch waste was sent to the lagoon and from windblown sand.

Prior to being discharged to the municipal sewer, solutions from Lagoon 5A are normally processed through DWUR where they are reduced from about 1-2 ppm U to less than 0.1 - 0.2 ppm U.

The DWUR system consists of two deep bed mixed media filters and an ion exchange column. The first deep bed filter is 30 inches in diameter, 5 feet tall and is about three-quarters filled with filter media. The purpose of this filter is to prevent the discharge of suspended solids into the sewer system. Uranium loading on the filter media is negligible.

The second deep bed filter is 36 inches in diameter and 6.5 feet tall. This filter vessel is also about three-quarters filled with filter media. This second filter has a finer media to remove any remaining small particles that would clog the IX resin bed.

The ion exchange column is 42 inches in diameter, 10 feet high, and is approximately half filled with resin. The resin bed has a volume of approximately 40 cubic feet. The resin used is a commercially available ion exchange resin. The highest average uranium loading observed in this type of resin during bench scale testing was 21 g U/l of resin.

The Metal Wash system is used to remove metals from the IX metal wash cycle. The uranium content of the process feed streams and effluents is less than 1.5 ppm U. The system is operated in batch mode which eliminates any potential significant accumulation of U.

Criticality safety is maintained for the DWUR system by means of safe concentration control. All inputs to the system are limited and monitored to assure that they will not exceed 140 g U/l. The only potential mechanism to concentrate uranium is the resin; however, lab analysis has verified that the resin will not load to greater than 140 g U/l.

Summary of Accident Conditions

Concentration of solids was considered. The filters are to be back-flushed on approximately a monthly basis to prevent a buildup of solids from clogging the filters. Even though it is not credible, if one postulates that for some reason Lagoon 5A solids were able to concentrate by a factor of 100, to about 100 g U/l, without plugging the filter, the resulting uranium concentration would still remain significantly below the safe

concentration of 140 g U/l. Regardless, such a buildup must be detectable, hence a requirement to sample and analyze the filter media for uranium buildup semi-annually.

Misroutings were considered. The backflush line from the secondary sand filter, when valved incorrectly, could be routed through the line that discharges to Lagoon 3. This line is shared by other lines that also discharge to Lagoon 3. Because the IX column and secondary deep bed filter are at a higher elevation than Lagoon 3, no credible mechanism exists to get Lagoon 3 solution back to the IX system. In addition, all the lagoons are limited to a concentration which is significantly below the safe concentration of 140 g U/l.

The only potential misrouting to the secondary deep bed filter involving uranium-bearing solutions, other than those coming from Lagoon 5A or Lagoon 4, would be as a result of misaligned valves and the discharge line shared by other processes becoming plugged, by a closed valve or debris, and for solution normally discharged to Lagoon 3 to back up into the secondary deep bed filter. Although plausible, this occurrence is not likely because: (1) the discharge line is large enough in diameter to make plugging from discharge solution solids or windblown debris unlikely; (2) the line is monitored for plugging due to crystallizing AlF_3; (3) the line between the secondary deep bed filter and the shared discharge line to Lagoon 3 has a backflow preventer; and (4) the backflush line between the outlet of the secondary deep bed filter and discharge line to Lagoon 3 also has two normally closed pneumatically actuated block valves. The consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

The only potential misrouting of uranium-bearing solutions into the IX column other than those coming from Lagoon 5A or Lagoon 4, is for solution normally discharged to Lagoon 3 to back up into the DWUR IX columns as a result of a plugged discharge line. The pump used in the Lagoon 3 neutralization system provides enough pressure to force solution back to the DWUR IX columns. Even so, the consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

A potential backup of eluate into other process systems that discharge into Lagoon 3 is also of no criticality safety consequence since the maximum possible concentration in the eluate is 2.55 g U/l which is much less than a safe concentration of uranium regardless of the system geometry.

Misrouting of the eluate to the metal wash system would result in a higher than normal concentration of uranium in the solution. However, under worst case conditions the mass would be limited to about 24 kgU due to the limited IX column resin capacity.

15.4.3.2 Radiation Protection

The lagoons, which are never allowed to reach a dry state, are within SPC's fenced area. The lagoons themselves are in a controlled access radiation-controlled area and have a separate fence around them. Bird alarms are in use to keep birds away from the lagoons. In the Lagoon 5A IX area the uranium-bearing solutions are in closed containers.

Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

15.4.3.3 Fire Safety

Fire in the lagoons is not credible. The Lagoon 5A IX system buildings contain manual pull alarm stations and fixed/rate-of-rise temperature sensors to alarm a fire and the buildings are rated noncombustible. There are portable fire extinguishers available at the Lagoon 5A IX.

15.4.3.4 Environmental Safety

The lagoons are equipped with multiple liners (minimum of two) with a leak detection system between the liners to detect leaks prior to reaching groundwater. In addition there is an extensive network of groundwater sampling wells associated with the lagoon system (see Chapter 5).

The Lagoon 5A IX system resides in a building addition to the Ammonia Recovery Facility. The addition is built on a sealed concrete floor with curbs which drains to a main sump. All uranium-bearing material is in closed containers or process vessels.

15.4.3 Lagoons

Lagoons used at SPC serve two different purposes. The first is to collect and store solutions that cannot be discharged to the municipal sewer system without additional processing because of uranium or chemical content. The lagoons used for this purpose are Lagoons 1, 2, 3, 4, and 5B. Of these, Lagoon 3 is used to store uranium solutions with the highest uranium concentrations. Uranium concentrations in the 200 to 1,000 parts per million (ppm) range are typical of the solutions transferred to Lagoon 3. Lagoon 3 solutions are further processed for uranium recovery.

The second purpose is to serve as a "surge tank" for solutions with a low uranium content (approximately 1 ppm or less) and chemical constituent concentrations that are suitable for discharge to the municipal sewer. The lagoon used for this purpose is Lagoon 5A. Lagoon 5A solutions are normally processed through the Discharged Waste Uranium Reduction (DWUR) equipment before being discharged to the municipal sewer. Solution discharges are controlled so that the quantities of chemicals discharged are within the limits of SPC's State Waste Discharge Permit.

The Lagoon system consists of the following components:

1) Lagoons 1 and 2 (high pH lagoons);
2) Lagoons 3, 4, and 5B (lagoons with pH controlled to $\leq$ 8.0); and
3) Lagoon 5A (sewering lagoon); Discharged Waste Uranium Reduction (DWUR) equipment (Lagoon 5A IX and associated sand filters); and the IX regeneration metal wash system.

The lagoon system is located east and south of the UO_2 Building. Lagoons 1, 2, 3, and 4 are located side-by-side at the same elevation with approximately three feet of soil separating them. Lagoons 5A and 5B are located about 20 feet above and to the east of Lagoons 1 and 2, and are separated from these lagoons by about 60 feet and from each other by about 20 feet of soil.

Lagoon 1 is constructed from two liners and a cover made from High Density Polyethylene (HDPE). The lagoon is 245 feet wide by 219 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 2 is constructed with two Hypalon liners, overlain with a HDPE liner and cover. The lagoon is 245 feet wide by 119 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 3 is constructed with two Hypalon liners. The lagoon is 243 feet wide by 382.5 feet long by an average of 7 feet deep. Lagoon 4 is constructed from two Hypalon liners overlain by a HDPE liner. The lagoon is 240.5 feet wide by 287.5 feet long by an average of 7 feet deep. Lagoons 5A and 5B are constructed from two Hypalon liners. The lagoons are 240 feet wide by 175 feet long by an average of 7.5 feet deep.

