Docket-50201--11

MASTER

AUG 9 1965

Before the

NP-15312

UNITED STATES ATOMIC ENERGY COMMISSION

Washington, D. C.

(1) West Valley Reprocessing Plant

In the Matter of the Application of

(3) NUCLEAR FUEL SERVICES, INC.

For Licenses for a Spent Fuel Processing Plant

Under Sections 53, 63, 81, 104 (b), and 185 of the

Atomic Energy Act

AEC Docket No. 50-201

(2) Submission No. 15 -- Final Safety Analysis Report

Revision of Section VII -- Protection of the Public

Revision 2, August 20, 1964

4604

VII PROTECTION OF THE PUBLIC

Summary

7.1 The plant and process which have been described in detail in preceding sections are designed to operate so that, under all normal operating procedures, any discharge of radioactivity to the environment will be well within the limits set forth in 10 CFR Part 20.

7.2 Radioactivity can be lost from the process complex at the following points:

1. Stack
2. Waste storage tanks
3. Storage lagoon
4. Burial ground
5. Egress of personnel and material
6. Product shipment

In subsequent paragraphs, each of the above possibilities is analyzed to show that the statement of Paragraph 7.1 is valid. Some of the detailed calculations are shown in Appendicies as noted.

7.3 Further, this plant and its site are shown to be so designed and located that, in the unlikely event of the most serious accident which could possibly be deemed credible, there will be no discharge to the environment which results in levels of exposure in excess of those set forth in Sections 100.11(a)(1), (2) and (3) of 10 CFR Part 100; and further that steps can be taken to assure that, even in the event of such an accident, the discharges to surface waterways at the site boundary can be kept within the limits specified in 10 CFR Part 20 through the use of reasonable correction measures after the accident or release has occurred.

7.4 The following abnormal events have been postulated:

1. The complete rupture of a waste tank releasing 600,000 gallons of high-level waste.

2. A criticality incident anywhere in the plant involving a total of 10^{19} fissions in a single burst or a multiple continuing event totalling 10^{20} fissions.

3. A criticality incident in the fuel storage pool which sets up a 10-mwt boiling water reactor which operates for as long as 3 hours before it can be shut down.

4. A chemical explosion in the plant which is assumed to rupture a vessel containing a full day's charge of the maximum fission product content possible.

5. The complete failure of the iodine removal equipment so that for a period of up to one day the complete charge of iodine is lost to the atmosphere.

The rationale for the selection of these events has been to select for the plant, the stack, and the tank farm, events which represent the upper limit of catastrophe which could occur in each of these areas, even though we believe that the likelihood of occurrence is very small. In subsequent paragraphs, each of the above possibilities is analyzed.

7.5 Throughout this section, a number of assumptions recur. Values for such recurring assumptions are collected in Table 7.5. Assumptions specifically related to a particular calculation are included in the calculation.

Normal Operations

Stack

7.6 As explained in Paragraphs 6.3 through 6.21, the ventilation systems are designed to assure that, under normal operating conditions, flow of air is always from areas of least contamination into those of higher contamination. There are separate systems for vessels, dissolvers, and the cells themselves. These join together and are filtered before discharge through a 65-meter stack. The total volume of air discharged is 32,000 cfm. Iodine removal facilities are dsigned to collect 99.5% of the incident iodine. It is assumed that all of the noble gases in a daily charge escape during the course of the day. Under normal operating conditions, the amount of solid fission products taken into the gas stream is assumed to be low enough that the filtering of this stream will reduce them to the point where they are negligible in comparison to the gaseous activity. Calculations are based on an average fuel which we may expect to process in this plant represented by the following parameters:

Table 7.5

Assumptions Used in Calculations

Sections VII & VIII

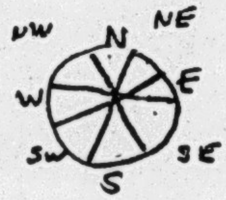
1. The dispersion parameters used are those given in Table 2.14 and in "Nuclear Safety", Volume 2, No. 4, June 1961. Figures V-1 and V-2 provide horizontal and vertical dispersion coefficients respectively for distances up to 10^5 meters and for meteorological conditions ranging from "extremely unstable" to "moderately stable". In all calculations performed in this section, "slightly unstable" coefficients have been assumed to represent average conditions and "moderately stable" coefficients have been assumed to represent inversion conditions.

   Wind velocities of 1 meter/second (≈2 mi/hr) for inversion conditions and 4 meters/second for average conditions have been used.

   The following wind distribution data has been used:

   Wind Distribution (Basis?)

   (Per Cent Per Octant)



Wind Direction	Summer	Winter	Average
N	9%	8%	8.5%
NE	4	2	3
E	5	2	3.5
SE	17	9	13 (West Valley)
S	23	21	22
SW	13	25	19
W	9	12	10.5
NW	20	21	20.5

most prevalent

west Valley

2. Fuel is cooled 150 days before processing.

3. High-level waste is stored at 410 gallons per ton which is equivalent to:

132 c/gal	Sr-90
166 c/gal	Cs-137
57 c/gal	Ru-106

at the time of storage.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Table 7.5 (Cont'd)

4. The rate of travel in the surficial till is 1.0 foot/day. The rate of travel in the silty till is 5×10^{-5} foot/day.

5. 90% of Sr-90 is associated with sludge in the tank.

6. 99.9% of Sr-90 is adsorbed on soil on passage through it.

7. 99.99% of Cs-137 is adsorbed on passage through the 700 feet of soil. what 700'

8. No Ru-106 is adsorbed at all.

9. Tritium is assumed to go 25% to stack, 10% to waste tanks, 65% to steam.

10. For long-lived isotopes the fission products are taken as 70% from U^{235} - 30% from Pu^{239}. For short-lived isotopes they are taken as 60% from Pu^{239} - 40% from U^{235}.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Burnup	20,000 mwd/ton
Specific Power	32 mw/ton
Irradiation Time	2 years
Load Factor	85 per cent
Cooling Time	150 days

Using these parameters the input activity to the plant was calculated. The gaseous activity* input is:

Kr-85	6.3×10^3 curies
I-129	0.022 curie
I-131	1.8 curies
Xe-131m	1.0 curies
Xe-133	3.8×10^{-3} curie
Tritium	50 curies

Under the conditions stated above, the total daily discharge from the stack using the average activity level fuel contemplated will be:

Kr-85	6.3×10^3 curies
I-129	1.1×10^{-4} curie
I-131	9.0×10^{-3} curie
Xe-131m	1.0 curie
Xe-133	3.8×10^{-3} curie
Tritium	50 curies

7.7 The concentrations of each of these isotopes at various distances and under various meteorological conditions are calculated from the following formulae:

For short-term calculations:

$$X = \frac{Q}{\pi \sigma_y \sigma_z u} \exp\left[-\frac{h^2}{2\sigma_z^2}\right] \qquad (7.7a)$$

For Long-period average concentration:

$$\frac{2^{\frac{1}{2}}\, 0.01 f\, Q}{\pi^{\frac{1}{2}} \sigma_z u x} \; \frac{2\pi}{8} \; \exp\left[-\frac{h_1^2}{2\sigma_z^2}\right] \qquad (7.7b)$$

* At 150 days cooling these are the only significant gaseous isotopes.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Where X = concentration in curies/m^3 (μc/cc)
Q = emission rate in curies/second
σ_y, σ_z = dispersion coefficients in meters
h = stack height in meters
u = wind velocity in meters/second
x = distance downwind in meters
f = wind frequency in per cent/octant

The calculation has been carried out for both inversion and average conditions over the range 1500 to 51,000 meters (see Appendix 7.7). The results of these calculations are presented in Table 7.7. The maximum concentrations are given for both the average and inversion conditions. For average conditions the maximum concentration occurs at the site boundary; under inversion conditions the maximum concentration occurs over the range of about 4000 to 10,000 meters downwind from the stack. It can be seen that all of the concentrations are well within the MPC values with the exception of the Kr-85 concentration under inversion conditions. The inversion concentrations given are centerline concentrations and include no wind diversity factor; they are not expected to persist for more than a few hours at a time. The yearly average concentration, which is permitted under 10 CFR Part 20, will not be significantly increased by these occurrances.

7.8 Although 10 CFR Part 20 contains no provision for limits on the deposition of radioiodine on pasturage, the plant is designed to release iodine at concentrations lower than the MPC for concentration in air in order to protect those areas surrounding the plant site which are used for dairying. Using the long-period average concentration and a deposition velocity of 0.01 meter per second, the deposition rate has been calculated (Appendix 7.8). Since yearly average concentrations are used, it is reasonable to assume that the equilibrium conditions are reached; i.e. the rate of deposition equals the rate of decay. The south, southwest and northwest octants have the highest yearly average wind frequencies, ranging from about 19 to 22 per cent. Therefore, a wind frequency of 25 per cent per octant has been used in these calculations. It was found after the Windscale incident that a grazing area contamination level of 1 μc per square meter resulted in about 0.1 μc/liter of milk*. Using this relationship the resultant activity levels in milk have been calculated. The milk activity levels are shown in Table 7.8.

7.9 The Federal Radiation Council has established a <u>Radioactivity Intake Guide for Iodine-131</u> of 100 μμc per day, based on the uptake by children as the most sensitvie segment of the population. As can be seen from Table 7.8, the consumption of about five liters of milk per day from dariy cattle grazing immediately adjacent to the site boundary would be required to equal the level of intake as established by

*TID-8206, Page 56

Table 7.7

Maximum Concentration of Gaseous Isotopes Under Inversion and Average Meteorological Conditions

		X, μc/cc		
Isotopes[d]	Curies/Second	Inversion[a]	Average[b]	MPC[c] μc/cc
Kr-85	7.3×10^{-2}	7.3×10^{-7}	1.6×10^{-8}	3×10^{-7}
I-129	1.3×10^{-9}	1.3×10^{-14}	2.8×10^{-16}	6×10^{-11}
I-131	1.0×10^{-7}	1.0×10^{-12}	2.2×10^{-14}	3×10^{-10}
Xe-131m	1.15×10^{-5}	1.15×10^{-10}	2.5×10^{-12}	4×10^{-7}
Xe-133	4.4×10^{-8}	4.4×10^{-13}	9.7×10^{-15}	3×10^{-7}
Tritium	5.8×10^{-4}	5.8×10^{-9}	1.3×10^{-10}	2×10^{-7}

a Maximum concentration occurs at about 6000 meters from the stack; concentration within about 10% of the maximum occur from about 4000 to 10,000 meters from the stack.

b Maximum concentrations occur at the site boundary (1500 meters).

c Table II, Appendix B, 10 CFR Part 20.

d At 150 days cooling, these are the only significant gaseous isotopes.

e Based on 1 triton produced per 10^4 fissions (reported as 1 in 1 to 4×10^4) with 25% lost up the stack, 65% lost in liquid waste effluent, 10% to storage tanks.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Table 7.8

Iodine Deposition and Milk Concentration[a]

Distance in Meters	Ground Concentration $\mu\mu c/m^2$	Milk Concentration $\mu\mu c$/liter
1500	200	22
2000	150	15
5000	31	3.1
10000	8.9	0.89
20000	2.6	0.26

a See Table 7.5 for assumptions and Appendix 7.8 for detailed calculations.

this Guide. This rate of consumption is higher than any that can be expected, probably by a factor of at least four. In addition, no credit is taken for dilution (during processing) by milk containing lesser (or no) amounts of radioiodine or the fact that cattle are pastured in Western New York State only about half the year.

Waste Storage Tanks

7.10 The design of the waste storage tanks has been discussed in detail in Paragraphs 5.50 through 5.56 and in Submission 1 date July 1, 1963. These tanks are built in a "cup-and-saucer" design. Operating procedures call for monitoring of the annular space between the tank and its saucer and of the water introduced under the tanks. If there is significant leakage from the tank into the saucer, the entire tank contents will be transferred into a spare tank kept for that purpose. Thus, under normal operating conditions there will be no loss of activity from these tanks. except for volatile activity

Storage Lagoon

7.11 The very low-level wastes from this process--overheads from acid fractionation, solvent wastes, and miscellaneous wastes--can be put through the general purpose evaporator and the overheads from this can be put through ion exchange columns if necessary. It is expected that the normal activity content of the overheads from the general purpose evaporator will contain about 10^{-6} μc/cc of activity. This can be further reduced by a factor of 30 by the use of simple, non-regenerated cationic ion exchange resulting in a concentration of 3×10^{-8} μc/cc. The expected volume of these wastes is 40,000 gal/day. The average available flow in Buttermilk Creek is 41 cfs which is equal to 2.7×10^{7} gal/day. Thus, the available on-site dilution factor is 6.8×10^{2}. In Cattaraugus Creek an additional dilution factor of about 8.5 is available. The concentration in Cattaraugus Creek would be expected to be about 10^{-10} μc/cc. Furthermore, the residual activity in this stream will be largely Ru-106 and I-131 with some Zr-Nb-95. The MPC's for these isotopes are 1×10^{-5}, 2×10^{-6}, 6×10^{-5}, and 1×10^{-4} μc/cc rather than 1×10^{-7} for unknown activities when radium is absent. Therefore, the available factor of safety is about 10^{3} without any analyses of the effluent and about 10^{4} if we choose to carry out specific fission product analyses on this effluent stream. This stream will also carry about 130 curies per day of tritium since there is no known way to process it to remove the tritium. The concentration of tritium on-site in Buttermilk Creek will average 1.3×10^{-3} μc/cc. The on-site MPC is 10^{-1} μc/cc. In Cattaraugus Creek the tritium concentration is expected to average 1.5×10^{-4} μc/cc; the MPC here is 3×10^{-3} μc/cc.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

7.12 This low-level stream can be discharged directly to Buttermilk Creek and the level of activity at the site boundary will remain well within the MPC levels of 10 CFR Part 20. In addition there will be a series of lagoons available for use as an emergency holdup area. Their use will permit time for the decay of shorter-lived isotopes and will allow the adsorption on the soil of some of the longer-lived isotopes. The low level waste streams from the plant discharge into the interceptor, a concrete pit of 50,000 gallons capacity, which is designed for batching of wastes. A valved interceptor drain line will permit collection of one days output from the plant which will then be sampled for gross alpha, beta, gamma and tritium. The pH of the sample will be checked and the interceptor contents neutralized if necessary to pH to 6 to 8. A line is available for pumping the interceptor contents back to the plant for further processing. Normally, after sampling, the interceptor drain valve will be opened and the contents allowed to drain by gravity to the first holding pond, a 300,000-gallon settling basin with a high level overflow to the second pond. The second and third ponds each have capacity of about 2.3 million gallons. Between the second and third ponds will be a high level overflow and a valved drain line about 18 inches above the bottom of the pond. A valved drain line from the third pond will discharge to the creek. The capacity of the ponds above the overflows will allow complete holdup of 100 days output from the plant.

7.13 In view of the factors of safety available, no hazard will be presented by the routine handling of this aspect of the operation.

<u>Burial Ground</u>

7.14 Two types of wastes will be buried in the ground in conjunction with the operation of this plant. One is low-level solid trash of all sorts coming either from the plant operation itself or shipped in for burial from off-site users of radioactivity. The other is high-level solid trash in the form of leached hulls or equipment discarded from the plant. Activity associated with the former type is considered to be "available" in the sense that it could be leached out of the waste if it were contacted with water. The radioactivity associated with hulls and discarded equipment,

on the other hand, is not considered to be "available". In the case of the hulls, the radioactivity is induced in the hulls themselves which are either stainless steel or zirconium. Both of these metals are highly refractory and and would not be expected to corrode in the burial environment to any significant extent. They will have been carefully leached in boiling nitric acid prior to burial, inspected, and an aliquot analyzed to assure that significant quantities of fuel values are not being discarded with them. Equipment to be discarded will have been exhaustively decontaminated in place before bringing it out of the cells and it will then be further decontaminated in the Equipment Decontamination Room before it is buried. Hence, significant quantities of "available" activity is not expected to be associated with this type of waste either.

7.15 Burial of both types of solid waste will be done in the silty till described in paragraphs 2.17 through 2.25 and 2.41. We have now had considerable experience in working with this material in various excavations in the course of constructing the plant and in the operation of a low-level waste burial operation for wastes of the first type described in paragraph 7.14. From this experience it is possible to accept the very low permeability figures which were obtained during the subsurface investigations reported in Section II. Therein a calculated horizontal flow rate of 5 x 10^{-5} ft/day was reported. Since we expect to carry out no burial operations within 100 feet of any ravine, this calculates to something over 5000 years for any leached activity reach the ravine. Further this silty till has been shown to have good ion exchange capacity for the longer lived isotopes, Cs-137 and Sr-90. Thus, we expect the natural defenses of this material to contain completely the activity buried in it.

7.16 Silty till does not, however, act as a natural ion exchange material for ruthenium. This is a relatively short-lived isotope, however. For the sake of illustration assume that a curie of ruthenium were to escape from the burial site and begin to work its way toward on of the ravines. Further assume that discontinuities or chemical reaction of the waste with the soil should increase its velocity by a factor of 100. It would still take over 50 years for the activity to reach the stream. In this period of time the curie ruthenium would have decayed to 10^{-15} curie. The yearly flow in Cattaraugus Creek averages 3.5 x 10^{13} cc. Thus, for each curie/year which was leached from the burial ground, the concentration in Cattaraugus Creek would be 3 x 10^{-23} μc/cc. The MPC is 10^{-5} μc/cc.

7.17 We expect the release of activity to the environment from the operation of the waste burial ground--either from low-level trash containing "available" activity or from the high-level waste described above--to be completely inconsequential.

Egress of Personnel or Material

7.18 The control of release of activity into the environment by carrying it out on the persons or clothing of personnel or on material leaving the plant must be accomplished by administrative means. Personnel working with radioactivity in the plant will be provided with protective clothing which must be changed before they leave the plant. They will also be required to take a shower. Hand and foot counters will be provided for monitoring all persons--visitors included--who leave the working areas.

7.19 Similarly procedures will be set up whereby nothing may be sent off the plant without first having been surveyed and smeared by Health-Safety personnel. Guards will be instructed not to pass out any material which does not have Health-Safety certification.

7.20 While it is possible that occasionally barely detectable quantities of activity might slip through these procedures, it is essentially impossible for significant quantities of activity to get outside the plant in this manner. No difficulty in contamination of the environment is expected from this operation.

Product Shipment

7.21 Radioactive shipments are covered by AEC regulations in 10 CFR Part 71 and 72 primarily. All regulations in effect at the time of the shipment pertaining to such shipments are expected to be complied with by the shipper and the carrier. The only way in which radioactivity could enter the environment by way of product shipments is for the shipment to become involved in a serious accident. The regulations on product shipping containers are designed with that possibility in mind. The hazard thus involved is not one peculiar to this plant, its design, or its operation. There is a considerable body of experience on this aspect of the business and we expect in no way to increase the degree of risk above that which has already been accepted.

7.17 We expect the release of activity to the environment from the operation of the waste burial ground--either from low-level trash containing "available" activity or from the high-level waste described above--to be completely inconsequential.

Egress of Personnel or Material

7.18 The control of release of activity into the environment by carrying it out on the persons or clothing of personnel or on material leaving the plant must be accomplished by administrative means. Personnel working with radioactivity in the plant will be provided with protective clothing which must be changed before they leave the plant. They will also be required to take a shower. Hand and foot counters will be provided for monitoring all persons--visitors included--who leave the working areas.

7.19 Similarly procedures will be set up whereby nothing may be sent off the plant without first having been surveyed and smeared by Health-Safety personnel. Guards will be instructed not to pass out any material which does not have Health-Safety certification.

7.20 While it is possible that occasionally barely detectable quantities of activity might slip through these procedures, it is essentially impossible for significant quantities of activity to get outside the plant in this manner. No difficulty in contamination of the environment is expected from this operation.