All the lagoons have an inter-liner leak detection/leachate collection system consisting of an inter-liner layer of sand (Lagoons 2-5B) or Geonet spacer fabric (Lagoon 1), along with associated collection tubing.

15.4.3.1 Criticality Safety

The uranium concentrations in the lagoon solutions range from less than one ppm to hundreds of ppm. Since the minimum critical concentration for 5.0% enriched UO_2-water is about 280 g U/l (about 280,000 ppm uranium by weight), a large safety factor exists for the liquid phase at normal conditions. Although the uranium concentration is low, the total quantity of uranium in the lagoon is large; therefore, uranium precipitation which results in a slab (or other geometry) of solids at the lagoon bottom with a uranium concentration near 280 g U/l approaches conditions where a criticality accident is possible.

Because the lagoons are unfavorable geometry vessels, criticality safety is provided by maintaining uranium concentration control such that any variations in concentration or sampling errors will not result in exceeding the general plant safe concentration limit of 140 g U/l. In addition the enrichment is controlled to 5%, maximum.

- Lagoons 1 and 2

Lagoons 1 and 2 receive aqueous solutions from the UF_6/UNH to UO_2 conversion and Miscellaneous Uranium Recovery System (MURS) processes. These streams consist of ammonium hydroxide, ammonium nitrate, and ammonium fluoride solutions that also contain a few ppm uranium. These lagoons, which are essentially large bladder tanks as they are covered to prevent the escape of ammonia and to minimize evaporation, provide feed solutions to the Ammonia Recovery Facility (ARF). Lagoons 1 and 2 contain high pH solutions and therefore, to minimize the potential for uranium precipitation, uranium concentration in the feed streams to these two lagoons is closely monitored and controlled to very low concentrations to minimize the need to routinely monitor for sludge build-up and sample for uranium content.

Criticality safety is maintained for Lagoons 1 and 2 by concentration control. By limiting the input to trace quantities of uranium compounds (1.5 ppm, maximum), no surveillance for buildup of uranium compounds is required. Concentrations at or below 1.5 ppm are not considered significant since the uranium will remain in solution. The criticality safety analysis for these lagoons analyzed the potential pathways which would result in feed streams exceeding an average input of 1.5 ppm uranium.

Summary of Accident Conditions

The main criticality safety concern involving Lagoons 1 and 2 is the possible addition of high uranium concentration solutions into the lagoons resulting in the possibility of localized precipitation. Lagoons 1 and 2 receive aqueous solution from the UF_6/UNH to UO_2 conversion and the MURS processes. The feed streams to Lagoons 1 and 2 are:

- ARF bottoms recycle stream;
- Ammonia vaporizer blowdown sump;
- UO_2 Line 1 proportional sampler from Line 1 IX column;
- UO_2 Line 2 proportional sampler from Line 2 IX column;
- UO_2 proportional sampler from MURS IX columns and Dry Conversion;
- Inter-lagoon transfer system; and
- Tank farm sump.

A brief discussion of how each of the above pathways is limited to low concentrations of U is provided below.

The ARF bottoms recycle stream contains the same uranium concentration that is in Lagoon 2. Dilution of the Lagoon 4 feed stream to ARF (typically 10-15 ppm uranium), required by process to prevent plugging, results in its having a uranium concentration approximately the same as Lagoon 1 and 2 limits (1.5 ppm).

The ammonia vaporizer blowdown sump does not contain uranium-bearing materials.

The UO_2 Line 1 and Line 2 IX columns are controlled to ensure that all effluent goes through two IX columns in series before being discharged through a uranium monitor and a proportional sampler which verify that only low concentrations of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and interlocked to minimize their probability of occurrence.

Waste streams from the MURS IX columns and dry conversion both discharge through uranium monitoring equipment and a proportional sampler which verify only low amounts of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and alarmed to minimize their probability of occurrence.

The inter-lagoon transfer system has the capability to transfer material among lagoons. The transfer capability from Lagoons 3, 4, 5A and 5B to Lagoons 1 or 2 is unusable because the piping is disconnected and the pump is locked out of service to prevent uncontrolled transfer from the high uranium concentration lagoons to low uranium concentration lagoons.

The tank farm sump does not contain uranium bearing materials.

- Lagoons 3,4, and 5B

Lagoons 3, 4 and 5B contain soluble uranium in the form of UNH and UO_2F_2. Both the uranium concentration (the control limit is 1000 ppm) and the pH are controlled in these lagoons. These solutions also contain high concentrations of ammonium fluoride, sulfate and nitrate. The solutions are well buffered against large pH changes. Feed streams containing significant quantities of uranium are routed to Lagoon 3 for uranium recovery.

Summary of Accident Conditions

The lagoons would have to exceed the minimum critical concentration of 280 g U/l before a criticality would be possible. All feed streams to Lagoons 3, 4 and 5B are controlled such that they contain much less than the critical concentration and such that the pH is less than 8.0, to minimize uranium precipitation.

Uranium precipitation, potentially caused by the following conditions, has been evaluated:

- Concentration due to evaporation densification (uniform precipitation);
- Reduced solubility during cold weather (uniform precipitation);
- Addition of solutions/slurries with a uranium concentration greater than the solubility limit in the lagoon (local precipitation unless very large volumes are present);
- Raising the lagoon pH via addition of large volumes of a base such as NaOH or NH_4OH (local precipitation unless very large volumes are present. It is noted that transfers from Lagoons 1, 2 or 5A are equivalent to adding a basic solution); and
- Adding a reagent which reduces the uranium from a soluble valence state to a less soluble valence state (local precipitation unless very large volumes are present)

Uniform precipitation is discussed below.

The uniform precipitation of uranium compounds from solution in Lagoons 3, 4 and 5B which could form a slab with a depth greater than the safe limit (3.6 inches) and having a concentration greater than the safe concentration (140 g U/l) is considered to be an incredible event. Concentrations would have to be 20 times the 1,000 ppm uranium

control limit before the concentration could reach 140 g U/l as a result of precipitation. About 280 g U/l is required before criticality is possible. The sludge in Lagoons 3, 4, and 5B is periodically sampled. The results of the analyses of such samples demonstrate that the maximum lagoon uranium sludge concentration historically has been 22 g U/l.

Raising the pH to 8.5-8.7 coupled with low temperatures could result in uranium precipitation. Therefore, the maximum acceptable pH for lagoon solutions was set at 8.0 which will serve to reduce the probability of general precipitation. Laboratory tests have shown that solids that have precipitated from Lagoon 3 solutions have a low U concentration.

Lagoon 3 is the largest lagoon with the highest concentration of U. Based on a 1000 ppm uranium control limit, a uniform precipitation of all the uranium in solution in a layer with a minimum critical density of 280 g U/l would result in a layer about 0.17 inches thick. This layer would be 4.72% of the 3.6 inch safe slab limit. Assuming the uranium precipitated into a layer 3.6 inches deep, the resulting concentration is 13.9 g U/l which is 4.96% of the minimum critical concentration. Therefore, uniform U precipitation forming a uniform slab thickness will be subcritical either by geometry or by concentration.

An additional characteristic of Lagoon 3 sludge is that it contains a minimum of 1.4 g Gd/l. Gd concentrations over about 0.1 wt.% in UO_2 make criticality impossible in a well moderated system. Gd is insoluble in Lagoon 3 and the ELO solvent extraction raffinate discharged to Lagoon 3 provides a source of Gd which is deposited with insoluble uranium compounds that form in the lagoon.

Review of historical lagoon sludge laboratory analytical data indicates that no results above 22 g U/l have been observed. Although criticality safety relies on a concentration limit of 140 g U/l, a control limit of 22 g U/l has been chosen to provide an action point for criticality safety. Exceeding 22 g U/l will initiate a review of the lagoon in question to determine what actions, if any, should be taken. The 22 g U/l limit also provides a large safety factor to help assure that stratification and other nonhomogeneous distributions of uranium will not exceed 140 g U/l before action is taken.

Localized precipitation is discussed below.

Lagoon 3 has the following feed streams:

- ELO liquid wastes;
- UF_6 cylinder wash solutions;
- DWUR eluate; and
- Lagoon transfer system.

The solutions from these sources are controlled to well below the general plant safe concentration limit of 140 g U/l. Also, the Lagoon 3 feed streams are mixed together before entering the lagoon. This feature assures that discharges to the lagoon which exceed 1000 ppm uranium will be diluted before entering the lagoon, thereby minimizing the potential for localized precipitation. Additionally, the large volume of Lagoon 3 would require the addition of significant quantities of material to alter its chemistry because this lagoon is well buffered against large pH changes.

A major constituent of the ELO liquid waste is the raffinate from the Gadolinia Scrap Uranium Recovery (GSUR) system. The raffinate has a low pH, contains less than 1000 ppm uranium, except under special conditions (greater than 1000 ppm, with additional checks and sampling, may be discharged to Lagoon 3), and normally contains a significant amount of Gd. Solutions from the ELO drain system are also discharged to Lagoon 3 and also generally contain less than 1000 ppm U. The ELO proportional sampler confirms that the average discharge to Lagoon 3 is less than 1000 ppm U.

The cylinder wash and the DWUR eluate are generated by batch processes with safe batch limits and are diluted as they enter the lagoon.

Cylinder wash tank UO_2F_2-HF-H_2O solutions from UF_6 cylinder washing are discharged to Lagoon 3. These discharges are limited to 15.9 kg U per day (one safe batch at 5.0% enrichment). These discharges may occasionally have uranium concentrations as high as 20,000 ppm. To preclude problems due to insolubility at these high concentrations, all solutions from cylinder washing are diluted by the waste neutralization system immediately before they enter Lagoon 3.

About once every six months eluate from the DWUR system is discharged to Lagoon 3. The DWUR elution cycle discharges a maximum of about 10 kg uranium each cycle. The concentration of this solution varies between 100 - 500 ppm uranium.

Reagents are used to cause uranium precipitation at LUR. Assuming that some of these reagents then transfer from Lagoon 4 to Lagoon 3 may be equivalent to adding dilute LUR reagent. The reagents used at LUR have slow kinetics which limit the potential for localized precipitation. The reagents typically take several hours to form a precipitate. This allows time for diffusion (dilution) throughout the lagoon.

- Lagoon 5A, Discharged Waste Uranium Reduction (DWUR) Equipment - Lagoon 5A IX and Deep Bed Filters and the Metal Wash System

The solutions which Lagoon 5A receives are destined for discharge to the city sewer.

This lagoon does not have feed streams which could potentially contain large quantities of uranium during normal or abnormal conditions. Lagoon 5A does contain a thin layer of sedimentation which contains up to 3 g U/l in an insoluble form. Much of this sedimentation is from Zr precipitate from when etch waste was sent to the lagoon and from windblown sand.

Prior to being discharged to the municipal sewer, solutions from Lagoon 5A are normally processed through DWUR where they are reduced from about 1-2 ppm U to less than 0.1 - 0.2 ppm U.

The DWUR system consists of two deep bed mixed media filters and an ion exchange column. The first deep bed filter is 30 inches in diameter, 5 feet tall and is about three-quarters filled with filter media. The purpose of this filter is to prevent the discharge of suspended solids into the sewer system. Uranium loading on the filter media is negligible.

The second deep bed filter is 36 inches in diameter and 6.5 feet tall. This filter vessel is also about three-quarters filled with filter media. This second filter has a finer media to remove any remaining small particles that would clog the IX resin bed.

The ion exchange column is 42 inches in diameter, 10 feet high and is approximately half filled with resin. The resin bed has a volume of approximately 40 cubic feet. The resin used is a commercially available ion exchange resin. The highest average uranium loading observed in this type of resin during bench scale testing was 21 g U/l of resin.

The Metal Wash system is used to remove metals from the IX metal wash cycle. The uranium content of the process feed streams and effluents is less than 1.5 ppm U. The system is operated in batch mode which eliminates any potential significant accumulation of U.

Criticality safety is maintained for the DWUR system by means of safe concentration control. All inputs to the system are limited and monitored to assure that they will not exceed 140 g U/l. The only potential mechanism to concentrate uranium is the resin; however, lab analysis has verified that the resin will not load to greater than 140 g U/l.

Summary of Accident Conditions

Concentration of solids was considered. The filters are to be back-flushed on approximately a monthly basis to prevent a buildup of solids from clogging the filters. Even though it is not credible, if one postulates that for some reason Lagoon 5A solids were able to concentrate by a factor of 100, to about 100 g U/l, without plugging the filter, the resulting uranium concentration would still remain significantly below the safe

concentration of 140 g U/l. Regardless, such a buildup must be detectable, hence a requirement to sample and analyze the filter media for uranium buildup semi-annually.

Misroutings were considered. The backflush line from the secondary sand filter, when valved incorrectly, could be routed through the line that discharges to Lagoon 3. This line is shared by other lines that also discharge to Lagoon 3. Because the IX column and secondary deep bed filter are at a higher elevation than Lagoon 3, no credible mechanism exists to get Lagoon 3 solution back to the IX system. In addition, all the lagoons are limited to a concentration which is significantly below the safe concentration of 140 g U/l.

The only potential misrouting to the secondary deep bed filter involving uranium-bearing solutions, other than those coming from Lagoon 5A or Lagoon 4, would be as a result of misaligned valves and the discharge line shared by other processes becoming plugged, by a closed valve or debris, and for solution normally discharged to Lagoon 3 to back up into the secondary deep bed filter. Although plausible, this occurrence is not likely because: (1) the discharge line is large enough in diameter to make plugging from discharge solution solids or windblown debris unlikely; (2) the line is monitored for plugging due to crystallizing AlF_3; (3) the line between the secondary deep bed filter and the shared discharge line to Lagoon 3 has a backflow preventer; and (4) the backflush line between the outlet of the secondary deep bed filter and discharge line to Lagoon 3 also has two normally closed pneumatically actuated block valves. The consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

The only potential misrouting of uranium-bearing solutions into the IX column other than those coming from Lagoon 5A or Lagoon 4, is for solution normally discharged to Lagoon 3 to back up into the DWUR IX columns as a result of a plugged discharge line. The pump used in the Lagoon 3 neutralization system provides enough pressure to force solution back to the DWUR IX columns. Even so, the consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

A potential backup of eluate into other process systems that discharge into Lagoon 3 is also of no criticality safety consequence since the maximum possible concentration in the eluate is 2.55 g U/l which is much less than a safe concentration of uranium regardless of the system geometry.

Misrouting of the eluate to the metal wash system would result in a higher than normal concentration of uranium in the solution. However, under worst case conditions the mass would be limited to about 24 kgU due to the limited IX column resin capacity.

15.4.3.2 Radiation Protection

The lagoons, which are never allowed to reach a dry state, are within SPC's fenced area. The lagoons themselves are in a controlled access radiation-controlled area and have a separate fence around them. Bird alarms are in use to keep birds away from the lagoons. In the Lagoon 5A IX area the uranium-bearing solutions are in closed containers.

Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

15.4.3.3 Fire Safety

Fire in the lagoons is not credible. The Lagoon 5A IX system buildings contain manual pull alarm stations and fixed/rate-of-rise temperature sensors to alarm a fire and the buildings are rated noncombustible. There are portable fire extinguishers available at the Lagoon 5A IX.