Product Shipment

7.21 Radioactive shipments are covered by AEC regulations in 10 CFR Part 71 and 72 primarily. All regulations in effect at the time of the shipment pertaining to such shipments are expected to be complied with by the shipper and the carrier. The only way in which radioactivity could enter the environment by way of product shipments is for the shipment to become involved in a serious accident. The regulations on product shipping containers are designed with that possibility in mind. The hazard thus involved is not one peculiar to this plant, its design, or its operation. There is a considerable body of experience on this aspect of the business and we expect in no way to increase the degree of risk above that which has already been accepted.

Conclusion

7.22 On the basis of the data and calculations presented in Paragraphs 7.6 through 7.21, in the normal operation of the chemical processing plant described herein, there will be no discharge of radioactivity to the environment in excess of the limits set forth in 10 CFR Part 20.

Abnormal Operations

7.23 In Paragraph 7.4 five abnormal events were hypothesized. These events range from the unlikely to the incredible but they delineate, we believe, the upper limit of any catastrophe which could occur in this plant and its related facilities. None of these accidents would result in levels of exposure to the general public exceeding the quide limits for gaseous emission suggested in Section 100.11 of 10 CFR Part 100; and further there is reasonable assurance that liqiud discharges at the site boundary could be kept within the concentrations for drinking water purpose specified in 10 CFR Part 20.

Loss from High-Level Waste Tanks

7.24 Careful measures have been taken to ensure the reliability of the high-level waste tanks, to provide multiple means of detecting any leakage in the unlikely event that any defects should develop and to minimize the effects on the environment of such leakage.

7.25 There are several methods of detecting leakage from the waste tanks barriers between the stored waste and the environment. The tanks have been equipped with liquid level measurement systems which are accurate to 1/4 inch or about 700 gallons. The tanks are located within saucers and each saucer is equipped with a liquid monitoring system. Each tank and saucer is contained within a reinforced concrete vault; the vault in turn is constructed upon four feet of graded gravel into which water is introduced for the primary purpose of maintaining the moisture content--and thus the bearing properties--of the underlying silty till. There are eight wells located within a foot of the vault which go down into the gravel area and through which the level of the water is measured and from which samples may be drawn to determine if there has been any leakage through the first three barriers. If there should have been any large penetration of the first three barriers, it would be possible to retrieve the activity with relatively little dilution by pumping out of the gravel area through any of the eight wells. This area thus represents the forth barrier to the escape of activity.

7.26 The local environment provides two additional barriers to the escape of radioactivity from the site. The tanks are located in the approximate center of a peninsula with a thick layer of silty till. It has been shown that the permeability of this silty till is so low that essentially complete containment would be expected of any waste that did escape the first four barriers. The till, then, is a fifth and most important barrier. The peninsula is bounded by Erdman Brook and Quarry Creek. USGS geologists who did the survey work on the site assure us that any radioactivity which escaped either onto or into the ground on this peninsula would eventually have to show up in one or the other of these creeks if it were not adsorbed on the soil by ion exchange. At the confluence of these two creeks there is established a sampling station to determine again that activity has not escaped from the site. The average yearly flow at this point is about 2 cfs. While it would be expensive, it would not be impossible to collect the total flow at this point and pump it back up to the plant site for additional processing if this should prove to be necessary. This represents the sixth barrier. There is still a final sampling of the discharge in Cattaraugus Creek at the point where the effluent leaves the plant property. This will provide the legal record of the plant discharges.

7.27 A spare tank identical to the working tank is provided so that in case the working tank begins to leak the contents may be transferred to the spare. Initially there will be a 1:1 sparing ratio. It is contemplated that during the first 15 years of operation of the plant two additional working tanks will be built and that the spare will serve all three. The eventual sparing ratio will be dictated by plant experience.

7.28 We believe that a waste tank could be ruptured only by sabotage or by a major earthquake. The former is outside the scope of the requirements of this review. The latter has been shown to be highly unlikely (see Paragraphs 2.46 through 2.48). In the event that a tank should rupture, however, the combination of the vault, the gravel area and wells, and the impermeability of the surrounding silty till can be expected to maintain the tank contents within the immediate area for a long period of time. There would be more than ample time to arrange a temporary piping system to permit pumping the waste solution from the tank, the saucer, or wells into the gravel, into the spare tank.

7.29 The multiplicity of methods for determining any leakage from the tank make it essentially impossible that such leakage could remain undetected. There are so many barriers between the waste and the environment that significant escape into the uncontrolled environment is also considered impossible. We even consider it possible to suffer a complete tank rupture--a most serious hypothetical and unlikely accident--and still maintain Cattaraugus Creek below the MPC levels of 10 CFR Part 20.

Criticality Incident Anywhere in the Plant

7.30 There have been eleven criticality incidents in solution systems.* Eight of these have resulted in a total number of fissions ranging from 4 x 10^{16} to 1.3 x 10^{18}. One, that at Idaho Chemical Processing Plant in October, 1959, resulted in 4 x 10^{19} fissions. Except in one case in which there was some warping of a tank bottom, none of these resulted in any physical damage. The assumption is made here that a criticality incident producing 10^{19} fissions in a single burst or 10^{20} fissions in a repeating incident is experienced anywhere in the plant and that the entire production of noble gaseous fission products plus 1/3 of the iodines (from 10^{20} fissions) are lost. The value of 10^{19} fissions is chosen to conform to calculations made at Savannah River suggesting this value as the upper limit of a single burst. These same calculations suggest 10^{20} fissions as the resultant of a maximum repeated burst. It will be shown that the limiting problem with this incident is not a public protection problem but rather the exposure of in-plant personnel to penetrating radiation at the time of the burst. For a repeating incident there would be time to evacuate personnel after the first burst and the exposure to penetrating radiation can be considered equivalent to that from a 10^{19} fission burst. This is considered in Paragraphs 8.26 and 8.27. Insofar as the general public is concerned there is no hazard from the immediate radiation at the time of the burst. It is well established that the limiting condition in an occurrence of this type is the thyroid dose from the iodine isotopes released. Therefore, this event is analyzed on the basis of thyroid dose to a person on the periphery of the site, at Springville, and at Buffalo. All three are calculated for the average and inversion conditions specified in Table 7.5. In the case of Springville and Buffalo the total population dose is calculated and expressed in man-rem.

* Nuclear Safety, Quarterly Literature Review, Vol. 3, No. 2, Dec. 1961, Pages 34-37 plus a subsequent Hanford incident and one in Charlestown, Rhode Island in July, 1964.

7.31 Table 7.31 lists the peak activity of each of the iodine isotopes 131 through 135 and the time after the accident when the peak occurs. These have been calculated using NRDL-456, "Calculated Activities and Abundances of U-235 Fission Products". With one exception, the peak activities have been assumed in calculating the population dose. This procedure is conservative but by a relatively small amount over the time periods involved. The one exception is the activity of iodine-134 at the time it reaches Buffalo under inversion conditions. The transit time in this case is so large in relation to the half-life of iodine-134 and its precursors that its activity level was found to be negligible compared to the remaining iodine isotopes.

7.32 The off-site doses have been computed assuming that the iodine is released from the stack instantaneously. The total inhaled activity has been calculated using Equation 7.7a for short-term center-line concentrations. The calculations have been performed for average (slightly unstable) meteorological conditons and for inversion (moderately stable) conditions. The distances involved are:

Site periphery	1,500 meters
Springville	7,200 meters
Buffalo	51,000 meters

The use of Equation 7.7a i valid for the first two distances. Extrapolation to 50,000 meters is questionable, but gives a fair estimate. The results so obtained are given in Table 7.32a. Then using the approximations suggested in 10 CFR Part 100 for the thyroid dose from each of these isotopes, the total rem per person and the fraction of the 300 rem reference value are calculated for the three locations and for both types of meteorology. Total man-rem values have also been calculated. These date are presented in Table 7.32b. Calculations supporting the numbers shown in these three tables are given in Appendix 7.32. It can be seen that in no case is the reference value used for evaluaton of reactor sites exceeded or even closely approached. The highest value indicated, a 1.95-rem/person dose in Springville under inversion conditions, is not expected to be encountered since it is the opinion of meteorologists (see Paragraph 2.13) that an inversion aimed at Springville would be caught and held in the Buttermilk-Cattaraugus Valley systems. Even this value is only about 0.7 per cent of an emergency dose of 300 rem.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Table 7.31

Quantities of Iodine Isotopes Formed from 10^{20} Fissions[a]

Peak time in USNDRL-456	Isotope	Time of Peak Activity	USNRDL	Peak Activity, Curies	½ Life
5.16 hours	I-131	5.2 hours	73 x ⅓ =	25	8.05 D
7.6 hours	I-132	7.6 hours	244 x ⅓	80	2.3 H
3.5 hours	I-133	3.5 hours	1250 x ⅓ =	420	21 H
46 min	I-134	46.0 hours	—	5770	53 M
2 min	I-135	2.2 hours	4320 x ⅓	1470	6.7 H
			Total	7765	

minutes, not hours

---

a Assuming 1/3 of the iodines are lost from the stack.

Table 7.32a

Total Dose Due to Radioiodines, Rem/Person[a]

Location	Inversion (Moderately Stable)	Average (Slightly Unstable)
Site Boundary	0.09	0.63
Springville	1.95	0.06
Buffalo	0.33	2.8×10^{-3}

a From instantaneous release of 1/3 the iodines from 10^{20} fissions.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Table 7.32b

Individual and Population Doses at Several Points

In Event of a Criticality Incident

	Site Periphery		Springville		Buffalo	
	Inversion[a]	Average[a]	Inversion[a]	Average[a]	Inversion[a]	Average[a]
Individual Dose, Rem/ Person[c]	0.09	0.63	1.95[b]	0.06	0.33[b]	2.8×10^{-3}
Fraction of 300 Rem/ Person Dose	3.1×10^{-4}	2.6×10^{-3}	6.3×10^{-3}[b]	2.1×10^{-4}	1.1×10^{-3}[b]	9.3×10^{-6}
Exposed Population Dose, Rem Total	---	---	24[b]	0.8	583[b]	5

a See Table 7.5 for conditions assumed.

b It is not expected that, under inversion conditions, any activity will reach Springville or Buffalo; but rather will be trapped in Cattaraugus Valley.

c See Table 7.32a.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Criticality Incident in Fuel Pool

7.33 The fuel pool is designed to hold 1000 fuel elements in racks of such geometry that the establishment of a critical array is impossible even if the elements were all of the maximum reactivity of any fuel before it is irradiated. Allowance is made for moving through the storage array an element of the highest reactivity. This is discussed in Section VI and the occurrence of a criticality incident here is shown to be extremely unlikely. Despite the fact that a criticality incident in the fuel pool is extremely unlikely, the following event is hypothesized:

> It is assumed that an element is jammed into the interstice between four elements and that the five elements are involved in a critical event, that a 10-mwt boiling water reactor will be set up, and that it will operate 3 hours before it is possible to shut it down. It is further assumed that all five elements are defective and, thus, that some gaseous activity can escape from the element.

7.34 Calculations supporting this section are shown in Appendix 7.34. The heat released would raise the temperature of the water in the storage pool only about 16F even if the pool water coolers failed to operate. Therefore, there is no danger that the water level in the pool would drop significantly and consequently the shielding provided by the water would prevent any hazard from increased radiation levels from direct radiation. EBWR defect test studies have shown that the fraction of noble gaseous activity lost per second from a defective fuel element is about 4×10^{-8}. This same test showed that the iodine loss was at least an order of magnitude less than this. The total inventory of gaseous activity in the five fuel elements assumed to be involved in this incident and the amounts which may reasonably be lost from the fuel pool water are shown in Table 7.34. These quantities of iodine isotopes are much less than the amounts which have already been shown to be readily tolerated by this environment (see Paragraphs 7.30 to 7.32). Consequently the iodine releases result in less hazard than has already been shown to be acceptable. The releases of kryptons are also much less than those which have already been shown to be within MPC. Similarly, the xenon-133 discharge results in concentrations under the worst condtions of only 0.01 MPC. The only aspect of this hypothetical incident which has not already been calculated in the section is the xenon-138 release.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Table 7.34

Gaseous Activities Lost from Fuel Pool

During Assumed Criticality Incident

Isotope	Inventroy Curies	Fraction Lost In 3 Hours	Total Lost in 3 Hours, Curies
Kr^{85m}	6.1×10^4	4×10^{-4}	24
Kr^{85}	2.5×10^3	4×10^{-4}	1
Kr^{88}	2.4×10^5	4×10^{-4}	10
I^{131}	2.7×10^3	4×10^{-5}	0.1
I^{132}	3.2×10^5	4×10^{-5}	13
I^{133}	5.4×10^4	4×10^{-5}	2.2
I^{134}	1.6×10^6	4×10^{-5}	64
I^{135}	1.6×10^5	4×10^{-5}	6.4
Xe^{133m}	5.2×10^2	4×10^{-4}	0.21
Xe^{133}	9×10^3	4×10^{-4}	3.6
Xe^{135}	1.5×10^6	4×10^{-4}	600
Xe^{138}	3.7×10^6	4×10^{-4}	1500

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Using the method employed in Paragraph 7.7 (Equation 7.7a) the concentration of xenon-138 at the site boundary under inversion conditions is 1.4×10^{-6} μc/cc. No MPC for this isotope is given in either 10 CFR Part 20 or in NBS Handbook 69 but it would not appear that this would result in any hazard. This event can, therefore, be tolerated without exceeding published MPC's.

<u>Chemical Explosion</u>

7.35 The assumption is next made that a vessel containing one full day's charge of fuel in solution suffers an explosion which ruptures the vessel distributing the contents throughout a cell and putting some fraction of the contained solution into the ventilating system. The ventilating system will withstand the rupturing of a tank. However, there might be some plugs or windows loosened. So long as ventilation is maintained air flow should remain into the cell except for the instant of the explosion. In analyzing this event some assumptions contained in "Radiochemical Facility Hazard Evaluation", by E. D. Arnold, A. T. Gresky, and J. P. Nichols, ORNL-CF-61-7-39, July 10, 1961 are used. This is a very similar analysis of a completely analogous situation to that considered here. The assumptions are made therein that aerosols penetrating high-efficiency filters will contain 0.14 mg/M^3 of material with the same concentration as the original dispersed solution and that the MPC for mixed fission products is 6.6×10^{-9} μc/cc. The ventilating air passing through the filters of this plant amounts to 32,000 cfm or 900 M^3/min. Then 0.14×900 or 125 mg/min of the original solution may be assumed to pass through the filter. We further assume that the gaseous activity has already been released and that in twenty minutes the ventilating system will have picked up nearly all of the gross activity that it is going to. Under these conditions about 2.5 grams of solution will be released. The maximum activity to be expected in the plant is about 700 curies per liter or 0.45 curie per gram for a total discharge of 1.1 curies. Following the methods of Paragraph 7.7 the poorest value of X/Q (at a distance of about 5,000 meters) is 1×10^{-5}. Q is equal to $1.1/3600 \doteq 3 \times 10^{-4}$ curie/sec. The $X = 3 \times 10^{-9}$ μc/cc. This is less than the MPC for mixed fission products assumed by ORNL in the above report and it would appear possible to accept this particularly untoward accident. There would be, of course, a big cleanup job in the cells. This would be undertaken according to methods outlined in Paragraphs 8.8 and 6.54 through 6.56.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

Failure of Iodine Removal Equipment

7.36 Finally it is assumed that the silver reactors and other iodine removal equipment all fail and that this is not discovered for a period of one day. That this could remain undetected for 24 hours is extremely unlikely since the stack monitor would detect the iodine increase at once. If the entire charge of iodine-131, 1.7 curies, were to be lost during a day the value of Q is 2×10^{-5} curie/sec. Under worst conditions (at a distance of about 5,000 meters) the poorest value of X/Q is 1×10^{-5} and the concentration of iodine-131 at this point would then be 2×10^{-10} µc/cc. This is less than the MPC for continuous exposure off-site.

" 1×10^{-10} (11/24/64)

Conclusion

7.37 All of the abnormal incidents hypothesized in Paragraph 7.4 have been analyzed. It has been shown that in all cases except the 10^{20} fission criticality incident the limits prescribed in 10 CFR Part 20 for continuous exposure are met and that in this one case there is no dose at any point which exceeds, or even closely approaches, the guides suggested in 10 CFR Part 100 for emergency conditions. Since we expect the probability of these events to be very low, to the point of incredibility, and since they can be handled by the environment even if they should occur, we submit that the operation of this plant does not constitute an undue hazard to the general public beyond the site boundary.

PART VIII

Before the

UNITED STATES ATOMIC ENERGY COMMISSION

Washington, D. C.

In the Matter of the Application of

NUCLEAR FUEL SERVICES, INC.

For Licenses for a Spent Fuel Processing Plant

Under Sections 53, 63, 81, 104 (b), and 185 of the

Atomic Energy Act

AEC Docket No. 50-201

Submission No. 16 - Final Safety Analysis Report

Revision of Section VIII - Protection of Plant Personnel

Revision 2, August 20, 1964

4604

VIII PROTECTION OF PLANT PERSONNEL

Design Criteria

8.1 The design criteria and the operating rules of the NFS plant have been set up so that the plant will conform to the rules and regulations specified in 10 CFR Part 20, Standards for Protection Against Radiation.

8.2 The plant will have an across-the-board industrial safety program (see Section IX) aimed at reducing accidents of all types. It will maintain a constant program designed to increase the safety morale of all of its personnel, both in the area of normal industrial safety and in that of radiation safety.

8.3 The radiation safety program is designed to protect the plant personnel from:

a. external radiation,
b. inhalation,
c. ingestion.

All three have been taken into consideration in the design of the plant. They also dictate the conditions under which the plant will be operated. In subsequent paragraphs each of these areas is discussed in detail to demonstrate that the plant as designed can be operated in accordance with the provisions of 10 CFR Part 20. In addition, the accidents which were hypothesized in Section VII are reanalyzed from the standpoint of personnel in the plant; and some less serious but more probable events are discussed from the viewpoint of personnel protection.

Protection from External Radiation

8.4 The primary protection for the worker from penetrating radiation is to interpose sufficient shielding between him and the radioactivity at all times. The plant shielding has been described in some detail in Paragraphs 6.59 through 6.65. The shielding has been designed so that, when the most active unit which could be in any particular section of the plant is present, the radiation level on contact outside the shielding in a normal access area would be 1 mr/hr. In many cases the point of contact will not be readily accessible to personnel and the percentage of the time that the shielding wall is subjected to the maximum activity level is small. The shielding design has been based on a "design"

fuel having the following irradiation on history:

Burnup	30,000 MWD/T
Specific Power	35 MW/T
Cooling Time	150 Days

8.5 Fuel is brought into the plant in shielded casks which have had their design carefully checked to ensure that adequate protection is available. A shipment will be surveyed before it is sent out. It will be surveyed again upon arrival at the plant. Before the carrier is opened, it is placed under sufficient water (see Paragraph 3.7) so that, as a fuel element is removed, there will be at least 11 feet of water over the top of the longest type of fuel element. Movement of the elements in the storage pool and their storage are also conducted under at least this much water. Transfer to the PMC is done remotely under water and back of concrete shielding. The mechanical operations in the PMC and GPC are carried out remotely back of concrete shielding. The transfer to the CPC is handled remotely. All operations in the CPC are remote. Transfers to the remaining contact-maintained cells are fluid transfers carried out remotely. All operations in the entire process, therefore, are carried out behind shielding until product is decontaminated to the point where external radiation is no longer a problem. Plutonium products containing high concentrations of Pu-240 will be placed semi-remotely into containers with sufficient shielding so that they may be handled safety.

8.6 Sampling is an operation which can contribute significantly to exposure of personnel. The sampling systems, which were described in detail in Paragraphs 6.22 through 6.36, have been designed to permit most of the sampling to be carried out completely behind shielding and to provide working background of 1 mr/hr or less. Many dilutions will be made inside the shielding and only the diluted analytical sample will be brought out. This will reduce considerably the potential for spillage and also the resultant exposure in the event of spillage.