15.4.3.4 Environmental Safety

The lagoons are equipped with multiple liners (minimum of two) with a leak detection system between the liners to detect leaks prior to reaching groundwater. In addition there is an extensive network of groundwater sampling wells associated with the lagoon system (see Chapter 5).

The Lagoon 5A IX system resides in a building addition to the Ammonia Recovery Facility. The addition is built on a sealed concrete floor with curbs which drains to a main sump. All uranium-bearing material is in closed containers or process vessels.

15.4.3 Lagoons

Lagoons used at SPC serve two different purposes. The first is to collect and store solutions that cannot be discharged to the municipal sewer system without additional processing because of uranium or chemical content. The lagoons used for this purpose are Lagoons 1, 2, 3, 4, and 5B. Of these, Lagoon 3 is used to store uranium solutions with the highest uranium concentrations. Uranium concentrations in the 200 to 1,000 parts per million (ppm) range are typical of the solutions transferred to Lagoon 3. Lagoon 3 solutions are further processed for uranium recovery.

The second purpose is to serve as a "surge tank" for solutions with a low uranium content (approximately 1 ppm or less) and chemical constituent concentrations that are suitable for discharge to the municipal sewer. The lagoon used for this purpose is Lagoon 5A. Lagoon 5A solutions are normally processed through the Discharged Waste Uranium Reduction (DWUR) equipment before being discharged to the municipal sewer. Solution discharges are controlled so that the quantities of chemicals discharged are within the limits of SPC's State Waste Discharge Permit.

The Lagoon system consists of the following components:

1) Lagoons 1 and 2 (high pH lagoons);
2) Lagoons 3, 4, and 5B (lagoons with pH controlled to ≤ 8.0); and
3) Lagoon 5A (sewering lagoon); Discharged Waste Uranium Reduction (DWUR) equipment (Lagoon 5A IX and associated sand filters); and the IX regeneration metal wash system.

The lagoon system is located east and south of the UO_2 Building. Lagoons 1, 2, 3, and 4 are located side-by-side at the same elevation with approximately three feet of soil separating them. Lagoons 5A and 5B are located about 20 feet above and to the east of Lagoons 1 and 2, and are separated from these lagoons by about 60 feet and from each other by about 20 feet of soil.

Lagoon 1 is constructed from two liners and a cover made from High Density Polyethylene (HDPE). The lagoon is 245 feet wide by 219 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 2 is constructed with two Hypalon liners, overlain with a HDPE liner and cover. The lagoon is 245 feet wide by 119 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 3 is constructed with two Hypalon liners. The lagoon is 243 feet wide by 382.5 feet long by an average of 7 feet deep. Lagoon 4 is constructed from two Hypalon liners overlain by a HDPE liner. The lagoon is 240.5 feet wide by 287.5 feet long by an average of 7 feet deep. Lagoons 5A and 5B are constructed from two Hypalon liners. The lagoons are 240 feet wide by 175 feet long by an average of 7.5 feet deep.

All the lagoons have an inter-liner leak detection/leachate collection system consisting of an inter-liner layer of sand (Lagoons 2-5B) or Geonet spacer fabric (Lagoon 1), along with associated collection tubing.

15.4.3.1 Criticality Safety

The uranium concentrations in the lagoon solutions range from less than one ppm to hundreds of ppm. Since the minimum critical concentration for 5.0% enriched UO_2-water is about 280 g U/l (about 280,000 ppm uranium by weight), a large safety factor exists for the liquid phase at normal conditions. Although the uranium concentration is low, the total quantity of uranium in the lagoon is large; therefore, uranium precipitation which results in a slab (or other geometry) of solids at the lagoon bottom with a uranium concentration near 280 g U/l approaches conditions where a criticality accident is possible.

Because the lagoons are unfavorable geometry vessels, criticality safety is provided by maintaining uranium concentration control such that any variations in concentration or sampling errors will not result in exceeding the general plant safe concentration limit of 140 g U/l. In addition the enrichment is controlled to 5%, maximum.

- Lagoons 1 and 2

Lagoons 1 and 2 receive aqueous solutions from the UF_6/UNH to UO_2 conversion and Miscellaneous Uranium Recovery System (MURS) processes. These streams consist of ammonium hydroxide, ammonium nitrate, and ammonium fluoride solutions that also contain a few ppm uranium. These lagoons, which are essentially large bladder tanks as they are covered to prevent the escape of ammonia and to minimize evaporation, provide feed solutions to the Ammonia Recovery Facility (ARF). Lagoons 1 and 2 contain high pH solutions and therefore, to minimize the potential for uranium precipitation, uranium concentration in the feed streams to these two lagoons is closely monitored and controlled to very low concentrations to minimize the need to routinely monitor for sludge build-up and sample for uranium content.

Criticality safety is maintained for Lagoons 1 and 2 by concentration control. By limiting the input to trace quantities of uranium compounds (1.5 ppm, maximum), no surveillance for buildup of uranium compounds is required. Concentrations at or below 1.5 ppm are not considered significant since the uranium will remain in solution. The criticality safety analysis for these lagoons analyzed the potential pathways which would result in feed streams exceeding an average input of 1.5 ppm uranium.

Summary of Accident Conditions

The main criticality safety concern involving Lagoons 1 and 2 is the possible addition of high uranium concentration solutions into the lagoons resulting in the possibility of localized precipitation. Lagoons 1 and 2 receive aqueous solution from the UF_6/UNH to UO_2 conversion and the MURS processes. The feed streams to Lagoons 1 and 2 are:

- ARF bottoms recycle stream;
- Ammonia vaporizer blowdown sump;
- UO_2 Line 1 proportional sampler from Line 1 IX column;
- UO_2 Line 2 proportional sampler from Line 2 IX column;
- UO_2 proportional sampler from MURS IX columns and Dry Conversion;
- Inter-lagoon transfer system; and
- Tank farm sump.

A brief discussion of how each of the above pathways is limited to low concentrations of U is provided below.

The ARF bottoms recycle stream contains the same uranium concentration that is in Lagoon 2. Dilution of the Lagoon 4 feed stream to ARF (typically 10-15 ppm uranium), required by process to prevent plugging, results in its having a uranium concentration approximately the same as Lagoon 1 and 2 limits (1.5 ppm).

The ammonia vaporizer blowdown sump does not contain uranium-bearing materials.

The UO_2 Line 1 and Line 2 IX columns are controlled to ensure that all effluent goes through two IX columns in series before being discharged through a uranium monitor and a proportional sampler which verify that only low concentrations of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and interlocked to minimize their probability of occurrence.

Waste streams from the MURS IX columns and dry conversion both discharge through uranium monitoring equipment and a proportional sampler which verify only low amounts of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and alarmed to minimize their probability of occurrence.

The inter-lagoon transfer system has the capability to transfer material among lagoons. The transfer capability from Lagoons 3, 4, 5A and 5B to Lagoons 1 or 2 is unusable because the piping is disconnected and the pump is locked out of service to prevent uncontrolled transfer from the high uranium concentration lagoons to low uranium concentration lagoons.

The tank farm sump does not contain uranium bearing materials.

- Lagoons 3,4, and 5B

Lagoons 3, 4 and 5B contain soluble uranium in the form of UNH and UO_2F_2. Both the uranium concentration (the control limit is 1000 ppm) and the pH are controlled in these lagoons. These solutions also contain high concentrations of ammonium fluoride, sulfate and nitrate. The solutions are well buffered against large pH changes. Feed streams containing significant quantities of uranium are routed to Lagoon 3 for uranium recovery.

Summary of Accident Conditions

The lagoons would have to exceed the minimum critical concentration of 280 g U/l before a criticality would be possible. All feed streams to Lagoons 3, 4 and 5B are controlled such that they contain much less than the critical concentration and such that the pH is less than 8.0, to minimize uranium precipitation.

Uranium precipitation, potentially caused by the following conditions, has been evaluated:

- Concentration due to evaporation densification (uniform precipitation);
- Reduced solubility during cold weather (uniform precipitation);
- Addition of solutions/slurries with a uranium concentration greater than the solubility limit in the lagoon (local precipitation unless very large volumes are present);
- Raising the lagoon pH via addition of large volumes of a base such as NaOH or NH_4OH (local precipitation unless very large volumes are present. It is noted that transfers from Lagoons 1, 2 or 5A are equivalent to adding a basic solution); and
- Adding a reagent which reduces the uranium from a soluble valence state to a less soluble valence state (local precipitation unless very large volumes are present)

Uniform precipitation is discussed below.

The uniform precipitation of uranium compounds from solution in Lagoons 3, 4 and 5B which could form a slab with a depth greater than the safe limit (3.6 inches) and having a concentration greater than the safe concentration (140 g U/l) is considered to be an incredible event. Concentrations would have to be 20 times the 1,000 ppm uranium

control limit before the concentration could reach 140 g U/l as a result of precipitation. About 280 g U/l is required before criticality is possible. The sludge in Lagoons 3, 4, and 5B is periodically sampled. The results of the analyses of such samples demonstrate that the maximum lagoon uranium sludge concentration historically has been 22 g U/l.

Raising the pH to 8.5-8.7 coupled with low temperatures could result in uranium precipitation. Therefore, the maximum acceptable pH for lagoon solutions was set at 8.0 which will serve to reduce the probability of general precipitation. Laboratory tests have shown that solids that have precipitated from Lagoon 3 solutions have a low U concentration.

Lagoon 3 is the largest lagoon with the highest concentration of U. Based on a 1000 ppm uranium control limit, a uniform precipitation of all the uranium in solution in a layer with a minimum critical density of 280 g U/l would result in a layer about 0.17 inches thick. This layer would be 4.72% of the 3.6 inch safe slab limit. Assuming the uranium precipitated into a layer 3.6 inches deep, the resulting concentration is 13.9 g U/l which is 4.96% of the minimum critical concentration. Therefore, uniform U precipitation forming a uniform slab thickness will be subcritical either by geometry or by concentration.

An additional characteristic of Lagoon 3 sludge is that it contains a minimum of 1.4 g Gd/l. Gd concentrations over about 0.1 wt.% in UO_2 make criticality impossible in a well moderated system. Gd is insoluble in Lagoon 3 and the ELO solvent extraction raffinate discharged to Lagoon 3 provides a source of Gd which is deposited with insoluble uranium compounds that form in the lagoon.

Review of historical lagoon sludge laboratory analytical data indicates that no results above 22 g U/l have been observed. Although criticality safety relies on a concentration limit of 140 g U/l, a control limit of 22 g U/l has been chosen to provide an action point for criticality safety. Exceeding 22 g U/l will initiate a review of the lagoon in question to determine what actions, if any, should be taken. The 22 g U/l limit also provides a large safety factor to help assure that stratification and other nonhomogeneous distributions of uranium will not exceed 140 g U/l before action is taken.

Localized precipitation is discussed below.

Lagoon 3 has the following feed streams:

- ELO liquid wastes;
- UF_6 cylinder wash solutions;
- DWUR eluate; and
- Lagoon transfer system.

The solutions from these sources are controlled to well below the general plant safe concentration limit of 140 g U/l. Also, the Lagoon 3 feed streams are mixed together before entering the lagoon. This feature assures that discharges to the lagoon which exceed 1000 ppm uranium will be diluted before entering the lagoon, thereby minimizing the potential for localized precipitation. Additionally, the large volume of Lagoon 3 would require the addition of significant quantities of material to alter its chemistry because this lagoon is well buffered against large pH changes.

A major constituent of the ELO liquid waste is the raffinate from the Gadolinia Scrap Uranium Recovery (GSUR) system. The raffinate has a low pH, contains less than 1000 ppm uranium, except under special conditions (greater than 1000 ppm, with additional checks and sampling, may be discharged to Lagoon 3), and normally contains a significant amount of Gd. Solutions from the ELO drain system are also discharged to Lagoon 3 and also generally contain less than 1000 ppm U. The ELO proportional sampler confirms that the average discharge to Lagoon 3 is less than 1000 ppm U.

The cylinder wash and the DWUR eluate are generated by batch processes with safe batch limits and are diluted as they enter the lagoon.

Cylinder wash tank UO_2F_2-HF-H_2O solutions from UF_6 cylinder washing are discharged to Lagoon 3. These discharges are limited to 15.9 kg U per day (one safe batch at 5.0% enrichment). These discharges may occasionally have uranium concentrations as high as 20,000 ppm. To preclude problems due to insolubility at these high concentrations, all solutions from cylinder washing are diluted by the waste neutralization system immediately before they enter Lagoon 3.

About once every six months eluate from the DWUR system is discharged to Lagoon 3. The DWUR elution cycle discharges a maximum of about 10 kg uranium each cycle. The concentration of this solution varies between 100 - 500 ppm uranium.

Reagents are used to cause uranium precipitation at LUR. Assuming that some of these reagents then transfer from Lagoon 4 to Lagoon 3 may be equivalent to adding dilute LUR reagent. The reagents used at LUR have slow kinetics which limit the potential for localized precipitation. The reagents typically take several hours to form a precipitate. This allows time for diffusion (dilution) throughout the lagoon.

- <u>Lagoon 5A, Discharged Waste Uranium Reduction (DWUR) Equipment - Lagoon 5A IX and Deep Bed Filters and the Metal Wash System</u>

The solutions which Lagoon 5A receives are destined for discharge to the city sewer.

This lagoon does not have feed streams which could potentially contain large quantities of uranium during normal or abnormal conditions. Lagoon 5A does contain a thin layer of sedimentation which contains up to 3 g U/l in an insoluble form. Much of this sedimentation is from Zr precipitate from when etch waste was sent to the lagoon and from windblown sand.

Prior to being discharged to the municipal sewer, solutions from Lagoon 5A are normally processed through DWUR where they are reduced from about 1-2 ppm U to less than 0.1 - 0.2 ppm U.

The DWUR system consists of two deep bed mixed media filters and an ion exchange column. The first deep bed filter is 30 inches in diameter, 5 feet tall and is about three-quarters filled with filter media. The purpose of this filter is to prevent the discharge of suspended solids into the sewer system. Uranium loading on the filter media is negligible.

The second deep bed filter is 36 inches in diameter and 6.5 feet tall. This filter vessel is also about three-quarters filled with filter media. This second filter has a finer media to remove any remaining small particles that would clog the IX resin bed.

The ion exchange column is 42 inches in diameter, 10 feet high, and is approximately half filled with resin. The resin bed has a volume of approximately 40 cubic feet. The resin used is a commercially available ion exchange resin. The highest average uranium loading observed in this type of resin during bench scale testing was 21 g U/l of resin.

The Metal Wash system is used to remove metals from the IX metal wash cycle. The uranium content of the process feed streams and effluents is less than 1.5 ppm U. The system is operated in batch mode which eliminates any potential significant accumulation of U.

Criticality safety is maintained for the DWUR system by means of safe concentration control. All inputs to the system are limited and monitored to assure that they will not exceed 140 g U/l. The only potential mechanism to concentrate uranium is the resin; however, lab analysis has verified that the resin will not load to greater than 140 g U/l.