8.7 In order to maintain the background levels in the plant at design levels, it is necessary not only to have adequate shielding but also to maintain strict controls to prevent spillage. This is done first by keeping the activity back of the shielding--there are no planned withdrawals of activity except for the samples, many of which have been already diluted; second by a careful and continual radiation survey program to detect areas in which there may have been an inadvertent introduction of activity; and third by a prompt and immediate cleanup of such areas at the same time determining the cause of the event and correcting it.

8.8 Maintenance work, both routine and major, can be expected to contribute somewhat to the whole body radiation of the plant personnel. It is the intention of NFS to permit maintenance work only under such conditions that no worker will be exposed in excess of the limits defined in 10 CFR Part 20. The maintenance procedures, which are described in detail in Section IX have been set up to minimize the exposure of the personnel. However, it is clear that maintenance work will have to be done in high radiation areas (areas in which the background levels exceed 100 mr/hr). Such work will be controlled by a work permit system as described in the Health-Safety portion of Section IX and be authorized by the plant manager. In attacking any maintenance job, the area is carefully surveyed and the amount of time that may be permitted a worker in the are is calculated. Work in the radiation field is done under closely supervised conditions. Accurate time is kept from outside the field. Recording meters as well as film badges are worn during the operation and a log of the exposure is kept and this is added to each worker's permanent radiation record. The level to which an area will be decontaminated before maintenance is attempted will vary with the amount of time needed to carry out the job, but in no case will a worker be allowed to enter a radiation field exceeding 2 r/hr without special approval of the plant manager. It will be normal plant practice to limit the exposure of any individual for any single maintenance job to 0.2 rem. Subject to the maximum limitation specified above, the balance between time and activity level will be a decision to be made by plant supervision in each instance.

8.9 In the normal operation of the plant we expect that an operator will spend no more than two hours per day in the full 1 mr/hr permitted in a normal access area. It is expected that most of the normal access area will have a background much less than this. For planning purposes we have assumed that the additional six hours per day will be in an average background of 1/6 mr/hr. The total background radiation for the quarter would then amount to 0.2 rem. This would leave about 1 rem per quarter for maintenance operations without exceeding 1.25 rem/quarter. With exposure limited to 0.2 rem/maintenance jobs, a given individual could perform five such maintenance jobs per quarter. There will be about sixty men in the plant who can be called upon to carry out such jobs so that the plant can carry out a maximum of 300 such operations per quarter, about five per day.

Inhalation

8.10 The primary protection of the workers from inhalation ~~lies~~ in keeping the activity inside the process equipment itself. As a second line of defense, all of the equipment is contained in cells maintained by a separate ventilation system at a pressure negative to the working areas. As third line of defense, masks and supply-air equipment are available. These ventilation systems have been described in detail in Paragraphs 6.3 through 6.21. Under all normal operating conditions no process activity is expected to escape past the first two barriers and into the operating areas.

8.11 There will be a system of fixed air samplers backed up by a program of air monitoring with portable air monitors to assure that the air in the working area does, indeed, remain free of activity. This monitoring program has already been described (see Paragraphs 6.66 through 6.76). The monitors will have audible and visual alarms set to operate at the lowest practical level so that remedial action may be taken before any consideration of evacuation is necessary.

8.12 Consideration has also been given to the mechanism whereby activity could be brought into the plant by recycle into the building air intake of air discharged from the plant stack which is located on top of the building. In Appendix 8.12 there are shown calculations for average and inversion conditons which indicate that the amount of recycle to be expected is completely negligible in either case. There is, however, an infrequent condition whereby the discharge from a stack may come directly down upon the stack. Under these conditions the amount of dilution could be small. A calculation is shown in Appendix 8.12 for the normal iodine-131 discharge. This shows the concentration of Iodine-131 at the stack exit with no dilution at all except that afforded by the ventilation air in the stack itself. The concentration of iodine discharged from the stack would be 6.7×10^{-8} μc/cc which is only a factor of 7.5 higher than the occupational MPC of 10 CFR Part 20. This particular meteorological condition is not expected to occur very frequently or to persist for any long period of time. Even with no dilution, and it would be expected that there would be some—perhaps a factor of ten, the concentration is such that under the provisions of Paragraph 20.103b the iodine-131 present in the building air could be tolerated for five hours. Such a condition would be picked up very quickly by one or more of the monitors. This iodine concentration would be attained only during the course of a dissolution; there would be ample time to shut down the dissolver or evacuate the building or both.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

8.13 There will be an ample supply of protective equipment such as Scott Air Packs available for use during emergency conditions or during maintenance work inside cells. The Health-Safety program (see Section IX) will include frequent training sessions and drills for all personnel in the use of this equipment so that in an emergency the equipment should be used promptly and properly.

Ingestion

8.14 The control of the problem of ingestion of radioactivity is largely one of developing within the workers good safety morale and habits of personal hygiene and of providing them with adequate protective clothing, devices, and monitors to facilitate the execution of the program. It is a problem which has been dealt with routinely at all of the presently operating chemical processing plants of the AEC without creating any serious hazards.

8.15 Protective clothing will be issued to all personnel working in the plant areas and must be worn therein. This clothing will not be worn outside the plant areas. It will be laundered at the plant and returned to service or discarded to solid waste depending on monitoring preceding and following the laundering process. An ample supply of other specialized protective clothing such as surgical, heavy rubber, and cotton gloves, caps, boots, and tape (for taping gloves to coveralls, for instance) also will be maintained.

8.16 Eating and smoking will be controlled throughout the plant. Eating will be done only in the designated lunch room. Protective clothing will not be worn into the lunch room. There will be hand and foot counters at the door. The area will be checked frequently by the Health-Safety survey. Smoking will be done only in designated areas.

8.17 At the conclusion of each shift each individual who works in the plant areas will be required to change clothes, and check his hands and shoes before leaving the premises. Two hand and foot counters are provided.

8.18 The above program of hygiene has proved to be satisfactory to maintain the ingestion of activity to negligible levels at other installations. The common practice to back up this program with a medical program will be followed at the NFS plant. The medical plans for the plant are as follows:

> The medical program will consist of a very thorough pre-employment medical history and physical examination for each prospective employee. The medical history will be aimed at not only past illnesses and injuries but particular attention will be paid to history of past radiation exposure, allergies, blood dyscrasias, tumors, and any evidence of emotional instability. The laboratory studies on all applicants will consist of a minimum of complete blood count, serology, urinalysis, chest X-ray, and vital capacity determinations. Each employee will have a complete physical examination yearly. A complete blood count will be done twice yearly; clinical urinalysis monthly. Bio-assays will be done on an "across-the-plant statistical survey" plan and follow-up examination, as this survey may indicate. The pre-employment physical examination and laboratory studies will be repeated on each individual leaving the employ of the company.
>
> A dispensary will be maintained for care of ordinary minor on-the-job injuries. There will be facilities for intensive first-aid care of severe injuries such as burns, fractures, and gross contamination with radioactive material. Immunization against tetanus will be routine for all employees.
>
> Close liaison with the Health and Safety Department will be maintained. The medical director will assist in health and safety training and indoctrination. He will review with the superintendent of health and safety all industrial radiation exposure records; air, water, and plant radiation survey records. He will cooperate with the superintendent of health and safety in plant inspections.

Detailed records of all the above will be maintained by the medical director.

8.19 As explained in the foregoing paragraphs we anticipate no difficulty in conducting the normal operation of this plant within the framework of permissible levels of exposure. It remains in the remainder of this section to analyze the consequence to employees of accidents.

Analysis of Accidents

8.20 In Paragraph 7.4 five highly abnormal hypothetical incidents were proposed and the effect of these upon the public was considered in Paragraphs 7.24 through 7.37. These same incidents are now considered with reference to the plant personnel.

Tank Rupture

8.21 It has been shown that the soil in which the tanks will be constructed in quite impervious and that the liquid from a ruptured tank would be held in the immediate vicinity for some period of time. It is proposed that the waste be transferred into one of the spare tanks as quickly as possible. The type of action envisioned would involve pumping the solution into a spare tank probably through temporary lines which might be laid overground with only a minimum of shielding. The laying of this pipe would not require personnel exposure except for the connection into the ruptured tank. This would be done by lowering a flexible hose into the tank through one of the spare nozzles on the tank. If necessary, such an operation could be accomplished from back of a temporary shield constructed outside the radiation field and pushed into place with a payloader or crane. If the earth shield remained intact, no additional shielding would be required. If the condenser system was inoperative, it might well be necessary to carry out this operation with the protection of supply-air masks. The transfer system would probably be set up with two pumps in the system in an effort to avoid any maintenance on the pumps during the transfer operation. The pumps would be operable from outside the radiation field.

8.22 Maintenance of the pumps, if required during this operation, would certainly entail operations in a high radiation. In the transfer set-up a tee would be inserted upstream from the pumps so that the lines could be flushed and decontaminated somewhat before such

maintenance would be attempted. It would have to be done from behind a portable shield. In the case of so serious a problem as this there would be no question that operations of the plant would be shut down and all available exposure time would be used in solving this problem. Supervisory personnel to the highest levels and individuals from other plants operated by the company—those who receive no radiation in the course of their work—could be brought in if necessary. No individual, however, need be exposed beyond permissible levels.

8.23 Most of the exposure associated with this incident would be in cleaning up afterward. Dismantling the highly contaminated lines, pumps, and valves and disposing of them would certainly require operations in high radiation fields. However, the need for speed would no longer be present and enough time and people would be used to assure that the task was accomplished within the permissible radiation exposures.

Criticality Incident in Plant

8.24 This incident, discussed in Paragraphs 7.30 through 7.32, assumed that the ventilation system remained in working order since that situation results in the most immediate and complete discharge of the gaseous isotopes to the environment. In that event the air inside the plant would be completely safe, as evidenced by the calculations shown in Appendix 8.12, in all cases except that of the unlikely recycle. In Appendix 8.25 it is shown that if such a downdraft occurs under average conditions the amount of dilution will amount to a factor of about 500. If it occurs under inversion conditions the dilution factor will be about 25. For the purpose of this calculation the dilution is taken as 10. It is further assumed that during the course of the entire discharge (assumed to be 10 minutes) the downdraft will be centered precisely on the air intake ten percent of the time. It is also assumed that some personnel are exposed to the resulting concentration for the entire ten minutes and that they are so preoccupied with rendering assistance to other personnel or are otherwise so upset that they did not make use of the available supply-air equipment. Under these circumstances they would be exposed to the concentrations and receive the thyroid doses shown in Table 8.24. These calculations are also shown in Appendix 8.25. The total thyroid dose is less than the dose suggested as an emergency guide in 10 CFR Part 100.

Table 8.24

Thyroid Dose During Recycle Coincident With a Criticality Incident

Isotope	Conc., μc/cc	$\frac{X}{Q}$ x Frequency	Dose Rate, Rem/ μc/(cc)(sec)	Time, Seconds	Dose, Rem
I-131	2.6×10^{-3}	$\frac{1}{100}$	110	600	5
I-132	6.3×10^{-3}	$\frac{1}{100}$	4	600	0.7
I-133	0.04	$\frac{1}{100}$	31	600	24
I-134	0.6	$\frac{1}{100}$	2	600	22
I-135	0.16	$\frac{1}{100}$	6	600	23
				Total	74.7

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

8.25 There is no reason to assume that the events which could lead to a criticality incident would also lead to shutting down the ventilation system. There may be, however, a small probability that the two events might occur simultaneously. The possibility is a difficult one to analyze since the amount of leakage of activity from the cell would be expected to vary considerably depending on the conditions. If the supply air remains on, the exterior of the cells would remain at a higher pressure than the cells and little, if any, leakage should occur. If both the supply air and the exhaust go out, there may still be a little negative pressure in the cells due to the natural draft of the 65-meter stack. If the static pressure in the cell becomes equal to that outside the cells, some leakage would occur but it should not be large since any leakage path would be tortuous. There would not seem to be a mechanism whereby the cells would reach a higher pressure than the surroundings. Failure of the ventilation system will activate an alarm which will require evacuation of the plant unless countermanded by plant supervision. We conclude, therefore, that if a criticality incident were to occur coincident with a failure of the ventilating system, the plant would be evacuated long before anyone could receive a significant dose from inhalation.

8.26 The most important aspect of protection of plant personnel in connection with a criticality incident is to assure that no one receives a serious dose of penetrating radiation at the time of the incident. The first line of defense is, of course, to prevent the occurrence of the incident. Great care is being exercised in the design of this plant and in the setting up of its operating procedures to ensure that a criticality incident does not take place. The whole subject of criticality control throughout the plant has been presented in detail in the final paragraphs of Section VI. We believe that we have reduced the probability of such an incident to an absolute minimum. However, there have been eleven such accidents in solution systems. Every major site save one has had one. There have been five incidents in metal-air systems at Los Alamos.

8.27 An Oak Ridge study* has calculated the prompt neutron and gamma dose at the outside of a normal concrete shield from a nuclear reactor of 10^{18} fissions and these data are shown in Table 8.27. They can be used for a 10^{19} fission event by direct ratio. The concrete shielding walls

---

* ORNL-CF-61-7-39, "Radiochemical Facility Hazard Evaluation", E. D. Arnold, A. T. Gresky, and J. P. Nichols, July 10, 1961, Page 6.

Table 8.27

The Prompt Neutron and Gamma Dose at the Outside Of a Normal Concrete Shield From a Nuclear Reaction of 10^{18} Fissions[a, b]

Ordinary[c] Concrete Shield Thickness, Ft	Dose at Outside of Shield, rem	
	Metal Nuclear Reaction	Nuclear Reaction in Aqueous Solution
1	88,000	5,200
3	317	23
4	17.0	1.9
5	0.960	0.14
6	0.059	0.012

---

a The dose rate may be calculated for any other number of fissions through the use of a direct proporation.

b ORNL-CF-61-7-39, "Radiochemical Facility Hazard Evaluation", E.D. Arnold, A.T. Gresky, and J.P. Nichols, July 10, 1961, Page 6.

c For high density concrete the gamma dose is reduced by a factor of 1.6 for a given concrete thickness.

for the GPC, PMC and CPC have openings for viewing windows which are equivilant in shielding value to the concrete walls for gamma radiation but offer less protection than the concrete for neutron radiation. Table 8.27 does not reflect the increased neutron dose to an employee who might be in front of one of the viewing windows. In the case of a 10^{19} burst from a criticality accident in the dissolver, the total prompt neutron plus gamma dose to an employee at the nearest viewing window would be about 300 rem, if the window were completely transparent to neutrons. The only place in the plant where a metal-air incident is at all possible is in the PMC - GPC. There we have four feet of high density concrete shielding and the resulting dose would be negligible. A solution system event could conceivably occur from the dissolver on. In the CPC there are six feet of concrete and the dose would be even less than in the PMC. In Cell #1 there are five feet of concrete shielding. The dose would still be negligible. In the remaining four cells there are three feet. At the lower end of the process there is no need for this much shielding from the fission product content. The minimum of three feet of concrete shielding has been carried down to the end of the process in order to assure that even if a 10^{19} fission critical incident should occur, and a worker should be standing right opposite the point in the cell at which the event occurred, he would still not receive a MLD of penetrating radiation.

8.28 When the product must be removed from the plant and put into storage and eventually onto a truck for shipment, contact with the product is required. Therefore, particular care has been exercised with product shipment plans. This is discussed in Paragraph 7.21.

Criticality Incident in the Fuel Pool

8.29 The hazard of a criticality incident in the fuel pool to the general public has been discussed in Paragraphs 7.33 and 7.34. It was shown therein that the amount of heat released is not enough to destroy the integrity of the water shielding which is enough to keep such an incident from irradiating anyone significantly from the prompt neutrons and gammas. It is necessary to consider the gaseous activity which is given off, however. The quantities of gaseous isotopes expected to be released during three hours was shown in Table 7.34. In Table 8.29 these quantities are shown as µc/cc and their concentrations in the fuel receiving and storage area air are shown assuming that it is diluted with the 11,000 cfm of ventilating air which is drawn through

Table 8.29

Gaseous Activities Lost into Fuel Receiving and Storage Area During Assumed Criticality Incident

Isotope	Activity Released μc/sec	Conc, μc/cc	MPC
Kr-85m	2300	4.4×10^{-4}	6×10^{-6}
Kr-85	93	1.8×10^{-5}	1×10^{-5}
Kr-88	930	1.8×10^{-4}	-
I-131	9.3	1.8×10^{-6}	9×10^{-9}
I-132	1200	2.3×10^{-4}	2×10^{-7}
I-133	200	3.8×10^{-5}	3×10^{-8}
I-134	6000	1.1×10^{-3}	5×10^{-7}
I-135	600	1.1×10^{-4}	1×10^{-7}
Xe-133m	20	3.9×10^{-6}	-
Xe-133	330	6.4×10^{-5}	1×10^{-5}
Xe-135m	5.5×10^{4}	1×10^{-2}	-
Xe-138	1.5×10^{5}	2.7×10^{-2}	-

that area. These concentrations range from twice the 40-hour MPC for Kr-85 to 2000 times the MPC for I-134. These MPC's are for continuous breathing and can be scaled up or down with time. Taking the I-134 as controlling, the room would have to be evacuated within 1/2000 of 40 hours or in just under one minute in order not to exceed one week's allowable inhalation. It will certainly be possible to evacuate this room in less than a minute and an event such as this would be immediately obvious to anyone in the room. Presumably there would be a visible flash. Monitors would trip and alarm, and the fuel pool itself would be visibly agitated. After evacuation, personnel could put on supply-air equipment in other parts of the building before re-entering to take remedial action.

Chemical Explosion

8.30 In Paragraph 7.35 a chemical explosion is assumed which ruptures a tank containing an entire day's charge of activity less the gaseous activity (since, in order to have the full day's charge in solution, it will have to have been through the dissolution step during which the gaseous activity is lost). The cell ventilation system has been designed to withstand the effects of such an explosion. So long as the ventilation system is maintained, no activity should get out of the cell in which the explosion took place except some that would be lost during the period of overpressure following the explosion. This period is estimated to be about one second. The calculations of Appendix 8.12 show that, for all conditions except a direct recycle of stack discharge into the air intake, there will be negligible concentration of activity in the building air. In the unlikely event that such a recycle and an explosion should coincide and using a calculative method analogous to that shown in Appendix 8.25, the concentration of unfiltered solid activity at thr throat of the stack would be:

$$\frac{0.125 \text{ g/min} \times 0.45 \text{ curie/gram} \times 10^6 \ \mu\text{c/cc}}{32{,}000 \text{ cfm} \times 28317 \text{ cc/cf}} = 6.2 \times 10^{-5} \ \mu\text{c/cc}$$

As in Appendix 8.25 a dilution factor of 1/10 from stack to intake and a frequency factor of 1/10 were used. The resulting concentration in the building would be 6.2×10^{-7} µc/cc. This is about 100 times the MPC assumed by Oak Ridge for mixed fission products as aerosols and it implies that about 25 minutes would be available for evacuating the plant. This is more than adequate.

Revision 1, Oct. 29, 1962
Revision 2, Aug. 20, 1964

8.31 Although we believe that the ventilation system will be maintained in operation if an event such as this should occur the possibility that it does not continue to function must be considered. As in the discussion of Paragraph 8.25 we find this situation difficult to analyze and for the same reasons. In this case it is certain that the cell would be pressurized for a short time, perhaps several seconds, and that during this time some activity would escape. If the building ventilation system were not functioning, the air in the building will be essentially stagnant. In the immediate vicinity of the cell quite high concentrations can be hypothesized depending on the assumptions chosen. However, it seems difficult to hypothesize a mechanism whereby this activity will spread very quickly from the immediate area if the building air is not moving. An explosion would alert anyone close to it and the immediate area would be evacuated in a matter of seconds. Reconnaissance and remedial action would then be carried out with supply-air masks.