Summary of Accident Conditions

Concentration of solids was considered. The filters are to be back-flushed on approximately a monthly basis to prevent a buildup of solids from clogging the filters. Even though it is not credible, if one postulates that for some reason Lagoon 5A solids were able to concentrate by a factor of 100, to about 100 g U/l, without plugging the filter, the resulting uranium concentration would still remain significantly below the safe

concentration of 140 g U/l. Regardless, such a buildup must be detectable, hence a requirement to sample and analyze the filter media for uranium buildup semi-annually.

Misroutings were considered. The backflush line from the secondary sand filter, when valved incorrectly, could be routed through the line that discharges to Lagoon 3. This line is shared by other lines that also discharge to Lagoon 3. Because the IX column and secondary deep bed filter are at a higher elevation than Lagoon 3, no credible mechanism exists to get Lagoon 3 solution back to the IX system. In addition, all the lagoons are limited to a concentration which is significantly below the safe concentration of 140 g U/l.

The only potential misrouting to the secondary deep bed filter involving uranium-bearing solutions, other than those coming from Lagoon 5A or Lagoon 4, would be as a result of misaligned valves and the discharge line shared by other processes becoming plugged, by a closed valve or debris, and for solution normally discharged to Lagoon 3 to back up into the secondary deep bed filter. Although plausible, this occurrence is not likely because: (1) the discharge line is large enough in diameter to make plugging from discharge solution solids or windblown debris unlikely; (2) the line is monitored for plugging due to crystallizing AlF_3; (3) the line between the secondary deep bed filter and the shared discharge line to Lagoon 3 has a backflow preventer; and (4) the backflush line between the outlet of the secondary deep bed filter and discharge line to Lagoon 3 also has two normally closed pneumatically actuated block valves. The consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

The only potential misrouting of uranium-bearing solutions into the IX column other than those coming from Lagoon 5A or Lagoon 4, is for solution normally discharged to Lagoon 3 to back up into the DWUR IX columns as a result of a plugged discharge line. The pump used in the Lagoon 3 neutralization system provides enough pressure to force solution back to the DWUR IX columns. Even so, the consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

A potential backup of eluate into other process systems that discharge into Lagoon 3 is also of no criticality safety consequence since the maximum possible concentration in the eluate is 2.55 g U/l which is much less than a safe concentration of uranium regardless of the system geometry.

Misrouting of the eluate to the metal wash system would result in a higher than normal concentration of uranium in the solution. However, under worst case conditions the mass would be limited to about 24 kgU due to the limited IX column resin capacity.

15.4.3.2 Radiation Protection

The lagoons, which are never allowed to reach a dry state, are within SPC's fenced area. The lagoons themselves are in a controlled access radiation-controlled area and have a separate fence around them. Bird alarms are in use to keep birds away from the lagoons. In the Lagoon 5A IX area the uranium-bearing solutions are in closed containers.

Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

15.4.3.3 Fire Safety

Fire in the lagoons is not credible. The Lagoon 5A IX system buildings contain manual pull alarm stations and fixed/rate-of-rise temperature sensors to alarm a fire and the buildings are rated noncombustible. There are portable fire extinguishers available at the Lagoon 5A IX.

15.4.3.4 Environmental Safety

The lagoons are equipped with multiple liners (minimum of two) with a leak detection system between the liners to detect leaks prior to reaching groundwater. In addition there is an extensive network of groundwater sampling wells associated with the lagoon system (see Chapter 5).

The Lagoon 5A IX system resides in a building addition to the Ammonia Recovery Facility. The addition is built on a sealed concrete floor with curbs which drains to a main sump. All uranium-bearing material is in closed containers or process vessels.

15.4.3 Lagoons

Lagoons used at SPC serve two different purposes. The first is to collect and store solutions that cannot be discharged to the municipal sewer system without additional processing because of uranium or chemical content. The lagoons used for this purpose are Lagoons 1, 2, 3, 4, and 5B. Of these, Lagoon 3 is used to store uranium solutions with the highest uranium concentrations. Uranium concentrations in the 200 to 1,000 parts per million (ppm) range are typical of the solutions transferred to Lagoon 3. Lagoon 3 solutions are further processed for uranium recovery.

The second purpose is to serve as a "surge tank" for solutions with a low uranium content (approximately 1 ppm or less) and chemical constituent concentrations that are suitable for discharge to the municipal sewer. The lagoon used for this purpose is Lagoon 5A. Lagoon 5A solutions are normally processed through the Discharged Waste Uranium Reduction (DWUR) equipment before being discharged to the municipal sewer. Solution discharges are controlled so that the quantities of chemicals discharged are within the limits of SPC's State Waste Discharge Permit.

The Lagoon system consists of the following components:

1) Lagoons 1 and 2 (high pH lagoons);
2) Lagoons 3, 4, and 5B (lagoons with pH controlled to $\leq$ 8.0); and
3) Lagoon 5A (sewering lagoon); Discharged Waste Uranium Reduction (DWUR) equipment (Lagoon 5A IX and associated sand filters); and the IX regeneration metal wash system.

The lagoon system is located east and south of the UO_2 Building. Lagoons 1, 2, 3, and 4 are located side-by-side at the same elevation with approximately three feet of soil separating them. Lagoons 5A and 5B are located about 20 feet above and to the east of Lagoons 1 and 2, and are separated from these lagoons by about 60 feet and from each other by about 20 feet of soil.

Lagoon 1 is constructed from two liners and a cover made from High Density Polyethylene (HDPE). The lagoon is 245 feet wide by 219 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 2 is constructed with two Hypalon liners, overlain with a HDPE liner and cover. The lagoon is 245 feet wide by 119 feet long by about 3.5 feet deep, and has a flat bottom. Lagoon 3 is constructed with two Hypalon liners. The lagoon is 243 feet wide by 382.5 feet long by an average of 7 feet deep. Lagoon 4 is constructed from two Hypalon liners overlain by a HDPE liner. The lagoon is 240.5 feet wide by 287.5 feet long by an average of 7 feet deep. Lagoons 5A and 5B are constructed from two Hypalon liners. The lagoons are 240 feet wide by 175 feet long by an average of 7.5 feet deep.

All the lagoons have an inter-liner leak detection/leachate collection system consisting of an inter-liner layer of sand (Lagoons 2-5B) or Geonet spacer fabric (Lagoon 1), along with associated collection tubing.

15.4.3.1 Criticality Safety

The uranium concentrations in the lagoon solutions range from less than one ppm to hundreds of ppm. Since the minimum critical concentration for 5.0% enriched UO_2-water is about 280 g U/l (about 280,000 ppm uranium by weight), a large safety factor exists for the liquid phase at normal conditions. Although the uranium concentration is low, the total quantity of uranium in the lagoon is large; therefore, uranium precipitation which results in a slab (or other geometry) of solids at the lagoon bottom with a uranium concentration near 280 g U/l approaches conditions where a criticality accident is possible.

Because the lagoons are unfavorable geometry vessels, criticality safety is provided by maintaining uranium concentration control such that any variations in concentration or sampling errors will not result in exceeding the general plant safe concentration limit of 140 g U/l. In addition the enrichment is controlled to 5%, maximum.

- Lagoons 1 and 2

Lagoons 1 and 2 receive aqueous solutions from the UF_6/UNH to UO_2 conversion and Miscellaneous Uranium Recovery System (MURS) processes. These streams consist of ammonium hydroxide, ammonium nitrate, and ammonium fluoride solutions that also contain a few ppm uranium. These lagoons, which are essentially large bladder tanks as they are covered to prevent the escape of ammonia and to minimize evaporation, provide feed solutions to the Ammonia Recovery Facility (ARF). Lagoons 1 and 2 contain high pH solutions and therefore, to minimize the potential for uranium precipitation, uranium concentration in the feed streams to these two lagoons is closely monitored and controlled to very low concentrations to minimize the need to routinely monitor for sludge build-up and sample for uranium content.

Criticality safety is maintained for Lagoons 1 and 2 by concentration control. By limiting the input to trace quantities of uranium compounds (1.5 ppm, maximum), no surveillance for buildup of uranium compounds is required. Concentrations at or below 1.5 ppm are not considered significant since the uranium will remain in solution. The criticality safety analysis for these lagoons analyzed the potential pathways which would result in feed streams exceeding an average input of 1.5 ppm uranium.

Summary of Accident Conditions

The main criticality safety concern involving Lagoons 1 and 2 is the possible addition of high uranium concentration solutions into the lagoons resulting in the possibility of localized precipitation. Lagoons 1 and 2 receive aqueous solution from the UF_6/UNH to UO_2 conversion and the MURS processes. The feed streams to Lagoons 1 and 2 are:

- ARF bottoms recycle stream;
- Ammonia vaporizer blowdown sump;
- UO_2 Line 1 proportional sampler from Line 1 IX column;
- UO_2 Line 2 proportional sampler from Line 2 IX column;
- UO_2 proportional sampler from MURS IX columns and Dry Conversion;
- Inter-lagoon transfer system; and
- Tank farm sump.

A brief discussion of how each of the above pathways is limited to low concentrations of U is provided below.

The ARF bottoms recycle stream contains the same uranium concentration that is in Lagoon 2. Dilution of the Lagoon 4 feed stream to ARF (typically 10-15 ppm uranium), required by process to prevent plugging, results in its having a uranium concentration approximately the same as Lagoon 1 and 2 limits (1.5 ppm).

The ammonia vaporizer blowdown sump does not contain uranium-bearing materials.

The UO_2 Line 1 and Line 2 IX columns are controlled to ensure that all effluent goes through two IX columns in series before being discharged through a uranium monitor and a proportional sampler which verify that only low concentrations of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and interlocked to minimize their probability of occurrence.

Waste streams from the MURS IX columns and dry conversion both discharge through uranium monitoring equipment and a proportional sampler which verify only low amounts of uranium are discharged to the lagoons. Conditions causing a high uranium discharge are monitored and alarmed to minimize their probability of occurrence.

The inter-lagoon transfer system has the capability to transfer material among lagoons. The transfer capability from Lagoons 3, 4, 5A and 5B to Lagoons 1 or 2 is unusable because the piping is disconnected and the pump is locked out of service to prevent uncontrolled transfer from the high uranium concentration lagoons to low uranium concentration lagoons.

The tank farm sump does not contain uranium bearing materials.

- Lagoons 3,4, and 5B

Lagoons 3, 4 and 5B contain soluble uranium in the form of UNH and UO_2F_2. Both the uranium concentration (the control limit is 1000 ppm) and the pH are controlled in these lagoons. These solutions also contain high concentrations of ammonium fluoride, sulfate and nitrate. The solutions are well buffered against large pH changes. Feed streams containing significant quantities of uranium are routed to Lagoon 3 for uranium recovery.

Summary of Accident Conditions

The lagoons would have to exceed the minimum critical concentration of 280 g U/l before a criticality would be possible. All feed streams to Lagoons 3, 4 and 5B are controlled such that they contain much less than the critical concentration and such that the pH is less than 8.0, to minimize uranium precipitation.

Uranium precipitation, potentially caused by the following conditions, has been evaluated:

- Concentration due to evaporation densification (uniform precipitation);
- Reduced solubility during cold weather (uniform precipitation);
- Addition of solutions/slurries with a uranium concentration greater than the solubility limit in the lagoon (local precipitation unless very large volumes are present);
- Raising the lagoon pH via addition of large volumes of a base such as NaOH or NH_4OH (local precipitation unless very large volumes are present. It is noted that transfers from Lagoons 1, 2 or 5A are equivalent to adding a basic solution); and
- Adding a reagent which reduces the uranium from a soluble valence state to a less soluble valence state (local precipitation unless very large volumes are present)

Uniform precipitation is discussed below.

The uniform precipitation of uranium compounds from solution in Lagoons 3, 4 and 5B which could form a slab with a depth greater than the safe limit (3.6 inches) and having a concentration greater than the safe concentration (140 g U/l) is considered to be an incredible event. Concentrations would have to be 20 times the 1,000 ppm uranium

control limit before the concentration could reach 140 g U/l as a result of precipitation. About 280 g U/l is required before criticality is possible. The sludge in Lagoons 3, 4, and 5B is periodically sampled. The results of the analyses of such samples demonstrate that the maximum lagoon uranium sludge concentration historically has been 22 g U/l.

Raising the pH to 8.5-8.7 coupled with low temperatures could result in uranium precipitation. Therefore, the maximum acceptable pH for lagoon solutions was set at 8.0 which will serve to reduce the probability of general precipitation. Laboratory tests have shown that solids that have precipitated from Lagoon 3 solutions have a low U concentration.

Lagoon 3 is the largest lagoon with the highest concentration of U. Based on a 1000 ppm uranium control limit, a uniform precipitation of all the uranium in solution in a layer with a minimum critical density of 280 g U/l would result in a layer about 0.17 inches thick. This layer would be 4.72% of the 3.6 inch safe slab limit. Assuming the uranium precipitated into a layer 3.6 inches deep, the resulting concentration is 13.9 g U/l which is 4.96% of the minimum critical concentration. Therefore, uniform U precipitation forming a uniform slab thickness will be subcritical either by geometry or by concentration.

An additional characteristic of Lagoon 3 sludge is that it contains a minimum of 1.4 g Gd/l. Gd concentrations over about 0.1 wt.% in UO_2 make criticality impossible in a well moderated system. Gd is insoluble in Lagoon 3 and the ELO solvent extraction raffinate discharged to Lagoon 3 provides a source of Gd which is deposited with insoluble uranium compounds that form in the lagoon.

Review of historical lagoon sludge laboratory analytical data indicates that no results above 22 g U/l have been observed. Although criticality safety relies on a concentration limit of 140 g U/l, a control limit of 22 g U/l has been chosen to provide an action point for criticality safety. Exceeding 22 g U/l will initiate a review of the lagoon in question to determine what actions, if any, should be taken. The 22 g U/l limit also provides a large safety factor to help assure that stratification and other nonhomogeneous distributions of uranium will not exceed 140 g U/l before action is taken.

Localized precipitation is discussed below.

Lagoon 3 has the following feed streams:

- ELO liquid wastes;
- UF_6 cylinder wash solutions;
- DWUR eluate; and
- Lagoon transfer system.

The solutions from these sources are controlled to well below the general plant safe concentration limit of 140 g U/l. Also, the Lagoon 3 feed streams are mixed together before entering the lagoon. This feature assures that discharges to the lagoon which exceed 1000 ppm uranium will be diluted before entering the lagoon, thereby minimizing the potential for localized precipitation. Additionally, the large volume of Lagoon 3 would require the addition of significant quantities of material to alter its chemistry because this lagoon is well buffered against large pH changes.