Failure of Iodine Removal Equipment

8.32 As in all of the situations in which activity is put up the stack, here again there is no hazard inside the plant at all except in the unlikely case of direct recycle the concentration of iodine that might be found in the building air would be:

$$\frac{20\ \mu c/sec \times 0.1 \text{ dilution factor} \times 0.1 \text{ frequency}}{1.5 \times 10^{7}\ cc/sec} = 1.3 \times 10^{-8} \mu c/cc$$

The 40-hour MPC for iodine-131 is 9×10^{-9} μc/cc which is lower than the above calculated concentration by only about 30 percent. Thus, this concentration could be permitted for over two days. It is unlikely that the recycle would be in just the right position for more than an hour during the day. In any event this concentration would trip all the building air monitors and the incident would be discovered more readily and the dissolver shut down.

Minor Accidents

8.33 We do not believe that the accidents which have been discussed in Sections VII and VIII will occur. It is a good deal more likely, however, that during the course of the operation of this plant there will be a number of much more minor occurrances which pose no hazard at all to the general public but which, if they were not handled properly, could lead to additional exposure of the plant personnel. Such

events might be illustrated by:

a. Spilling of activity, particularly analytical samples or special samples such as waste tank sample.

b. Tracking of spilled activity from one place to another.

c. Pulling activity into jet steam lines by improper venting.

d. Leaking waste lines in diversion boxes.

e. Spilling of product solution.

The problem with all of this type of event is the same. In one way or another they lead to an increase in the background radiation which the worker may receive. This is undesirable since in nuclear work one wishes to avoid any unnecessary radiation. It is also undesirable since it is important to keep the "operating background" as low as possible in order to leave a cushion with which to carry out the required maintenance work. There are several lines of defense against this sort of problem and they are the same for all of them:

a. First, the plant has been designed to eliminate, insofar as possible, the necessity for handling even small amounts of activity.

b. Second, the operating rules are designed to eliminate every possible exposure.

c. Third, the fixed monitoring system (see Paragraphs 6.66 through 6.76) is designed to detect increases in either background radiation or air concentrations.

d. The fixed monitoring system is backed up by a formal mobile monitoring and survey program (see Section IX).

e. Each employee will wear both meters and film badges. He will be trained to check his own exposure rate frequently and to use portable monitors himself so that he need not rely completely upon Health-Safety Coverage.

Thus, these minor accidents should not go undetected. None of these accidents could credibly result in exposure to plant personnel in excess of the limits set forth in 10 CFR Part 20.

Summary

8.34 In this section we have shown that we are able to operate the NFS plant under all normal conditions within the requirements of 10 CFR Part 20 as they pertain to the protection of the plant personnel. This includes protection from external radiation, inhalation, and ingestion. Both the operation of the process proper and all the necessary maintenance operations are included in this statement.

8.35 The same series of hypothesized major accidents that were discussed in Section VII have been considered from the standpoint of the protection of the workers in the plant. It is shown that each of these unlikely events could be sustained without undue risk of exposure to plant personnel.

8.36 Finally the problem of minor accidents that could lead to increases in the background radiation received by plant personnel is considered and the multiple series of defenses against these are shown.

8.37 We conclude that the NFS plant can be operated within the requirements of 10 CFR Part 20 as they apply to the protection of its own personnel.

Part IX

Before the

UNITED STATES ATOMIC ENERGY COMMISSION

Washington, D. C.

In the Matter of the Application of

NUCLEAR FUEL SERVICES, INC.

For Licenses for a Spent Fuel Processing Plant

Under Sections 53, 63, 81, 104 (b), and 185 of the

Atomic Energy Act

AEC Docket No. 50-201

Submission No. 18 - Final Safety Analysis Report

Paragraphs 9.0 through 9.96 of Section IX of the Safety Analysis

IX PLANT OPERATION

9.1 Detailed in this section are the following items: The organizational make up of the Spent Fuels Reprocessing Plant; aspects of administrative control and procedures in various operations of the plant; Training Program, Health and Safety Program; Fire Safety Program and Emergency Procedures; the uses of the Operating Procedures and Letters of Authorization; a discussion of Maloperation; and the use of Maintenance Procedures.

Organization

Plant Manager

9.2 The Plant Manager is responsible for all activities at the plant and is, therefore, concerned with all aspects of plant operation. The more important areas include production, technical services, health and safety, and nuclear safety.

Production Manager

The Production Manager is responsible for carrying out production in accordance with approved procedures and accepted Health and Safety standards.

Health and Safety Director

The Health and Safety Director serves in a police and guidance capacity to assure conformance to approved Standard Operating Procedures and to advise in plant operations from a Health and Safety standpoint.

Technical Services Manager

The Technical Services Manager is concerned with the technical soundness of the operations proposed, the surveillance of material, and particularly, as a member of the criticality group, the maintenance of a critically safe system. He generates applications for license revisions. He reviews proposed SOP's and Letters of Authorization to confirm compliance with the license.

Plant Criticality Committee

9.3 The Plant Criticality Committee consists of the Plant Manager, the Technical Services Manager, the Health and Safety Director and the Production Manager. This committee sits in individual judgment on all SOP's and Letters of Authorization. Each member satisfies himself that the proposed procedure is in compliance with approved Health and Safety policies and that no criticality problem is involved. Each member gives particular attention to the function that he represents. The usual sequence for review is: 1. Production Manager 2. Technical Services Manager 3. Health and Safety Director and 4. Plant Manager.

Administration

9.4 The main function of management is to safely and economically administer all operations relative to the plant. The Plant Manager, who has overall responsibility for Plant Operations, has delegated certain responsibilities as enumerated in paragraph 9.2. In addition to the above, other delegation of responsibility is as shown on the Administrative Organization Chart, Figure 9.4.

Operating Procedures and Letters of Authorization

9.5 Processing of all special nuclear material handled under the license is done in accordance with the criteria set forth in the license. All operations in the Spent Fuel Reprocessing Plant are done in accordance with approved operating procedures which define the methods to be used and incorporate criteria contained in the license.

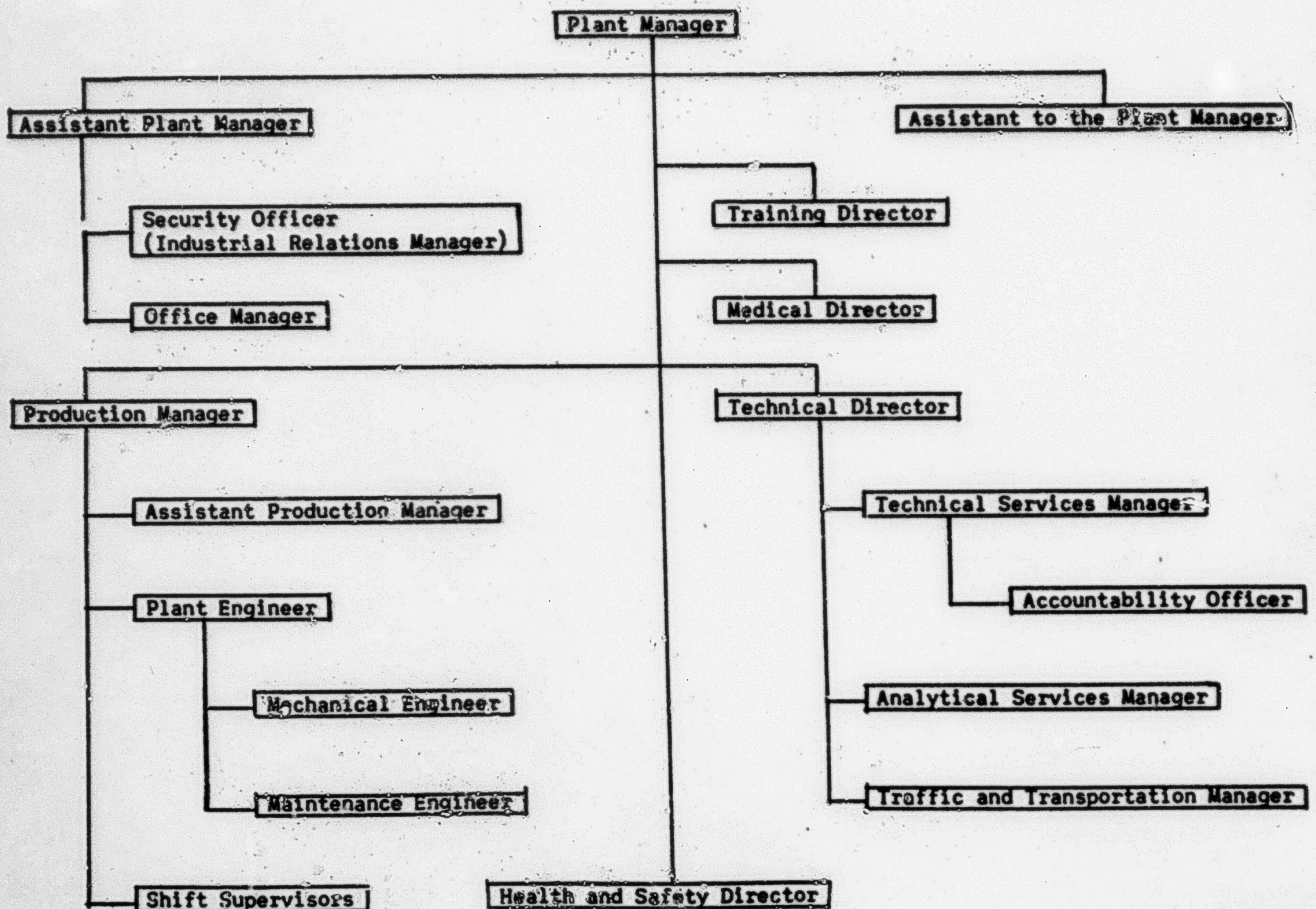
9.6 It will be the responsibility of each employee to read, understand and follow explicitly the directions contained in the Standard Operating Procedures for jobs which he is called upon to do. It is the responsibility of each supervisor to know the Standard Operating Procedures which apply in his area, to have copies of these SOP's available for employees to read and to be certain that individuals under his supervision read and understand each procedure. It is Management's responsibility to review and re-issue SOP's as necessary to reflect changes in the process and to insure that the instructions contained in SOP's represent a safe and efficient method for accomplishing the work.

9.7 Special nuclear material is received into the plant and processed by Approved Letters of Authorization which state the operating procedure(s) to be used, special handling where required, the customer for whom the processing is being done, the container(s) in which the material will be found and the material to be used as to type, enrichment and weight. Before a Letter of Authorization can be used it is independently reviewed by each member of the Plant Criticality Committee to assure its conformance with approved license criteria. It is the responsibility of each employee to read, understand and follow explicitly the directions contained in the Letter(s) of Authorization. It is the responsibility of each supervisor to have a copy of the Letter(s) of Authorization available for individuals under his supervision to read and to be certain that they read and understand the instructions contained in the Letter(s) of Authorization. It is Management's responsibility to issue Letter(s) of Authorization thereby scheduling work throughout the plant. Normally, process engineers under the supervision of the Production Manager or the Technical Services Manager draft the procedures or authorization. These engineers serve also in technical liaison and guidance in production and they conduct and supervise engineering development.

9.8 The general administrative philosophy will be to establish standard procedures for as many situations as possible and to control the effectiveness of these procedures by means of regularly maintained logs and check-off lists. These procedures, together with their

Figure 9.4

Plant Organization Chart



supporting logs and check-off lists, will be subject to regular, but random, inspection by higher levels of authority. For instance, certain routine examinations and measurements will be carried out daily according to approved check-off lists and duly logged. In these cases the next higher level of supervision will, once a week at a random time, follow through the specific procedure and determine that it is being properly carried out. Once every two months the next higher level of supervision will do likewise. Once a year these same procedures will be observed by the highest level of authority. Personal responsibility will be emphasized by having each one of these inspections recorded by signature and date; the logs will be kept as a permanent record. In addition, duty lists, addresses and telephone numbers will be maintained, and selected groups of off-duty personnel, at all levels of authority and skill, will be required to keep the plant informed on their whereabouts at all times for emergency call.

Training of Plant Personnel

9.9 The initial staff cadre will be largely made up of people with extensive experience in the handling, processing and monitoring of radioactive materials. This group, under the Training Director, will conduct the training courses for all additional employees. The curriculum (see Appendix 9.9) will be directed toward the education of certain plant personnel in the processes and related operations in such detail as to ensure complete familiarity with the equipment, its function and competence in its operation.

9.10 It is the intent of the training program to enable process operators to successfully satisfy AEC requirements for operators' licenses by test and examination. Approximately 75 operators will be so trained by permanent or temporary staff members. Initially, three types of operators will be trained for work in three different types of areas:

1. Manipulative Processing Operations
2. Chemical Processing Operations
3. Control Operations

The cadre, in addition to serving as the faculty, will take these and additional courses designed to satisfy AEC requirements for Senior Operators' Licenses. Certain employees such as watchmen, secretaries, etc. will be exempted from most of the more technical aspects of the curriculum but all employees will be exposed to a radiological familiarization curriculum. Written examinations, graded according to level of responsibility and work exposure, will be conducted.

9.11 The curriculum will include an introduction (comprising details of the background and descriptive material of the plant) details of the processes, health and safety, instrumentation, equipment description and usage, mechanical manipulation, process control, process maloperation, decontamination procedures, waste treatment, emergency measures, accountability, economic and criticality considerations and lay chemistry and

physics associated with reactor operations and chemical reprocessing. In addition, the curriculum for the cadre and others preparing for Senior Operators' licenses will include the conditions and limitations in the facility license, the design and operating limitations in technical specifications, the mechanism for any changes in the limitations in the license or specifications and more advanced study of chemistry and radioactivity. The training program for plant personnel will be a continuing one. Regular process operators will be given, periodically, a reorientation exposure to radiation safety and to processes and equipment involved in their particular plant specialty. New employees will be indoctrinated by training as are the initial employees and will be required to pass the same NFS examinations in addition to AEC license examinations.

Training of Outside Organizations

9.12 Partly as a matter of public relations but primarily to obtain effective and non-panicky assistance if an emergency requiring their cooperation should develop, local town, county, state police officers, fire departments of the area, civil defense organizations and elected officials will be invited to lectures at the plant. The subjects covered will be mainly those connected with protection of the public and will be designed to establish methods of liaison and cooperation if desirable and necessary under hypothetical emergency conditions so that assistance is most effective and radiological hazards to outsiders are minimized.

Health and Safety Program

9.13 The Health & Safety Department is charged with the responsibility for protecting plant personnel from all job hazards and the public from hazardous quantities of radiation and radioactive materials. Within the scope of this responsibility the Health & Safety Department will:

1. Monitor for radiation and contamination all plant areas and operations; (see Appendix 9.13 for equipment)

2. Monitor for radiation and contamination, areas external to the plant;

3. Approve procedures for work with radioactive materials;

4. Establish emergency procedures;

5. Establish liaison with all other departments and advise them in matters pertaining to health and safety;

6. Supervise the receipt and shipment of all hazardous materials;

7. Provide curriculum and teach aspects of the health and safety program;

8. Establish and maintain plant fire brigades trained to cope with radiation area fires;

9. Conduct a continuing safety training program for all employees;

10. Conduct inspections of all areas for fire and safety hazards and institute corrective action when necessary;

11. Maintain complete, accurate records of personnel exposure, radiation-contamination conditions in and around the plant, and perform radiation instrument calibration.

Health and Safety Organization

9.14 Specific responsibilities for members of the Health and Safety group are as follows:

Health and Safety Director

Plan, organize and supervise the work of the department. Maintain close liaison with the Medical Director advising and seeking advice concerning the employees' health and welfare. Maintain close liaison with other departments and advise them in matters pertaining to health and safety. Maintain complete, accurate records of plant, personnel and environmental radiation-contamination conditions. Administer health and safety aspects of training programs. Organize and train plant fire brigades. Inspect and maintain fire fighting and emergency equipment. Prepare material for use in safety meetings. Conduct fire and safety inspections.

Lead Technician

Perform routine and non routine monitoring tasks as directed. Write complete, accurate reports of conditions observed. Calibrate and check monitoring instruments. Obtain and count air samples. Perform safety inspections. Participate in shift safety training programs and safety meetings. Maintain exposure and survey record files. Check gamma dosimeters and record results. Prepare film badges for distribution and processing and record results.

Technician - Medical

Perform routine and non routine medical tests on employees including processing bio-assay specimens. Receive environmental and monitoring samples and prepare them for counting.

Technician - Shift

Perform routine and non routine monitoring and inspection tasks as directed. Participate in shift safety training programs and safety meetings. Write complete, accurate reports of activities.

Radiation Area Work Procedures

9.15 All radiation area work is governed by procedures approved by responsible persons in Production, Plant Engineering and Health and Safety. It is the intent of these procedures, in accordance with NFS policy, to incorporate sound industrial safety practice and to maintain exposure of employees to ionizing radiation and radioactive contamination at a level below the limits stated in 10 CFR 20.101 and appendix B, through the use of monitoring, decontamination and shielding techniques and through the use of protective clothing, respiratory protective devices and other safety equipment as required.

9.16 For the purpose of defining radiation areas, the following zones are established:

Zone I All areas beyond the site perimeter boundary;

Zone II All areas within the site perimeter boundary which are normally free of radiation--contamination in excess of 500 d/m alpha and 0.05 mrad/hr beta-gamma;

Zone III All areas within the site perimeter boundary which may have detectable radiation-contamination but in which the radiation level is normally less than 100 mrem/hr and the contamination level is not significant;

Zone IV All areas within the site in which the radiation level exceeds 100 mrem/hr or in which significant contamination exists.

Zoning of the plant and site will be the responsibility of Health and Safety.

9.17 The General Regulations for Radiation Area Work will apply to all work procedures. See Appendix 9.17 for listing of equipment.

General Regulations

The minimum requirements for protective clothing are:

a. For entry to Zones I and II, no protective clothing is required;

b. For entry to Zone III areas, for inspection only, the minimum protective clothing required shall be: Laboratory coat, shoe covers and gloves;

c. For entry to Zone III areas to perform work, the minimum protective clothing required shall be: Coveralls, shoe covers, gloves and cloth hat;

d. Protective clothing required for entry to Zone IV will be specified on a Special Work Procedure. No one will be permitted to enter a Zone IV area until a Special Work Procedure has been completed and signed and all provisions of that procedure have been implemented;

e. Respiratory protection requirements will be posted in the "hot" lobby.

The minimum requirements for personnel monitoring are:

a. For entry to the Plant, the minimum requirement for personnel monitoring shall be; --Badge

b. For entry to Zone III areas, the minimum requirement for personnel monitoring shall be;--Badge, dosimeters and dose rate type radiation survey meter.

c. For entry to Zone IV areas, the personnel monitoring requirements will be specified on the Special Work Procedure.

The exiting procedure is:

a. When leaving Zone IV areas the minimum requirement for personnel survey shall be A complete clothing and body survey by Health and Safety Personnel;

b. When leaving Zone III areas the minimum requirement for personnel survey shall be A complete self survey at the station monitors located at the Zone III - Zone II boundary;

c. When leaving Plant Zone II the minimum requirement for personnel survey shall be A hand and shoe check using the hand and shoe counters and station monitors in the building lobby. This survey shall also be made before entering the building lunch room.

The rules for radiation area conduct are:

a. No smoking, eating, drinking, or chewing shall be permitted in Zones III and IV. Zone II Plant areas in which smoking is not permitted will be so designated;

b. Every surface and every piece of equipment in Zones III and IV and every tool or article taken into these Zones shall be regarded as being contaminated until surveyed and released by a representative of Health and Safety;

c. All the provisions of applicable work procedures shall be read, understood and followed explicitly by the personnel performing the work;

d. Each employee is responsible for the care and treatment of equipment issued to him and for his conduct in the performance of assigned work. Careless or willful mishandling of equipment or misconduct on the job will not be tolerated and will constitute grounds for dismissal.

9.18 For work of a routine nature in areas normally free of significant radiation and/or contamination and where conditions are known and the work to be performed will not cause any significant change in these conditions, work is governed by Extended Work Procedures which may be modified or terminated at any time by Health and Safety personnel. Such Extended Work Procedures are given a date of termination not exceeding twelve months from the date of issue. On, or in advance of, the date of termination, the procedure is reviewed by responsible persons in Plant Engineering, Production, and Health and Safety, changed as necessary to reflect current working conditions, and re-issued with a new termination date.