A major constituent of the ELO liquid waste is the raffinate from the Gadolinia Scrap Uranium Recovery (GSUR) system. The raffinate has a low pH, contains less than 1000 ppm uranium, except under special conditions (greater than 1000 ppm, with additional checks and sampling, may be discharged to Lagoon 3), and normally contains a significant amount of Gd. Solutions from the ELO drain system are also discharged to Lagoon 3 and also generally contain less than 1000 ppm U. The ELO proportional sampler confirms that the average discharge to Lagoon 3 is less than 1000 ppm U.

The cylinder wash and the DWUR eluate are generated by batch processes with safe batch limits and are diluted as they enter the lagoon.

Cylinder wash tank UO_2F_2-HF-H_2O solutions from UF_6 cylinder washing are discharged to Lagoon 3. These discharges are limited to 15.9 kg U per day (one safe batch at 5.0% enrichment). These discharges may occasionally have uranium concentrations as high as 20,000 ppm. To preclude problems due to insolubility at these high concentrations, all solutions from cylinder washing are diluted by the waste neutralization system immediately before they enter Lagoon 3.

About once every six months eluate from the DWUR system is discharged to Lagoon 3. The DWUR elution cycle discharges a maximum of about 10 kg uranium each cycle. The concentration of this solution varies between 100 - 500 ppm uranium.

Reagents are used to cause uranium precipitation at LUR. Assuming that some of these reagents then transfer from Lagoon 4 to Lagoon 3 may be equivalent to adding dilute LUR reagent. The reagents used at LUR have slow kinetics which limit the potential for localized precipitation. The reagents typically take several hours to form a precipitate. This allows time for diffusion (dilution) throughout the lagoon.

- <u>Lagoon 5A, Discharged Waste Uranium Reduction (DWUR) Equipment - Lagoon 5A IX and Deep Bed Filters and the Metal Wash System</u>

The solutions which Lagoon 5A receives are destined for discharge to the city sewer.

This lagoon does not have feed streams which could potentially contain large quantities of uranium during normal or abnormal conditions. Lagoon 5A does contain a thin layer of sedimentation which contains up to 3 g U/l in an insoluble form. Much of this sedimentation is from Zr precipitate from when etch waste was sent to the lagoon and from windblown sand.

Prior to being discharged to the municipal sewer, solutions from Lagoon 5A are normally processed through DWUR where they are reduced from about 1-2 ppm U to less than 0.1 - 0.2 ppm U.

The DWUR system consists of two deep bed mixed media filters and an ion exchange column. The first deep bed filter is 30 inches in diameter, 5 feet tall and is about three-quarters filled with filter media. The purpose of this filter is to prevent the discharge of suspended solids into the sewer system. Uranium loading on the filter media is negligible.

The second deep bed filter is 36 inches in diameter and 6.5 feet tall. This filter vessel is also about three-quarters filled with filter media. This second filter has a finer media to remove any remaining small particles that would clog the IX resin bed.

The ion exchange column is 42 inches in diameter, 10 feet high, and is approximately half filled with resin. The resin bed has a volume of approximately 40 cubic feet. The resin used is a commercially available ion exchange resin. The highest average uranium loading observed in this type of resin during bench scale testing was 21 g U/l of resin.

The Metal Wash system is used to remove metals from the IX metal wash cycle. The uranium content of the process feed streams and effluents is less than 1.5 ppm U. The system is operated in batch mode which eliminates any potential significant accumulation of U.

Criticality safety is maintained for the DWUR system by means of safe concentration control. All inputs to the system are limited and monitored to assure that they will not exceed 140 g U/l. The only potential mechanism to concentrate uranium is the resin; however, lab analysis has verified that the resin will not load to greater than 140 g U/l.

Summary of Accident Conditions

Concentration of solids was considered. The filters are to be back-flushed on approximately a monthly basis to prevent a buildup of solids from clogging the filters. Even though it is not credible, if one postulates that for some reason Lagoon 5A solids were able to concentrate by a factor of 100, to about 100 g U/l, without plugging the filter, the resulting uranium concentration would still remain significantly below the safe

concentration of 140 g U/l. Regardless, such a buildup must be detectable, hence a requirement to sample and analyze the filter media for uranium buildup semi-annually.

Misroutings were considered. The backflush line from the secondary sand filter, when valved incorrectly, could be routed through the line that discharges to Lagoon 3. This line is shared by other lines that also discharge to Lagoon 3. Because the IX column and secondary deep bed filter are at a higher elevation than Lagoon 3, no credible mechanism exists to get Lagoon 3 solution back to the IX system. In addition, all the lagoons are limited to a concentration which is significantly below the safe concentration of 140 g U/l.

The only potential misrouting to the secondary deep bed filter involving uranium-bearing solutions, other than those coming from Lagoon 5A or Lagoon 4, would be as a result of misaligned valves and the discharge line shared by other processes becoming plugged, by a closed valve or debris, and for solution normally discharged to Lagoon 3 to back up into the secondary deep bed filter. Although plausible, this occurrence is not likely because: (1) the discharge line is large enough in diameter to make plugging from discharge solution solids or windblown debris unlikely; (2) the line is monitored for plugging due to crystallizing AlF_3; (3) the line between the secondary deep bed filter and the shared discharge line to Lagoon 3 has a backflow preventer; and (4) the backflush line between the outlet of the secondary deep bed filter and discharge line to Lagoon 3 also has two normally closed pneumatically actuated block valves. The consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

The only potential misrouting of uranium-bearing solutions into the IX column other than those coming from Lagoon 5A or Lagoon 4, is for solution normally discharged to Lagoon 3 to back up into the DWUR IX columns as a result of a plugged discharge line. The pump used in the Lagoon 3 neutralization system provides enough pressure to force solution back to the DWUR IX columns. Even so, the consequences of such a backup are negligible from a criticality safety standpoint because all solutions discharged to Lagoon 3 contain much less than a safe concentration of uranium.

A potential backup of eluate into other process systems that discharge into Lagoon 3 is also of no criticality safety consequence since the maximum possible concentration in the eluate is 2.55 g U/l which is much less than a safe concentration of uranium regardless of the system geometry.

Misrouting of the eluate to the metal wash system would result in a higher than normal concentration of uranium in the solution. However, under worst case conditions the mass would be limited to about 24 kgU due to the limited IX column resin capacity.

15.4.3.2 Radiation Protection

The lagoons, which are never allowed to reach a dry state, are within SPC's fenced area. The lagoons themselves are in a controlled access radiation-controlled area and have a separate fence around them. Bird alarms are in use to keep birds away from the lagoons. In the Lagoon 5A IX area the uranium-bearing solutions are in closed containers.

Personnel entering or working in the area, who require monitoring under 10 CFR 20.1502(a), are required to wear radiation monitoring devices and protective clothing/equipment (rubber shoe covers or equivalent, plastic gloves, coveralls, eye protection, respiratory protection) as appropriate for the work to be performed. Personnel are required to survey themselves prior to exiting the controlled area. Equipment leaving the controlled area must be released by Radiological Safety personnel. All personnel also receive initial and yearly refresher training on radiation protection principles and requirements.

15.4.3.3 Fire Safety

Fire in the lagoons is not credible. The Lagoon 5A IX system buildings contain manual pull alarm stations and fixed/rate-of-rise temperature sensors to alarm a fire and the buildings are rated noncombustible. There are portable fire extinguishers available at the Lagoon 5A IX.

15.4.3.4 Environmental Safety

The lagoons are equipped with multiple liners (minimum of two) with a leak detection system between the liners to detect leaks prior to reaching groundwater. In addition there is an extensive network of groundwater sampling wells associated with the lagoon system (see Chapter 5).

The Lagoon 5A IX system resides in a building addition to the Ammonia Recovery Facility. The addition is built on a sealed concrete floor with curbs which drains to a main sump. All uranium-bearing material is in closed containers or process vessels.