9.19 For work of a special or unusual nature or work in areas or on equipment which does involve significant radiation-contamination, a Special Work Procedure is issued. Each Special Work Procedure is valid for one shift only. Approval of responsible persons in Plant Engineering, Production and Health and Safety is required prior to the start of any work and before work can continue on succeeding shifts.

Job Planning and Scheduling

9.20 Each day responsible representatives of Plant Engineering, Production and Health and Safety meet to plan and schedule work for the following day. A Work Schedule is prepared and distributed and Special Work Procedures are prepared and approved in advance of the work. The Work Schedule lists the personnel assigned to each task, the time and place to meet for each job, the estimated duration of each job, the applicable procedures governing the work and other information of general interest.

9.21 The Plant Engineer is responsible for:

a. Estimating the time and manpower required to accomplish each maintenance job;

b. Assigning maintenance personnel to each scheduled maintenance job;

c. Assuring that all maintenance personnel read and understand applicable work procedures and are thoroughly trained in radiation-contamination work;

d. Assuring that scheduled maintenance personnel understand what work is to be accomplished and that the proper tools and equipment, in good condition, are available in advance of the job;

e. Assuring that assigned maintenance personnel are available at the place and time indicated on the schedule.

9.22 The Production Manager is responsible for:

a. Establishing priority of maintenance in the plant;

b. Determining what the effect will be of scheduled maintenance work on plant operations;

c. Arranging for equipment or area shutdown as necessary to accomplish the scheduled work;

d. Arranging for pre-maintenance decontamination and/or shielding as required;

e. Assigning operating personnel to scheduled jobs as required;

f. Assuring that all operating personnel read and understand applicable work procedures and are thoroughly trained in radiation-contamination work;

g. Assuring that operating personnel understand what their duties will be for each scheduled job and that the necessary equipment, in good condition, is available in advance of the job;

h. Assuring that assigned operating personnel are available at the place and time indicated on the schedule;

i. Issuing the work schedule following each planning and scheduling meeting.

9.23 The Health and Safety Director is responsible for:

a. Determining what radiation-contamination conditions and/or other special hazards will be encountered in performing the scheduled work;

b. Determining whether or not a Special Work Procedure will be required for each scheduled job and if not, which Extended Work Procedure will apply;

c. Determining requirements for protective clothing and/or other safety equipment for scheduled work and assuring that such equipment, in good condition, is available in advance of the work;

d. Scheduling and leading a pre-job conference if required;

e. Assigning Health Physics personnel to scheduled jobs as required;

f. Assuring that all Health Physics personnel read and understand applicable work procedures, are thoroughly trained in all phases of radiation-contamination work and are trained and equipped to respond to unusual or emergency conditions;

g. Assuring that assigned Health Physics personnel are available at the place and time indicated on the schedule;

h. Initiating Special Work Procedures following each planning and scheduling meeting.

Unconditional Release

9.24 Release surveys of equipment are the responsibility of Health and Safety. Any item leaving Zone IV or Zone III to go to Zone II or Zone I or any item leaving the plant site from any Zone, must be accompanied by a completed Unconditional Release. The original of the release accompanies the equipment, and one copy (in the case of an item leaving the plant site) is presented to the Plant Security Guard who is responsible for enforcing this procedure. This procedure also applies to commercial vehicles and railway cars. The Unconditional Release states the radiation-contamination levels on the items described, and releases them with no conditions or restrictions as to their use.

Conditional Release

9.25 The use of a Conditional Release is normally restricted to equipment which is not to leave Zone III. For example, a process pump which is to be taken to the Equipment Decontamination Room or the Maintenance Shop for repair will require a Conditional Release. The Conditional Release describes the item released, lists the radiation-contamination status of the item and lists any special precautions which must be taken for handling, dismantling, and repairing the item.

Lock and Tag Procedure

9.26 The Lock and Tag Procedure is used to lock out valves, controls, and switches, the unauthorized or inadvertent use of which could cause process upset, damage to facilities and equipment or personal injury. Each department will have its own locks and will be responsible for applying

locks to equipment as required for employee protection even if this practice results in several locks on the same switch. The responsibility for removing locks will rest with the department head (or his delegated assistant) of the department responsible for applying the lock. Non compliance with this provision will not be tolerated. Maintenance locks are normally applied only during maintenance work on equipment and are removed when the work is completed. The tags are used to indicate the reason for the lock and to warn all personnel of the possible consequences of violating this procedure.

Safety Hazard Tag Procedure

9.27 Any NFS employee is responsible for tagging or posting any equipment or condition which represents a safety hazard and/or unsafe working condition. After taking such action he should notify his foreman or supervisor so that the condition may be corrected promptly. The Supervisor or Foreman shall notify the Director of Health and Safety.

Radiation and Contamination Protection

9.28 In this paragraph there are discussed a number of administrative limits of radiation exposure for the NFS Plant. It is expected that these limits may be modified as plant experience dictates. NFS employees may be exposed to radiation up to the limits stated in the following table with the approval of the employee's immediate supervisor:

Table 9.28

Rems Per Calendar Quarter

a. Whole body; head and trunk; active blood forming organs; lens of eyes; or gonads	1-1/4
b. Hands and forearm; feet and ankles	18-3/4
c. Skin of whole body	7-1/2

Whole body exposure to penetrating radiation in any 24 hours period shall be limited to 0.1 rem or, if approved in advance by the Health and Safety Director, 0.2 rem. Planned single exposures in excess of 0.2 rem must be approved in advance by the Plant Manager.

In emergencies involving the life of personnel, it shall be the responsibility of the NFS Senior representative present to determine and authorize, if such be his decision, entry into higher fields of radiation.

9.29 The whole body dose and skin dose is available from badge readings. The dose to extremities is controlled in the field. If the dose rate to the hands and forearms or feet and ankles is more than 15 times the dose rate to the whole body, the time limit for the work is based on the dose rate to the extremities. With prior approval of the Plant Manager and the individual concerned, an employee of NFS may be

permitted to receive a dose to the whole body greater than that permitted under paragraph 9.28 provided that:

a. During any calendar quarter the total whole body dose shall not exceed 3 rems; and
b. The dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5 (N-18) rems where "N" equals the employee's age in years at his last birthday; and
c. The employees accumulated occupational dose to the whole body has been determined using Form AEC-4, in accordance with the instructions in paragraph 20.102 of 10 CFR-20.

9.30 The consequence for intentionally causing erroneous film badge or dosimeter readings is dismissal.

9.31 NFS employees, who have been certified in the use of radiation monitoring instruments by the Health and Safety Director, may in the course of their normal duties, self monitor in areas where the dose rate does not exceed 100 mr/hr, except Zone IV areas. In areas in which the dose rate exceeds 100 mr/hr or in all Zone IV areas monitoring for any entry shall be by Health and Safety Technicians. In no case shall employees enter an area in which the dose rate exceeds 2 r/hr unless prior approval of the Plant Manager has been obtained. (See 9.28)

Maximum Permissible Levels of Radioactivity

9.32 The maximum allowable surface contaminations for the West Valley Plant are shown in Table 9.32a. The Maximum Permissible Concentrations in air of some radionuclides expected to be encountered in the West Valley Plant are shown in Table 9.32b. The Maximum Permissible Concentration in on-site, nonpotable water in Buttermilk Creek of some radionuclides expected to be encountered at the West Valley Plant are shown in Table 9.32c.

Air Sampling

9.33 The air sampling program provides for the evaluation of alpha and beta-gamma air contamination in all building areas, the plant site and the site perimeter. Included in the program are 54 in-plant area particulate samplers, 19 remote in-cell particulate samplers, 7 in-plant continuous air monitors, 1 plant site sampler and 3 site perimeter air monitors. This equipment is described in Appendix 9.33, is located as per Figure 6.67, and discussed in Paragraphs 6.66 to 6.67.

9.34 The filter paper used for particulate sampling is Whatman #41 or equal, two inches in diameter. Whatman #41 filter paper has a collection efficiency of 98 per cent for 0.18 micron particulate or larger at a flow velocity of 50 centimeters per second. To obtain this flow velocity a minimum flow rate of 60 liters per minute is used for in-plant air samplers. Self absorption in Whatman #41 paper is zero for beta and about 0.3 for alpha.

Table 9.32a

Maximum Allowable Surface Contamination for West Valley Plant

Surface	Smearable Alpha d/(m)/(100 cm^2)	Smearable Beta-Gamma As Shown/100 cm^2	Non-Smearable Alpha d/(m)/(100 cm^2)	Non-Smearable Beta-Gamma As Shown/100 cm^2
Skin	No Detectable		500	100 c/m
Personal Clothing	No Detectable		500	100 c/m
Plant Clothing	500	100 c/m	1,000	2,000 c/m
Plant Vehicles	500	100 c/m	1,000	5,000 c/m
Commercial Vehicles	500	100 c/m	500	0.4 mrad/hr
Zone I	Zone I limits are per 10 CFR - 20, Appendix B, Table II			
Zone II	500	100 c/m	500	100 c/m
Zone III	5,000	10 mrad/hr	5,000	100 mrad/hr
Zone IV *	50,000	2 r/hr	50,000	2 r/hr
Conditional Release	1,000	5,000 c/m	5,000	10 mrad/hr
Unconditional Release	500	100 c/m	500	100 c/m

* For personnel entry

Table 9.32b

Maximum Permissible Concentration (μc/ml)

Mixed Fission Products	
No respiratory protection	1×10^{-9}
Full face filter mask	2×10^{-8}
Supplied air mask	Above 2×10^{-8}
Strontium-90	
No respiratory protection	3×10^{-10}
Full face filter mask	6×10^{-9}
Supplied air mask	Above 6×10^{-9}
Cesium-137	
No respiratory protection	1×10^{-8}
Full face filter mask	2×10^{-7}
Supplied air mask	Above 2×10^{-7}
Plutonium 239	
No respiratory protection	2×10^{-12}
Full face filter mask	4×10^{-11}
Supplied air mask	Above 4×10^{-11}
Natural Uranium	
No respiratory protection	6×10^{-11}
Full face filter mask	1×10^{-9}
Supplied air mask	Above 1×10^{-9}
High Enriched Uranium	
No respiratory protection	1×10^{-10}
Full face filter mask	2×10^{-9}
Supplied air mask	Above 2×10^{-9}
Iodine-131	
No respiratory protection	9×10^{-9}
Supplied air mask	Above 9×10^{-9}
Krypton-85	
No respiratory protection	1×10^{-5}
Supplied air mask	Above 1×10^{-5}

Footnotes to Table 9.32b

Maximum Permissible Concentrations for other radio-nuclides is as indicated in 10 CFR-20, Appendix B, Table I. When a mixture of radionuclides is encountered and the identity and concentration of each radionuclide in the mixture are known, the Maximum Concentration is derived as follows: If radionuclides A, B, V, are present in concentrations Ca, Cb, Cc and the applicable MPC's are MPCa, MPCb, and MPCc respectively, than the concentrations shall be limited so that the following relationship exists:

$$\frac{Ca}{MPCa} + \frac{Cb}{MPCb} + \frac{Cc}{MPCc} \leq 1$$

Table 9.32c

Maximum Permissible Concentration (μc/ml)

	On-Site-Buttermilk Creek	Off-Site
Cesium-137	4×10^{-4}	2×10^{-5}
Cobalt-60	1×10^{-3}	3×10^{-5}
Tritium	1×10^{-1}	3×10^{-3}
Iodine-131	6×10^{-5}	2×10^{-6}
Plutonium-239	1×10^{-4}	5×10^{-6}
Ruthenium-103	2×10^{-3}	8×10^{-5}
Ruthenium-106	3×10^{-4}	1×10^{-5}
Strontium-90	4×10^{-6}	1×10^{-7}
Natural Uranium	5×10^{-4}	2×10^{-5}
High Enriched Uranium	8×10^{-4}	3×10^{-5}

Footnotes to Table 9.32c

Maximum Permissible Concentrations for other radionuclides are as stated in 10 CFR-20, Appendix B. When mixtures of radionuclides are encountered and the identity and concentrations of each is known, the procedure stated in the footnote to Table 9.32b is used to determine the MPC.

9.35 Air samples are collected and analyzed for radioactive material according to the schedule shown in Table 9.35. This schedule is subject to revision as experience is gained in operating the plant. Continuous air monitors are used in some occupied areas to provide an immediate alarm should high air contamination exist. The other remote samplers will be used occasionally to obtain very short, spot samples of air contamination conditions in the cells. These remote samplers are:

Miniature Cell

General Purpose Cell

Chemical Process Cell

Mechanical Cell

X-Cell 1

X-Cell 2

X-Cell 3

Product Purification and Concentration

Chemical Process Cell Crane Decontamination Area

Process Mechanical Cell Crane Decontamination Area

9.36 As each sample is removed from the sample head it is placed in an envelope which is marked with the sampler location, date-time started, date-time changed and the flow rate. When all samples have been changed, according to the schedule, they are brought into the Health Physics Lab, removed from the envelopes, placed in planchets and surveyed with portable beta-gamma and alpha detection instruments (Appendix 9.36). Any samples which show unusually high activity are segregated for special handling and prompt attention in the counting room.

9.37 Alpha, Beta proportional counters (Appendix 9.37) are used to analyze in-plant air samples. All samples receive a one minute alpha, beta count as soon as possible after being delivered to the counting room. The beta/alpha ratio is determined based on this count. Since the beta/alpha ratio is constant for natural activity, it may be possible at this time to make a preliminary estimate of the amount of long-lived emitters on the sample. The concentration of beta emitters on the sample will be determined based on the initial count. This is accomplished as shown in Appendix 9.37a. All samples receive a five minute alpha count five to seven hours after sampling and a second five minute alpha-beta count 23 to 25 hours after sampling. These counts are used to calculate the alpha counts due to long-lived alpha activity (product) on the sample. This is accomplished as shown in Appendix 9.37b. Any samples which, on the 24 hour count, show less than 1 c/m alpha and less than 1800 c/m beta are

Table 9.35

Start Up Schedule for Air Sampling

Shiftwise	Daily	Weekly
Hot Lobby	GPC Operating Aisle-west	Third Floor Office
Mechanical Operating Aisle-west	GPC Operating Aisle-east	Second Floor Office
Ram Equipment Room	Lower Warm Aisle-west	Main Lobby
Chemical Viewing Aisle-north	Lower Warm Aisle-east	Maintenance Shop
Ventilation Wash Room	Acid Recovery Pump Aisle	Utility Room
Process Sample Enclosure-1	Scrap Removal	Manipulator Repair Area
Process Sample Enclosure-2	Mechanical Operating Aisle-east	Product Packaging CAM
Analytical Aisle	X-Cell entrance air lock	Fuel Storage CAM
Extraction Sample Aisle-west	U-Product cell	EDR Viewing Station
Extraction Sample Aisle-east	Product purification cell	MCR Air Lock
Ventilation Exhaust Cell	Product Packaging 1, 2 and 3	Ventilation Supply Room
Pulser Aisle	Fuel Storage 1 and 2	Hot Lobby CAM
	Chemical Viewing Aisle-south	Mechanical Operating Aisle CAM
	Equipment Decontamination Room	VSR Access Aisle
	Chemical Operating Aisle-north	Off Gas Cell-3
	Chemical Operating Aisle-south	Analytical Cell Decon. Area
	Lower Extraction Aisle-east	Alpha Lab CAM
	Upper Warm Aisle-west	Lab Access Aisle
	Upper Warm Aisle-east	Control Room
	Off Gas Cell-2	Extraction Chemical Room CAM
	OGC-ARC Aisle	Plant Area
	Chem Lab-east and west	Perimeter-1
	Product Lab	Perimeter-2
	Emission Spec. Lab	Perimeter-3
	Mass Spec. Lab	GPC Crane Room
	Alpha Lab	Mechanical Crane Room
	Stack Sampler	Chemical Crane Room
	Upper Extraction Aisle-west	
	Upper Extraction Aisle-east	
	Extraction Chemical Room-east	
	Laundry	

discarded. These counts at maximum counting error, represent about 1% of MAC for plutonium-239 and strontium-90 respectively. Samples which exceed either or both of the counting limits will be held for a final count. The final 30-minute count on in-plant air samples is taken a minimum of four days after sampling to allow the natural activity to decay essentially to zero. All of the alpha counts are assumed to be counts due to product and the concentrations are calculated as follows:

Alpha

$$\mu c/ml = \frac{c/m\ (1.31 \times 10^{-12})}{M^3}$$

Since the counting error for a 30-minute count at 95 percent confidence level is $\pm$ 10% at 10 c/m, the minimum detectable alpha concentration on a 24-hour sample is:

$$\frac{10\ (1.31 \times 10^{-12})}{86.4} = 1.5 \times 10^{-13} \text{ with } \pm \text{ 10\% accuracy}$$

Beta-Gamma

$$\mu c/ml = \frac{c/m\ (9.19 \times 10^{-13})}{M^3}$$

9.38 Some in-plant air monitors are moving-filter type and the filter tape is not normally analyzed in the counting room. Portions of the tape may be counted and/or gamma scanned if this information is needed.

9.39 The perimeter samples are changed weekly and are analyzed once as soon as practical after sampling and again four days after sampling. The samples are analyzed by counting for one hour in a low background alpha, beta proportional system (see Appendix 9.39a). The geometry of this system is 50% for beta and 35% for alpha. The background is about 1 c/m. The concentration of beta emitters is determined as shown in Appendix 9.39b and the concentration of alpha emitters is determined as shown in Appendix 9.39c. A log is kept of air sample results. These results become part of the permanent record of radiation-contamination conditions in and around the plant.

9.40 Radioiodine activated charcoal filters from the stack and perimeter stations are analyzed as follows: The filters are gamma scanned to determine if there are other gamma emitting isotopes present and in what proportion. Since the radioiodine filter is preceded by a particulate filter, there will normally be no interference from other isotopes. The radioiodine filter is then counted in one of the proportional counting systems and the concentration is calculated as shown in Appendix 9.40.

9.41 The numbers used in this section for geometry of counters and efficiency of and self absorption in filter paper are numbers furnished by the manufacturers. The method used to determine actual counter geometry is described in the calibration section (Appendix 9.37). The collection efficiency of Whatman #41 filter paper can be checked by using a membrane type filter behind the Whatman #41 filter to test the penetration under various conditions of use in the plant. The self absorption of alpha in Whatman #41 can be determined by counting a filter, dissolving the filter, evaporating the solution on a planchet and counting the planchet. The absorption correction then becomes; filter count/planchet count. These tests will be run on each batch of filter paper received.

Radiation - Contamination Survey Program

9.42 Beta-gamma film badges are supplied to each employee and all visitors to the plant through an arrangement with a commercial film badge processor. Badges are exchanged and read weekly for most personnel; monthly for administrative personnel. This schedule is subject to change as operating experience is gained. Immediate notification by phone or wire is given for badges which show a dose in excess of 100 mrem. Neutron monitoring is accomplished on an area basis. Neutron badges are placed in the product storage and product packaging and handling areas to establish and check the neutron dose rate in these areas. The neutron badges are changed monthly during startup but this may be changed to quarterly at a later date.

9.43 Each production employee and each visitor is issued a 0-200 mr gamma dosimeter which is read and the dose recorded during the shift following the shift on which it is used. The dose is recorded on the "Dosimeter Readings" form, and is transferred later to the "Exposure Record" card which is also used to record badge readings. The 5 x 8 inch card, designed to be used in a "Victor Visible" type file, contains all of the information required by AEC Form 5. Each card represents 13 weeks exposure data. See Appendix 9.43 for the "Exposure Record" card referred to above.

9.44 A limited number of self reading dosimeters are available for use during "hot" area decontamination and maintenance work. These dosimeters will be used as the second line of defense against overexposure. The primary control will be monitoring, by Health and Safety or by the individual performing the work, and timekeeping, by the individual or by a timekeeper assigned to the job.

9.45 Health and Safety responsibility for product shipments entails checking the shipping papers for Production signature approval, for product specifications, accountability certification and surveying the shipping containers to insure conformance with all applicable federal, state, and local regulations. The signature of an authorized Health and Safety representative on the shipping papers will constitute approval to ship.

9.46 With the exception of Zone IV egress, personnel surveys are the responsibility of each employee. Health and Safety will audit the frequency and adequacy of such surveys. Personnel found in a Zone II or Zone I area with contaminated clothing may be subject to dismissal.

9.47 A regular schedule of routine surveys will be performed by Health and Safety. The routine survey program is designed to supplement the reports of radiation contamination conditions which are encountered during maintenance and other work, and to insure that all plant areas are surveyed on a regular basis. Each routine survey is described in considerable detail on the "routine survey" form (See Appendix 9.47) which will serve as a guide for the Health and Safety personnel performing the survey. A list of routine surveys is shown in Table 9.47. A written record is made of every survey performed by Health and Safety personnel. This record which is executed on pre-numbered survey log sheets becomes part of the permanent record of radiation-contamination conditions in and around the plant.

Environmental Survey Program

9.48 The environmental survey program, pre-operational and post-operational is divided into three categories:

1. Atmospheric monitoring including air particulate monitoring;

2. Water monitoring including surface and ground water sampling;

3. Earth and biota monitoring including samples of silt, mud, plankton, fish and shellfish from Buttermilk Creek and Cattaraugus Creek; soil, vegetation and milk samples from the site and surrounding area and small game from the site.

how done?

9.49 The pre-operational program is divided into two phases; the first phase, started in the spring of 1963, to establish on site gross activity background with a few analyses for specific isotopes and the second phase, starting in the fall of 1964, to include more analyses for specific isotopes. Phase II will continue into the post-operational period. Both Phases are detailed in Appendix 9.49. A summary of the Environmental Monitoring Program is presented in Tables 9.49a and 9.49b.

Waste Disposal Control Program--Gaseous Waste

9.50 Gaseous waste control is accomplished by treatment of waste gases before release, continuous monitoring at the point of release and environmental monitoring to determine the effect, if any, of released activity in the environment. Waste gas treatment is discussed in some detail in Section VI, Paragraphs 6.66 to 6.70. Prefilters, air scrubbers, silver reactors and high efficiency filters are used to minimize the amount of radioactive gases and particulates released routinely from the plant. It is anticipated that the routine releases will be well below the maximum allowable under applicable

Table 9.47

Routine Surveys

Survey No.	Title	Shift Assigned
S-1	Check Dosimeters and Record Results	1,2,3
S-2	Pick up Air Samples	1,2,3
S-3	Check Charts on Gamma Alarm, Sample System and Weather Monitoring System	1,2,3
S-4	Count Samples	1,2,3
D-1	Check Station Monitors and Hand Counters	3
D-2	Calibrate Instruments	3
D-3	Spot Check Laboratories	2
D-4	Survey Hot Lobby	3
D-5	Transfer Dosimeter Readings to Exposure Record Cards	1
D-6	Spot Check Sample Aisle, Pulser Aisle and Warm Equipment Aisle	3
D-7	Survey Lunch Room	2
D-8	Survey Step-off Pads	3
D-9	Prepare Control Samples for Counting	1
D-10	Prepare Environmental Samples for Counting	1
D-11	Spot Check Product, Packaging and Handling	2
W-1	Survey Alpha Lab	1
W-2	Survey Chem Labs	1
W-3	Survey Spec Labs	1
W-4	Survey Product Lab	1
W-5	Survey Zone III offices	3
W-6	Survey Mens Locker Room	2

Table 9.47 con't

Survey No.	Title	Shift Assigned
W-7	Survey Five Personnel	1,2,3
W-8	Survey Ventilation Penthouse	3
W-9	Survey Upper Warm Equipment Aisle	3
W-10	Survey Access Aisle	2
W-11	Survey Operating Aisles	2
W-12	Survey Sample Aisle	3
W-13	Survey Fuel Receiving & Storage	3
W-14	Survey Product Packaging & Handling	2
W-15	Survey Decontamination Area	3
W-16	Survey Scrap Transfer Area	3
W-17	Survey Health Physics Lab	1
W-18	Survey Mechanical Cell Viewing Area	2
W-19	Survey Laundry	3
W-20	Obtain Environmental Samples	1
W-21	Survey Womens Locker Room	1
W-22	Survey Warm Equipment Aisle	3
W-23	Survey Mobile Equipment	1
W-24	Survey Ventilation Equipment Rooms	2
M-1	Survey Analytical Viewing Area	2
M-2	Survey Instrument Shop	2
M-3	Survey Main Lobby	1
M-4	Survey Cold Chemical Penthouse	2
M-5	Survey Chemical Process Cell Viewing Area	2

Survey No.	Title	Shift Assigned
M-6	Survey Maintenance Shop	2
M-7	Survey Guard House	1
M-8	Survey Tank Farm	1
M-9	Survey Burial Ground	1
M-10	Survey Remote Operating Station	2
M-11	Survey First Aid	1
M-12	Obtain Environmental Samples	1
M-13	Autoradiograph Environmental Air Samples	1
Q-1	Survey Utility Building	3
Q-2	Survey Roads, Walks, Parking lot and R. R. Spur	2
Q-3	Survey Storage Lagoon and Hardstand Areas	1
Q-4	Survey Dry Wells	1
Q-5	Survey Zone II offices	3
Q-6	Obtain Environmental Samples	1

S = Shiftwise
D = Daily
W = Weekly
M = Monthly
Q = Quarterly

Table 9.49a

Environmental Monitoring

Phase I - Type of Analysis

	Weekly	Monthly	Semi-Annually
Air Sampling 3 Perimeter 1 Plant Site	Gross Alpha Gross Beta- Gamma		
Rain & Snow 1 Plant Site		Gross Alpha Gross Beta- Gamma, Tritium	
Surface Water 1 Erdman Brook 1 Buttermilk Creek 1 Cattaraugus Creek		Gross Alpha Gross Beta- Gamma, Tritium	
Mud and Silt 1 Erdman Brook 1 Buttermilk Creek 1 Cattaraugus Creek		Gross Alpha Gross Beta- Gamma	
Well Water 1 Plant Site		Gross Alpha Gross Beta- Gamma, Tritium	
Vegetation 3 Perimeter			Gross Alpha Gross Beta- Gamma I-131 Sr-90
Milk Neighboring Farm	Gross Beta Gamma	I-131 Sr-90	
Small Game 1 Plant Site			Gross Alpha Gross Beta- Gamma I-131 Sr-90

Table 9.49b

Environmental Monitoring

Phase II - Type of Analysis

	Weekly	Monthly	Semi-Annually
Air Sampling 3 Perimeter 1 Plant Site	Gross Alpha Gross Beta- Gamma	Gamma Scan	
Rain and Snow 1 Plant Site		Gross Alpha Gross Beta- Gamma Tritium	Sr-90
Surface Water 1 Erdman Brook 1 Buttermilk Creek 1 Cattaraugus Creek	Gross Alpha Gross Beta- Gamma, Tritium		
Mud and Silt 1 Erdman Brook 1 Buttermilk Creek 1 Cattaraugus Creek		Gross Alpha Gross Beta- Gamma	Sr-90
Well Water 1 Plant Site		Gross Alpha Gross Beta- Gamma, Tritium	
Vegetation 3 Perimeter		Gross Alpha Gross Beta- Gamma I-131	Sr-90
Milk 1 Plant Site	Gross Alpha Gross Beta- Gamma I-131		Sr-90
Fish and Shellfish 1 Cattaraugus Creek			Gross Alpha Gross Beta- Gamma I-131
Small Game 1 Plant Site			Gross Alpha Gross Beta- Gamma I-131 Sr-90

federal and state regulations. Spare units and automatic controls are used as necessary to prevent the escape of high level bursts of activity caused by major equipment failure.

9.51 A continuous stack gas monitor, described in Appendix 9.51, is used to detect concentrations of 3×10^{-12} μc/ml or less of gross beta-gamma particulate activity and about the same concentration of I-131. A significant increase in concentration of either particulates or radioiodine will cause an alarm in the plant control room. The exact alarm positions will be field selected based on operating experience; they will be kept at the lowest practical level to provide the earliest possible warning of off-standard conditions.

9.52 Environmental monitoring to determine the effects on the environment of waste gas disposal is concentrated in air sampling and sampling of soil, vegetation, milk and rainout. Three site perimeter continuous air monitoring stations are established to determine concentrations of radioactive particulates and radioiodine at these stations. One station is located 3,100 meters south-east of the plant, the second station is located 2,100 meters north-east of the plant and the third station is located 4,000 meters north-north-west of the plant. This places a monitoring station at either end of and adjacent to Buttermilk Valley and, according to prevailing wind patterns, will place one of the three monitors down wind of the stack nearly 60 per cent of the time.

9.53 The routine soil, vegetation, milk and rainout sampling program is defined in Table 9.49 b. The entire sampling program is subject to change as operating experience is gained but it is expected that any changes will be minor in nature. Special samples will be analyzed if the stack monitor indicates an alarm condition. The weather monitoring stations, (see Appendix 9.53) will supply data which may be used to determine the direction of travel of stack fumes and the distance at which the maximum ground level concentration occurs. A mobile motor-generator sampler set will allow sampling down wind of the stack regardless of wind conditions.

Waste Disposal Control Program -- Liquid Waste

9.54 The primary control of high level liquid waste is in the facilities provided. The waste tank itself, the concrete saucer for secondary containment, the impervious "silty till" formation and the spare tank all contribute to a high degree of confidence in the system. See Paragraphs 5.50 - 5.56, 7.10, 7.14 -7.18, 7.25 - 7.37. Facilities are provided for monitoring or sampling in the annular space between the tank and the vault. Routine surveys will be performed in the wells located adjacent to the waste tanks. A continuous water sampler located near the confluence or Erdman Brook and Quarry Creek will serve as a third monitoring point of control of liquid waste.

9.55 Low level liquid waste will be discharged to Cattaraugus Creek via Erdman Brook and Buttermilk Creek. Waste water at a volume of about 40,000 gallons per operating day is received in the interceptor, batch neutralized if necessary, and discharged to a series of holding ponds. The interceptor volume is about 50,000 gallons and the ponds

provide holdup for 4,000,000 gallons or 100 operating days above the minimum overflow points. Overflow points between ponds are a valved line at two feet above the bottom to provide for solids collection, and an open overflow at one foot from the top. The discharge line to the creek is valved so the amount of waste discharged may be regulated.

9.56 Stream gauging and sampling stations are provided near the confluence of Quarry Creek and Erdman Brook and on Cattaraugus Creek. Gauging is performed in order to determine the rate at which waste solutions may be metered into Erdman Brook. Samples from these stations will be collected and analyzed weekly. Analyses will include gross alpha, beta and gamma, tritium and specific isotope analyses as required for control. (Appendix 9.56)

Waste Disposal Control Program--High Level Solid Waste

9.57 A burial area for waste generated in the plant will be maintained in an area north of the plant between the waste tank farm and the confluence of Quarry Creek and Erdman Brook. This area will be reserved for process scrap and discarded process equipment. Process scrap, fuel element end pieces and leached hulls, will be packaged in 30 gallon drums, loaded into a shielding cask on a carry-all type trailer and transported to the burial area. (See Paragraph 7.14.) At the burial area a truck mounted crane with remote controls, 100 feet away, will be used to lift the lid of the cask, remove the scrap drum and place it in the trench. At the end of each burial operation, which may require several trips, the crane clam attachment or front end loader, will be used to backfill where necessary to maintain an exposure rate at the security fence of 2 mrem/hr. The drums will be covered with sufficient dirt to reduce the exposure rate at the edge of the trench to 200 mr/hr. Final backfilling when the trench, or a portion of the trench, is full will be to a radiation level of 1 mr/hr or less. The minimum dirt covering will be four feet thick.

9.58 A similar procedure will be followed for burial of process equipment. The equipment, after decontamination, will be suitably packaged and loaded on the truck in the Equipment Decontamination Room, transported to the burial area, loaded into the trench with the crane and backfilled. Packaging techniques will vary depending on the equipment itself and the radiation-contamination conditions. Generally a sprayed-on coating or a covering of plastic film will be used.

Medical Program

9.59 The medical program, under the direction of the Medical Director, will consist of a very thorough pre-employment medical history and physical examination for each prospective employee. The medical history will be aimed at not only past illnesses and injuries but particular attention will be paid to history of past radiation exposure, allergies, blood dyscrasias, tumors and any evidence of emotional instability. The laboratory studies on all applicants will consist of a minimum of complete blood count, serology, urinalysis, chest x-ray and vital capacity determinations. Each employee will have a complete physical examination yearly.

A complete blood count will be done twice yearly; clinical urinalysis monthly. The pre-employment physical examination and laboratory studies will be repeated on each individual leaving the employ of the company.

9.60 Bio-assays will be scheduled for employees using an "across-the-plant statistical survey" plan. The number of times each employee is sampled each year and the type analyses performed will depend on his work location. Office employees annually, for total alpha and gross fission products; mechanical head end, extraction operators, Health & Safety technicians, maintenance and utility operators semi-annually for total alpha and gross fission products; product purification and packaging operators quarterly for plutonium and total uranium. Additional samples will be obtained to confirm any positive result and special samples will be obtained when inhalation or ingestion is suspected for any employee.

9.61 Thyroid monitoring of employees will be performed at least once each year in conjuction with the annual physical examination. Special monitoring will be performed as indicated by air sample counting results.

9.62 A dispensary will be maintained for care of ordinary minor on-the-job injuries. There will be facilities for intensive first-aid care of severe injuries such as burns, fractures and gross contamination with radioactive materials. Immunization against tetanus will be routine for all employees.

9.63 Close liaison with the Health and Safety Department will be maintained. The Medical Director will assist in health and safety training and indoctrination. He will review with the Health and Safety Director, all industrial radiation exposure records; air, water and plant radiation survey records. He will cooperate with the Health and Safety Director in plant inspections.
Radiation exposure data for each employee shall be kept on form AEC-5 as part of the permanent record of each employee.
A permanent check-off list shall be attached to each employee's permanent record covering all of the plants' requirements regarding physical examinations and personal radiation exposure recording and control as well as all requirements of 10CFR-20.

Emergency Procedure

Fire Protection Organization

9.64 The Health and Safety department has the primary responsibility for training personnel and auditing procedures and activities for fire prevention as well as for fire fighting. The fire fighting function will be carried out through shift fire brigades organized as indicated in Appendix 9.64.

Organization for Radiation Emergencies

9.65 There are a very large number of combinations of conditions which might constitute or cause an emergency. It is, therefore, not possible to prescribe inflexible procedures for emergency action. However, there are

broad categories of emergencies for which general procedures may be stated and certain general rules which apply in nearly all cases. In any radiation emergency, the Health and Safety Department has the primary responsibility to define the magnitude and extent of the problem and to recommend a course of action which will restore the affected areas promptly and safely.

9.66 In any radiation emergency the responsible group (Production or Analytical) in the area in which the emergency condition exists must take immediate steps to accomplish the following:

a. Protect plant personnel by evacuating affected areas and take action to confine the condition and eliminate or moderate the cause.

b. Notify the Health and Safety Director (or Technician on off shift) giving all possible details about the nature and location of the emergency.

c. If the emergency involves property damage, personal injury, significant radiation levels, production interruption, or possible off-site contamination, the following must be notified:

Health and Safety Director
Medical Director
Laboratory or Production Manager
Plant Manager & Assistant Plant Manager
Assistant to the Plant Manager
Security Officer
Plant Engineer

d. Following the survey by Health and Safety, barricade and post the affected area to prevent inadvertent entry.

e. Devise a plan for restoring the area and assemble the required men and materials.

9.67 Generally, the following rules apply in handling an emergency condition:

a. If incident involves wreckage and a person is believed to be alive and trapped, make every possible effort to rescue him. The usual radiation rules may be abrogated upon the authority of the senior person present.

b. Segregate and detain for further examination those persons who have had possible contact with the radioactive material. Perform complete contamination surveys of such personnel and institute decontamination at once if significant exposure could result from a delay. Normally, it is best to leave skin decontamination to those persons with specific training in this function.

c. Remove injured persons from the scene with as little direct personal contact as possible. Limit first aid and medical procedures to

those that must be done promptly until the doctor is present.

d. Do only what is necessary to preserve life and property prior to the arrival of Health and Safety specialists.

e. Work within the framework of any applicable SOP's covering a specific type of emergency.

Plant Maintenance Program

9.68 The Nuclear Fuel Services maintenance program has been planned to insure continued safe operation of the plant, commensurate with Paragraphs 9.13 to 9.41, with a minimum of downtime consistent with economic considerations.

9.69 The routine inspection and maintenance program is similar to that for a normal chemical plant, except where modified to reflect more stringent requirements for the nuclear aspects of the plant. The maintenance program is based upon utilizing conventional methods and procedures for performing contact maintenance work. Special controls are incorporated to cover work within contamination and radiation zones. Work on contaminated equipment or systems is done under the surveillance of the Health & Safety Department which recommends required control measures. Careful planning, prewritten job procedures, and close coordination with Production and Technical Services Departments assure safe and efficient plant operation. Normal inspection contemplates periodic shutdowns to permit inspection and maintenance of those portions of the plant not readily accessible during routine operation.

9.70 Certain equipment is deemed vital to the safe and continuous operation of the plant. This equipment is defined as 1. equipment that could become critically unsafe from a nuclear standpoint, and 2. any malfunctioning piece of equipment which could reasonably require the shutdown of the plant.
A list, referred to as the Vital Equipment List initiated by the Production and Technical Services Departments and approved by the Plant Manager, is compiled and issued to the Production Department. (See 9.82) The list states the requirements to be met before the equipment is taken out of service, and what tests and requirements are to be met before the equipment is returned to service. All equipment not specifically designated on the Vital Equipment List is considered as non critical and may be taken out of service, repaired, and returned to service according to normal standard maintenance practice.

Organization

9.71 Maintenance work on Nuclear Fuel Services equipment and systems is performed by Plant Engineering. Plant Engineering is responsible for all mechanical, instrument and electrical maintenance work. Each of these categories is under the direction of a group leader. Close cooperation between these groups is maintained to facilitate scheduling, conserve manpower, and minimize downtime.

Under normal conditions, mechanical and electrical maintenance is accomplished on a day schedule, five days per week. Much of the routine instrument maintenance is carried out on a similar schedule; however, instrument technicians are normally on shift with operations personnel.

Plant Engineering Section

Personnel

9.72 Plant Engineering is composed of a plant engineer, mechanical engineers, maintenance mechanics, instrument technicians, and stenographer. The Plant Engineer is responsible for:

1. Planning, scheduling, and controlling personnel, materials, equipment and tools.

2. Initiating training and educational programs for maintenance personnel.

3. Establishing and supervising the maintenance of a readily accessible file of design and vendor information, parts data, preventive maintenance records, and historical records.

4. Supervision of all maintenance assignments, including instructions to cover safe working practices, radiation protection measures and approved maintenance repair procedures.

5. Making technical studies on maintenance of mechanical, instrument and electrical equipment, and making recommendations on design changes.

6. Preparing labor and material costs estimates for non routine work.

The Plant Engineer is primarily assisted by two mechanical engineers to whom any of the above responsibilities may be delegated. Technical support is available from the Technical Services and the Health and Safety Departments which will provide specialists as required.

Facilities

9.73 The Plant Engineering Section and shop facilities are organized primarily to perform field maintenance work. On site shop work consists basically of minor repairs, replacement of defective components and checkout of equipment. The bulk of the work is of short duration and minor complexity, and the shops are equipped accordingly. Machine, electric, instrument, pipe, carpentry and welding shops are provided. In cases where maintenance functions require facilities not provided at the site, privately operated shops in nearby Buffalo, New York will be utilized where possible.

Instrument Maintenance

Personnel

9.74 The maintenance of instrumentation and control systems is the responsibility of the Plant Engineer assisted by the Instrument Engineer. These responsibilities are as follows:

1. Adequacy of the maintenance facilities and the training of personnel to meet all requirements, both routine and emergency;

2. Planning and scheduling of all instrument maintenance in cooperation with mechanical maintenance personnel;

3. Establishment of a preventive maintenance program for all control systems and components, with particular emphasis on those involving the safety of the plant;

4. Planning and maintenance of a file system that contains the information necessary to analyze, design, order spare parts and components, apply preventive maintenance procedures and provide history of repairs on all equipment. This will be done in conjunction with mechanical maintenance.

Instrument Shop Facilities

9.75 The instrument shop is equipped with services, (water, air, electricity, tools and test equipment) necessary for the calibration and maintenance of either pneumatic or electronic instruments.

Maintenance Categories

9.76 Plant Engineering performs three categories of work; preventive maintenance and inspection, routine maintenance and non routine maintenance. Any of these categories of work may involve hazardous conditions due to radiation or contamination. The procedures used in performing this work depend on both the category of work and the degree of hazard involved due to direct radiation or contamination. These procedures will be subject to approval by the Health and Safety Director in those cases involving radiation hazards.

Preventive Maintenance and Inspection

9.77 The preventive maintenance program minimizes shutdowns and breakdowns by systematically inspecting equipment, making calibrations or adjustment, and scheduling repairs and overhauls before failure occurs. Each piece of equipment is studied thoroughly, and a schedule of routine inspections is determined and established under the following classifications:

a. A-Class: Major inspection (complete check of equipment;)
b. B-Class: A "middle-of-the-road" inspection. Usually made quarterly to semi-annually and, on occasions, monthly;
c. C-Class: A minor inspection (ordinarily visual and frequent.) Usually made monthly to quarterly and, on occasions, weekly.

As each piece of equipment is studied, a complete list of items to be checked on each inspection is made. A central control system indicates when inspections are due. If inspections do not interfere with normal plant operation, the inspections are scheduled and carried out in accordance with work loads in the section. Inspections that require shutdown of equipment or interfere with normal plant operations are coordinated with the Production Department. After an inspection is completed, information is transferred from the inspection sheet to a card as a continuing record. If any repairs are necessary, such repairs fall into the category of routine maintenance and are scheduled according to the urgency required.

Routine Maintenance

9.78 Routine maintenance includes all maintenance work on equipment or systems which is directed toward restoring the equipment or system to its normal functioning capability, without altering its basic design function. Routine maintenance is conducted during normal plant operation, as well as during scheduled shutdowns.
Normal routine maintenance work is either requested by the Production Department or results from the preventive maintenance program. Because there is generally a backlog of work, all work is given a level of priority to facilitate effective scheduling. Priority is based on safeguards considerations, production loss resulting from the equipment being shut down, or the probability of a breakdown if a repair is not made, with consequent damage to equipment.

Non Routine Maintenance

9.79 Non routine maintenance includes modifications or additions to systems or processes as differentiated from repair or replacement of faulty equipment. Depending upon the nature and extent of the work, maintenance or construction forces are used. In the latter case, Plant Engineering is responsible for maintaining close contact with the work to see that it is performed in accordance with specifications, within the cost estimate, and reporting on the progress of the job during the construction period.

Administrative Procedures for Carrying Out Program

9.80 All work performed in the various categories of the maintenance program, including those of the Plant Engineering Section both during normal plant operation and during plant shutdown, are in accordance with established administrative procedures described below. These administrative procedures deal with the conditions or requirements that must be satisfied to initiate and complete a maintenance operation rather than to exercise control over the actual repair work.

Non Vital Components

9.81 Administratively controlled maintenance procedures are not required on non vital components for safe operation of the facility. Therefore, preventive maintenance or routine maintenance operations on non vital components is carried out by the maintenance sections in accordance

with normal standard maintenance practice, except as noted in Section 9.83. The maintenance work on non vital components is coordinated with the Production Department to minimize downtime. Detailed maintenance procedures for most pieces of equipment are provided by the vendor or are written by maintenance personnel; for hazardous conditions the operation may be altered and is administratively controlled as described in Section 9.83. Non routine maintenance of a non vital component is discussed in Section 9.84.

Vital Components

9.82 Administratively controlled maintenance procedures are required on vital components for safe operation of the facility. Therefore, prior to performing preventive maintenance or routine maintenance, it is necessary to evaluate the effect of performing the maintenance work. Such an evaluation is made on all items listed as vital equipment. The Vital Equipment List is prepared by the Production Department and the Technical Services Department and approved by the Plant Manager. If the maintenance work does not involve a radiation or contamination hazard, the work is initiated after approval by the Production Manager. If a radiation or contamination hazard is associated with the maintenance job, it is necessary to alter the operation as described in Section 9.83. Non routine maintenance of vital components is discussed in Section 9.84.

Hazardous Maintenance

9.83 When hazardous conditions exist, it is necessary to alter normal maintenance procedures before maintenance is initiated. In all cases, a Special Work Procedure is required. This work procedure is obtained and is administered as described in Paragraph 9.17. The use of this permit provides maximum assurance that both the worker and management take adequate steps to minimize the consequences of radiation or contamination associated with the job.

In all cases involving hazardous maintenance, it is necessary to fulfill the requirements set forth in the Special Work Procedure. After this is done, the maintenance operation is performed in accordance with Sections 9.81 and 9.82.

Non routine Maintenance

9.84 Non routine maintenance involves changes in basic design or additions to equipment. When it is necessary to perform this type of maintenance, on either vital or non vital components, such maintenance is not carried out until a complete evaluation of such a change is conducted and approved by the Criticality Committee. After the procedure is approved, the maintenance operations are performed in accordance with Sections 9.81 9.82 or 9.83.

Work Completion

9.85 Representatives of Plant Engineering, Production and Technical Services (if involved) and Health and Safety Departments (if involved) observe the testing and return to operation of the components or system involved in maintenance.

Production Department

9.86 The Production Department is responsible for the operation and maintenance of the processing plant and its related process services. The organization and administration of the department has been planned to provide safety to the public and plant personnel and to effect operation and maintenance of the facility within the operating license limitations. In order to effectively operate the plant within the prescribed limitations, the Production Department has been broken down into groups to achieve effective control of the necessary operations. The group breakdowns are as follows:

a. Fuel and Mechanical Handling;
b. Chemical Processing;
c. Plant Engineering;
d. Utilities and Process Services.

9.87 The Fuel and Mechanical Handling group is responsible for the Fuel Receiving and Storage area including cask transport, handling fuel assemblies, transfer and storage; operation of the FRS water treatment facilities; Process Mechanical Cell operation including fuel assembly transfer, handling, disassembly by saw or mechanical means, fuel shearing, handling of scrap, utility services to the area and hot equipment repair or replacement; General Purpose Cell including the loading, handling, storage and transfer operations of fuel baskets, scrap material and equipment utility services; Chemical Process Cell-Equipment Decontamination Room including the charge of fuel into and discharge of leached hulls out of the dissolvers, replacement of equipment, and remote handling operations within the CPC and the EDR; Scrap removal including the handling and transfer operations of waste and materials into and out of the mechanical head end facilities. Accountability and material control coordination consistent with Production Department requirements.

9.88 Chemical Processing group responsibilities include feed dissolution, solvent extraction, solvent recovery systems, product purification and concentration, acid recovery, sampling, cold chemical make up, waste concentration and rework operations, process off gas systems, building ventilation and accountability in these areas consistent with Production Department requirements.

9.89 The Plant Engineering group is responsible for the maintenance of the facility as necessary to maintain continuity of operation as described in detail in Paragraphs 9.68 through 9.85.

9.90 The Utilities and Process Services group includes the operations of: all utility systems within the utility room, plant area and off-plant facilities; non radioactive systems for both solids and liquids; operation of the conventional low level burial and scrap removal from the plant; material handling including the transport, handling, warehouse and distribution of equipment and supplies as required for plant operations; decontamination of areas and facilities not included under other groups; material control including records of input, output and inprocess material necessary to effect control; and accountability of source material and

Production Department

9.86 The Production Department is responsible for the operation and maintenance of the processing plant and its related process services. The organization and administration of the department has been planned to provide safety to the public and plant personnel and to effect operation and maintenance of the facility within the operating license limitations. In order to effectively operate the plant within the prescribed limitations, the Production Department has been broken down into groups to achieve effective control of the necessary operations. The group breakdowns are as follows:

a. Fuel and Mechanical Handling;
b. Chemical Processing;
c. Plant Engineering;
d. Utilities and Process Services.

9.87 The Fuel and Mechanical Handling group is responsible for the Fuel Receiving and Storage area including cask transport, handling fuel assemblies, transfer and storage; operation of the FRS water treatment facilities; Process Mechanical Cell operation including fuel assembly transfer, handling, disassembly by saw or mechanical means, fuel shearing, handling of scrap, utility services to the area and hot equipment repair or replacement; General Purpose Cell including the loading, handling, storage and transfer operations of fuel baskets, scrap material and equipment utility services; Chemical Process Cell-Equipment Decontamination Room including the charge of fuel into and discharge of leached hulls out of the dissolvers, replacement of equipment, and remote handling operations within the CPC and the EDR; Scrap removal including the handling and transfer operations of waste and materials into and out of the mechanical head end facilities. Accountability and material control coordination consistent with Production Department requirements.

9.88 Chemical Processing group responsibilities include feed dissolution, solvent extraction, solvent recovery systems, product purification and concentration, acid recovery, sampling, cold chemical make up, waste concentration and rework operations, process off gas systems, building ventilation and accountability in these areas consistent with Production Department requirements.

9.89 The Plant Engineering group is responsible for the maintenance of the facility as necessary to maintain continuity of operation as described in detail in Paragraphs 9.68 through 9.85.

9.90 The Utilities and Process Services group includes the operations of: all utility systems within the utility room, plant area and off-plant facilities; non radioactive systems for both solids and liquids; operation of the conventional low level burial and scrap removal from the plant; material handling including the transport, handling, warehouse and distribution of equipment and supplies as required for plant operations; decontamination of areas and facilities not included under other groups; material control including records of input, output and inprocess material necessary to effect control; and accountability of source material and

special nuclear material as necessary for Production Department requirements.

9.91 The basic plant operation and control is carried out physically by the process operators and shift supervisors; however, in a large processing complex such as the NFS plant, additional support including technical and analytical services, monitoring, accountability, maintenance and control is necessary to assure proper operations. The groups, listed in Paragraph 9.86 and staffed by production supervisors, have been established within the Production Department to provide the defined portions of this support. Their primary function is to maintain an up-to-date intimate knowledge of their respective areas of responsibility. These staff functions have functional responsibility for their areas, however, administrative control is maintained by the Production Manager or an Assistant Production Manager. This type of organization provides a decentralized type of functional responsibility, yet maintains centralized control over operations.

9.92 To the maximum practical extent all details of plant operation are controlled by written procedures. These include Standard Operating Procedures, Run Sheets (including administrative controls) and Letters of Authorization. These procedures are maintained in a current status as described in Paragraphs 9.5 through 9.7 and 9.94.

9.93 The Standard Operating Procedures include a detailed step-by-step procedure for functional operation of each piece of equipment and/or process function in the plant. The format for SOP together with a general listing of the major systems covered by SOP are shown in Appendix 9.93. Included in each SOP is the scope encompassed, a general description of the operation involved, cautions to be observed in operations, administrative controls required during the operation, references to related SOP or other procedures, detailed instructions for functional operation of the equipment and, insofar as possible, the mechanical limitations of the equipment. This last item may, in some instances, more appropriately be included in Run Sheets.

9.94 Run Sheets are another set of procedures used to maintain control of the plant operation. They list the operating conditions for the campaign of a particular fuel beginning with mechanical processing and continuing through the process to product storage. They include the upper and lower limits for each flow of plant processing. For example, maximum and minimum flow rates are listed for each influent stream to each solvent extraction column as well as a desired operating flow. Separate Run Sheets are used for each flowsheet authorized under the operating license. The published Run Sheets available to the shift supervisor and his operators are generally more restrictive than those permissible under the operating license. This practice allows more strict enforcement and control of the plant operation. The shift supervisor cannot operate outside the specified limits of the Run Sheet. However, extension of these limits may be made, within the limits of the operating license, by an approved Letter of Authorization. If the supervisor cannot maintain the operation within the limit specified by the Run Sheet the affected portion of the operation must be shut down until the condition is corrected or approval to modify the run sheet is received. Run Sheets are reviewed periodically and amended as deemed necessary. Under no conditions is the plant operated outside the technical specifications included in the operating license.

9.95 Letters of Authorization are an administrative procedure directing actual plant operation as described in Paragraph 9.7. They are used to authorize a specific Run Sheet and/or auxiliary procedures for a particular processing campaign and in addition, are used to modify any of the restrictive procedures established for plant control. All Letters of Authorization are approved as discussed in Paragraph 9.7.

9.96 The actual operation of the complete processing plant is performed by personnel licensed as described in Paragraph 9.9 through 9.11. The basic areas of operator responsibility are broken down into specific catagories or areas of the plant consistent with production plant operating techniques. The specific areas are manned by operators consistent with their group license. The specifically-assigned areas for each shift are as follows:

1. Central Control Room;
2. Process Mechanical Cell;
3. General Purpose Cell;
4. Fuel Receiving and Storage-Chemical Processing Cell;
5. Sampling;
6. Chemical Makeup;
7. Product Packaging and Handling;
8. Waste Handling.

In addition, non licensed personnel are assigned to the following areas:

1. Utility Room;
2. Yards and ground, etc.

A brief description of each of these areas outlining the basic operator responsibilities for the respective areas is as follows:

1. Central Control Room

The Chemical processing portion of the plant is controlled from a Central Control Room located on the fourth floor of the process building. Processing beginning with dissolver operations and continuing through feed adjustment, solvent extraction, product purification, concentration and storage are operated from this location. Complete control of the process is exercised from the control room with the exception of non routine operations such as manual block valves for the process service requirements which are located in the Upper and Lower Extraction Aisles. Manual valving in the Upper and Lower Extraction Aisles is performed by other individuals at the request of the control room operators or shift supervisors. The control room panel is a semi-graphic type for ease of identification and efficient operation. In addition to posting the Run Sheets in the control room, many of the instruments are individually posted showing the limits of operation.

2. Process Mechanical Cell

a. Fuel assembly transfer and handling.
b. Fuel assembly disassembly using saw or mechanical means.
c. Removal of extraneous hardware.
d. Make up of fuel modules and shearing.
e. Handling individual fuel elements.
f. Scrap handling, cell decontamination and in-cell remote maintenance.

a prescribed detailed form listing the constituent concentrations and total amounts of each solution. The solution is then sampled and held for certification. Following certification, and upon process demand, the solution is then transferred to a run tank for subsequent introduction to the process or, in some cases, directly into the process vessels.

8. Product Packaging and Handling

a. Load out of plutonium product into bird cages and interim storage in the process building.
b. Load out of high enriched uranium into bird cages and interim storage.
c. Load out of low enriched uranium product to transport vessel.

All operations are conducted on a batch basis following specific instructions by the shift supervisor.

9. Supporting Areas

a. Scrap Removal Areas, including the receiving and transfer to the burial area of leached hulls and other head-end scrap generated during processing, and transfer of new materials to the General Purpose Cell for head-end processing.
b. Equipment Decontamination Room, including the mechanical handling to and from the chemical process cell.
c. Process Laundry for decontamination of the anti-contamination clothing used in the facility.

10. Utility Room Operation--All Plant Services Contained Within the Utility Room Complex

a. Water--raw, filtered, process, demineralized, and potable.
b. Air--process, instrumentation.
c. Steam--equipment, process and heating.
d. Electrical--normal and emergency.

Before the

UNITED STATES ATOMIC ENERGY COMMISSION

Washington, D. C.

In the Matter of the Application of

NUCLEAR FUEL SERVICES, INC.

For Licenses for a Spent Fuel Processing Plant

Under Sections 53, 63, 81, 104(b), and 185 of the

Atomic Energy Act

AEC Docket No. 50-201

Submission No. 21 - Final Safety Analysis Report

Paragraphs 9.97 through 9.117 of Section IX of the Safety Analysis,

Revision of Table of Contents for Chapter IX, and Paragraph 1.91

October 26, 1964

5067

CONTENTS

continued

5×10^{-3} $\frac{\mu c}{ml}$ 5×10^{-9} $\frac{c}{ml}$

IX PLANT OPERATION

1.91 Included in this section are details relating to the following subjects: Plant Organization, Plant Administration, the training of plant personnel, the Plant Health and Safety Program, the Plant Emergency Program, the Plant Maintenance Program, the operation and function of the Production Department, and a discussion of Process Maloperations.

1.92 Plant Organization discusses the duties of the Plant Manager, Production Manager, Health and Safety Director, Technical Service Manager and Plant Criticality committee.

1.93 Operating Procedures, Letters of Authorization, the procedures involved in initiating and changing same, and the methods used to insure that these procedures and Letters of Authorization are being followed are discussed in the Administration Section.

1.94 The Plant Training Program at various levels throughout the plant is covered under this topic. The Appendix to this section lists the curriculum to be employed in performing this training.

1.95 The Health and Safety section defines the responsibilities of the Health and Safety Department, the general regulations and procedures for performing radioactive work, the maximum allowable levels of radiation in the plant (by zones), the monitoring sampling procedures, and the medical program.

1.96 Details of the fire protection organization and general procedures to be followed in the event of radiation emergencies are defined in this section.

1.97 The operation of the Plant Maintenance Department, its organization, duties and functions are defined in this section.

1.98 Production Department operations, including administrative controls within the Production Department, a breakdown and a description of the operations in the plant by major areas are described in this section.

1.99 Process maloperations, results, the method determining the maloperation and the corrective action to be taken is presented, largely in tabular form, in this section.

Process Maloperation

9.97 Much design, operating information, and experience exists on the chemical processing of spent reactor fuel, particularly on processing by solvent extraction. The Purex-type of extraction process, which will be used in the NFS plant, is a thoroughly tested process and one which is expected to operate without unusual difficulty. Plant operation is predicated upon the "norm" or usual condition where the equipment operates as designed and no human mistakes are made. Obviously, such ideal conditions will not always exist. This section discusses possible maloperation in various areas of the plant, the results of such maloperation, the method of determining a maloperation, and the corrective action to be taken in the case of the particular maloperation. This information is largely presented in tabular form for ease in review and assimilation. A list of abbreviations used in the discussion is found in Table 9.97.

Mechanical (Head End) Processing.

9.98 Maloperations that may occur in the head-end processing are mechanical in nature. Most of the maloperations envisioned involve a failure of a manipulator grapple during the transfer of fuel elements or baskets and constitute little or no hazard, as such, but rather an inconvenience and time loss during processing. Maloperations in the FRS, PMC, GPC, and CPC are itemized in table 9.98a, b, c, and d.

Dissolution - Feed Adjustment.

9.99 Dissolution-Feed Adjustment steps under normal conditions are discussed in Sections 4.21 through 4.34. The nature of a maloperation can vary with the fuel being processed. For discussion purposes, the fuels will be divided into (1) ceramic UO_2 or ThO_2 fuels, cylindrical in form, clad in stainless steel or Zircaloy tubing (as represented by Consolidated-Edison, Yankee, Commonwealth-Edison, and Northern States Power Fuels), (2) uranium-aluminum alloy fuels (MTR type), and (3) Zr-U alloy fuels (STR type). Maloperations in dissolving these types of fuels will be fairly representative of difficulties that can be encountered in all types of fuels processed by NFS.

A summary of dissolution maloperation for these three fuel types, is given in table 9.99. Contents of this table are discussed in the following paragraphs:

Ceramic Fuels, Stainless- or Zircaloy-Clad.

Yankee, Commonwealth-Edison, and Northern States Power fuels are practically identical in processing. These fuels are chopped, loaded into baskets, and the baskets placed in the dissolvers, as described in Section IV. Dissolvent acid of the appropriate strength is added to the dissolvers, the solution heated, and the dissolution of the fuel proceeds. Too low or too high a dissolvent concentration or too little or too much dissolvent added to the dissolver are the maloperations most likely to occur. The results of, and corrective actions required by, such a maloperation are given in table 9.99.

Table 9.97
INSTRUMENT FUNCTIONS
(Nomenclature used in Maloperation Discussion)

Measured Variable	Symbol for Measured Variable	Display Devices: Indicating	Display Devices: Recording	Controlling Devices: Indicating	Controlling Devices: Recording	Controlling Devices: Shutdown or Startup Low	Local Devices for Indication	Alarm Devices: Low	Alarm Devices: High
Column Pulse (Frequency-Pressure)	C			CIC				CAL	CAH
Density	D	DI	DR		DRC			DAL	DAH
Flow	F	FI	FR		FRC		FG	FAL	
Interface Position (Column)	I				IRC (LRC-TRC)			IAH/L	IAH/L (high-low)
Liquid Level	L	LI	LR	LIC	LRC			LAL	LAH
Pressure	P	PI	PR		PRC		PG		PAH
Pressure Differential	Pd		PdR			PdCL		PdAL	PdAH
Temperature	T	TI	TR	TIC	TRC		TG	TAL	TAH

Table 9.98a
MALOPERATION IN FUEL RECEIVING AND STORAGE AREA (FRS)

what about gas release?

	Maloperation	Result	Indication	Corrective Action
1.	Grapple failure during fuel transfer.	Fuel element drops to floor of cask unloading pool. Releasing radio-activity	Visual.	Special underwater extension wrenches and tongs used to retrieve fuel. Water clean-up
2.	Fuel element cannot be retrieved from floor of cask unloading pool.	Inconvenience and time loss. more activity release	Poor visibility or binding between cask and pool wall or canisters.	Cask cover replaced and cask removed to decontamination area to provide working space.
3.	Fuel element stuck in individual shipping slot.	Inconvenience and time loss.	Visual.	Use underwater working tools or fabricate equipment for removal.

Table 9.98b
MALOPERATION IN PROCESS MECHANICAL CELL AREA (PMC)

	Maloperation	Result	Indication	Corrective Action
1.	Major breakdown of shear during operation.	Inoperative shear mechanism.	Visual.	Hold fuel element or segment in PMC as long as necessary, monitoring temperature occasionally. If temperature is too high, water cool with spray nozzles in shear magazine. Repair shear.
2.	Saw cut through fuel element (wet cutting).	Saw cuttings containing fuel particles drawn into saw coolant.	Visual. how?	Coolant will be processed if desirable.
3.	Saw cut through fuel element (dry cutting).	Saw cuttings containing fuel particles are drawn into blower system filter.	Visual. how?	Remove filter to fuel basket for subsequent processing in dissolvers if economics dictates recovery of fuel.

Table 9.98c

MALOPERATION IN GENERAL PURPOSE CELL AREA (GPC)

	Maloperation	Result	Indication	Corrective Action
1.	Grapple failure during transfer of loaded fuel basket.	Part of fuel may be spilled onto floor of GPC.	Visual.	*Power Manipulator (2V-73) brought in and pieces retrieved one at a time to fuel basket.
	*Note: Same procedure is used to retrieve spilled leached hulls.			
2.	Fines dropped on cell floor from dropped fuel basket.	Lost fines; inconvenience and time loss.	Visual.	Wash down cell floor to criticality safe sump. Remove sump pan and place fines in fuel basket.
3.	Sheared fuel lodged in reducer during descent.	Stuck fuel piece in reducer.	Gamma monitor (2-LAH-1) at 9-inch diameter point in reducer.	Remove fuel basket and fuel chute tip; remove fuel pieces with master slave manipulators or power manipulator.

Table 9.98d
MALOPERATION IN THE CHEMICAL PROCESS CELL AREA (CPC)

	Maloperation	Result	Indication	Corrective Action
1.	Grapple failure during transfer of fuel basket or leached hulls to or from Dissolvers 3C-1 and 3C-2.	Fuel or leached hulls spilled on floor of cell.	Visual.	Recover pieces with power manipulator.

Consolidated-Edison fuel is the exception in this group. This fuel contains mixed thorium-uranium oxides in the fuel and requires a much higher nitric acid concentration than other fuels of clad-oxide-fuel type, plus .04 M hydrofluoric acid in the dissolvent to dissolve the thorium oxide. Possible maloperations in this case include all the above cases plus insufficient, or excess, or omission of, the hydrofluoric acid.

Boric acid is also added to the dissolvent on the Consolidated-Edison fuels. Omission or change in concentration of this component is a criticality consideration and is discussed in Section VI.

Aluminum-Uranium Alloy Fuels

These fuels, primarily of the MTR type, are charged into the baskets without chopping. They are dissolved in 5.4 M nitric acid in which .005 M mercuric nitrate serves as a dissolution catalyst. Maloperations would include the use of acid with too low or too high a concentration, too little or too much acid of the correct concentration, the addition of too little, too much, or the omission, of the catalyst. These maloperations too, are shown in table 9.99.

The addition of too much or too little acid to the dissolver is unlikely since the dissolvent is made up batchwise as required and is certified prior to transfer in total to the dissolvers. The remaining maloperations, their consequences and corrective action required are given in table 9.99.

Zirconium-Uranium Alloy Fuels

Dissolution of fuels of this type is accomplished by the appropriate addition of 1.0 M nitric acid to the dissolver with baskets of unchopped fuel in place, and to which is added 27.6 M hydrofluoric acid at a sufficiently slow rate that little free fluoride ion is present (fluoride is complexed by the dissolving zirconium). After completion of the dissolution, aluminum nitrate-chromic acid solution is added to further complex the fluoride and to oxidize tin (from the Zircaloy) and uranium to their higher, and more soluble, valence states.

Maloperation can occur from incorrect quantities and concentrations of the three solutions added to the dissolver. Consequences of, and corrective measures to be taken after, such maloperations, are given in table 9.99. Stability regions for the dissolver product-feed solutions are given in TID-10089.

Other Fuels

The SCRUP fuel is clad in aluminum and this cladding is removed with an $NaOH-NaNO_3$ solution before dissolution of the fuel. Excess decladding solution or high component concentrations in this solution will result in higher-than-normal waste solution volumes but will have no serious process consequences. Insufficient decladding

Table 9.99
MALOPERATION AND CORRECTIVE ACTION DURING DISSOLUTION (3C-1 or 3C-2)

	Fuel Type	Maloperation	Result	Corrective Action
1.	Ceramic; Stainless Steel; Zirconium Clad.	Low acid concentration in dissolvent.	Low concentration of fertile material in dissolver product; all fuel not dissolved; low acid.	Recharge dissolver with additional dissolvent and complete dissolution. Acid adjustment in 3D-1.
2.	Ceramic; Stainless Steel; Zirconium Clad.	Too high an acid concentration in dissolvent.	High acid in extraction feed; low decontamination factors if run.	Dilute high acid in 3D-1; run with low concentrations of uranium, thorium, and plutonium through the partition cycle.
3.	Ceramic; Stainless Steel; Zirconium Clad.	Insufficient dissolvent.	LAL-2; LCL-2; high concentration of fertile and fissile materials in dissolver product. Low acid concentration.	Adjust concentrations in 3D-1 into HAF specifications; add additional solvent to dissolver.
4.	Ceramic; Stainless Steel; Zirconium Clad.	*Excess solvent.	High acid and low metals content of dissolver product.	Dilute to proper acid concentration in 3D-1; run to extraction system with low metals content.
5.	Uranium-aluminum alloy.	Low acid concentration in dissolvent.	Low aluminum concentration in dissolvent product. Acid deficient product. Some fuel may be undissolved.	Add additional dissolvent to 3C-1 and 3C-2 if necessary to complete dissolution. If necessary, add acid to 3D-1. Boil down to correct aluminum concentration.

*If filled too high, could overflow to the other dissolver or to 3D-1. In this event, a batchwise adjustment of the solution of all three vessels' contents in 3D-1 would be necessary.

NOTE: The indication in all of the above maloperations is by sample analysis.

Table 9.99 Continued
MALOPERATION AND CORRECTIVE ACTION DURING DISSOLUTION (3C-1 or 3C-2)

	Fuel Type	Maloperation	Result	Corrective Action
6.	Uranium- aluminum alloy.	High acid concentration in dissolvent.	High acid in dissolvent product; low salting strength for extraction.	Add $Al(NO_3)_3$ to 3D-1 and adjust to extraction feed specifications.
7.	Uranium-aluminum alloy	Low $Hg(NO_3)_2$.	Dissolution incomplete; dissolver solution low in aluminum, high in HNO_3.	Retain solution in dissolver; add $Hg(NO_3)_2$ and continue dissolution.
8.	Uranium-aluminum alloy.	High $Hg(NO_3)_2$.	No process consequences; however, may limit concentration of waste.	Adjust waste; boil off if necessary.
9.	Zirconium-uranium alloy.*	High HNO_3 concentration.	Possible precipitation from feed upon long standing.	Dilute solution in dissolver or in feed adjustment tank if dissolution has already occurred.

*Nitric acid is added to dissolvers batchwise. Hydrofluoric acid is metered separately into the nitric acid. Stability ranges are given in TID-10089 for zirconium-uranium dissolution.

	Fuel Type	Maloperation	Result	Corrective Action
10.	Zirconium-uranium alloy.	Low HNO_3 concentration.	Lowered solubility of zirconium in dissolver solution.	Add concentrated HNO_3 to dissolver or to feed adjustment tank if dissolution has already taken place.
11.	Zirconium-uranium alloy.	Excess HF.	Aluminum precipation in feed adjustment. High equipment corrosion.	Dilute dissolver product with water or additional HNO_3 as stability region permits.

NOTE: The indication in all of the above maloperations is by sample analysis.

Table 9.99 Continued
MALOPERATION AND CORRECTIVE ACTION DURING DISSOLUTION (3C-1 or 3C-2)

	Fuel Type	Maloperation	Result	Corrective Action
12.	Zirconium-uranium alloy.	Insufficient HF.	Zirconium precipitation in dissolver or feed adjustment. All alloy may not dissolve.	If solution is still in dissolver, add additional HF, heat, and sparge. Add HF at controlled rate, using dilution air.
13.	Zirconium-uranium alloy.	Excess $Al(NO_3)_3$.	Aluminum precipates.	Add additional HF to bring composition into stable range.
14.	Zirconium-uranium alloy.	Insufficient $Al(NO_3)_3$.	Zirconium precipitates; high corrosive rates on stainless steel equipment.	Add additional $Al(NO_3)_3$ to dissolver or feed adjustment accountability tank as required.

NOTE: The indication in all of the above maloperations is by sample analysis.

solution or low component concentrations in this solution will result in only partial jacket removal. As a result, dissolution may be incomplete or perhaps may not even start. A repeat of the decladding step will be necessary in this case. Decladding should not be attempted until all previous dissolver solution is removed from the dissolver so that precipitates of sodium diuranate cannot be formed. Maloperation during the actual fuel dissolution will be very similar to that for the oxide fuels and table 9.99 should be referred to for possible consequences and corrective steps. Maloperations in the feed adjustment and accountability tanks are concerned primarily with human error. The most important of these errors involve the failure to add the proper cold chemicals or to thoroughly mix the solution prior to sampling. These and other maloperations are detailed in table 9.99 for tanks 3D-1 and 4D-1. These maloperations will also apply to other feed adjustment and accountability tanks and to other downstream feed adjustment and neutralizer tanks.

<u>Solvent Extraction - Partition Cycle: Extraction Column (4C-1); Feed Pump Pots (4C-13a and 13b); and Meter Head Pot (4Y-14)</u>

9.100 The most likely maloperations that can occur on the column, the feed pump pots, and the meter head pot, will be discussed in this section.

<u>NOTE</u>: Many of these maloperations will be common to <u>all</u> pulse columns and tabulations made for this column will be applicable to downstream flowsheet columns as well. Further, it is recognized that maloperation of this column, in a cascade system such as is used here, will affect some of the downstream columns. A discussion of sequential difficulties will not be made here; this discussion will be used as being typical of downstream columns. The plant operating and surveillance procedures are designed to detect maloperations before consequences can significantly upset any column.

The maloperations that will be tabulated and which are applicable to other columns follow:

1. Incorrect pulse amplitude-frequency settings;
2. Incorrect flow ratios between the various streams;
3. Incorrect stream compositions;
4. Interface crud and organic quality;
5. Column flooding;
6. Loss of column jacket cooling water;
7. Nozzle plate fouling.

Pulse amplitude-frequency settings, if incorrect, can result in high column waste losses, or column instability and flooding combined with high waste losses. Figure 9.100 illustrates the variation of HETS (Height Equivalent to a Theoretical Stage) with varying pulse amplitude settings. If the combination of the column design and flowsheet requirements are met by conditions at point A (which represents minimum HA column pulse amplitude requirements for the Yankee fuel flowsheet), then operation to

Table 9.99 Continued
MALOPERATION OF FEED ADJUSTMENT AND ACCOUNTABILITY TANK (3D-1)

	Maloperation	Result	Indication	Corrective Action
1.	Low steam in coils.	Poor temperature control. Cannot evaporate solution for concentration correct-ion.	TI-2-5; LR-6; DR-4; Sample 3C.	Hold solution in tank until sample shows it is of correct concen-tration; add cold chemicals to proper concentration.
2.	Low cooling water in coils.	Poor temperature control for jetting.	TI-25; DR-4.	Check cooling water valve; hold solution in tank until proper condi-tions are achieved.
3.	Condenser water not on.	Loss of solution (vapors) to vent system.	TI-2-4 in condensate; LR-5 in 3D-2.	Check cooling water valve.
4.	Incorrect cold chemical addition.	Incorrect concentration of solution.	Sample 3C; LR-6; DR-4.	Hold solution in tank; add proper concentration of cold chemicals to bring the solution to proper concentration.
5.	Air sparger off.	Poor mixing; incorrect sample.	Sample 3C; HC-24.	Turn on air; hold solu-tion in Tank HC-24 until concentration is correct.

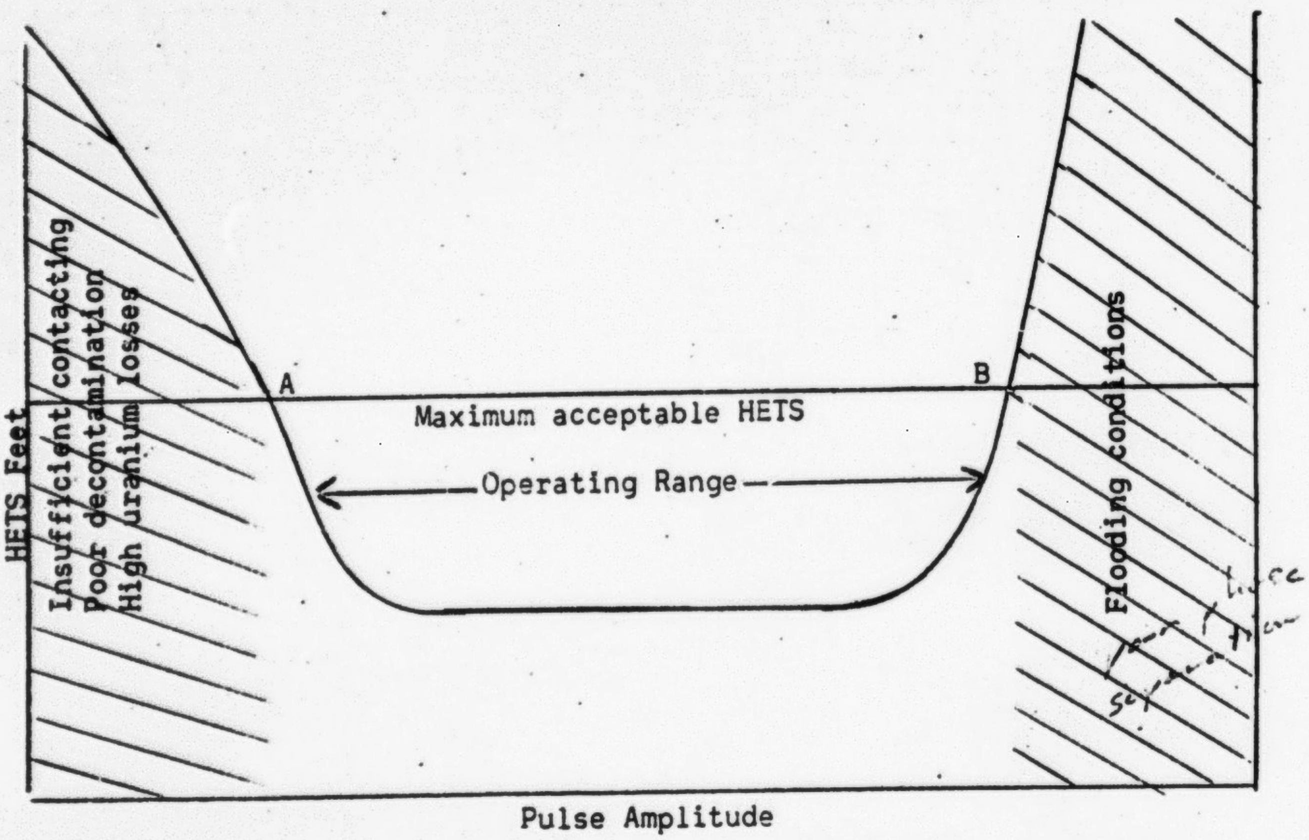
Table 9.99 Continued
MALOPERATION OF FEED TANK TO PARTITION CYCLE (4D-1)

	Maloperation	Result	Indication	Corrective Action
1.	Low cooling water.	Poor temperature control; high feed temperature, resulting in poor column efficiency if HAF is too hot.	TI-2-14.	Increase cooling water flow.
2.	No air sparging.	Poor mixing, which results in a bad sample.	HC-29 off; manual check of hand control valve.	Turn on Hand Control valve from air supply line (HC-29) 1/2 hour prior to taking sample.
3.	Incorrect cold chemical addition.	Wrong solution composition, which can cause a loss to product to the HAW stream or poor ~~df.~~ DF.	Sample 4C.	Certification and administrative check of proper amounts of cold chemicals to bring the solution to the proper concentration.

the left of this point would result in poor contacting, higher HETS values, fewer stages, and consequently high fissile material losses to the waste stream and poor decontamination of product. Point A in figure 9.100 represents minimum pulse amplitude-frequency conditions. The maximum amplitude-frequency situation would be represented by point B. Amplitudes above B would result in increased stage heights due to inadequate phase disengagement or other effects. Hence, for a given pulse frequency, the amplitude operating range would fall between points A and B. Operating outside these ranges would be considered maloperation.

Figure 9.100

HETS VARIATION WITH PULSE AMPLITUDE - HA COLUMN
At a particular frequency (cycles per minute).(See note)



NOTE: Different frequencies would generate a family of curves with similar characteristics.

For satisfactory operating conditions, low frequencies are necessarily combined with high amplitudes and high frequencies with low amplitudes. Workable operating combinations will be established for each column and flowsheet. Maloperation would be due to human error or equipment failure and the correction needed would be obvious in each case.

Flow ratios of the organic-aqueous streams (O/A ratio) have direct bearing on waste losses and decontamination factors. Losses from the HA column, as well as the IA, ID, and IIA columns, will decrease with increasing O/A ratios. The magnitude of O/A increase is limited, however, by the increased flow or ratio change possible in the downstream column, or by flooding the column in question. For example, the O/A ratio in the HA column for the Yankee flowsheet is normally about 1.7. If this ratio is decreased by increasing A (or the feed rate), to approximately 0.80, the waste losses in the HAW stream will start exceeding the economically permissible value of 0.1% of the uranium in the fuel. Likewise, increasing the O/A ratio (by increasing organic - the HAX stream) by a factor of 2.0 would result in a flooding condition in the column and again high uranium in the HAW and, additionally, organic phase in this stream.

Operating limits on the O/A ratios will be set on each of the columns in the system as discussed for the HA column above. Operation outside these limits would be considered maloperation and would be the result of human error, failed or erratic flowmeters, or metering pump.

In each of the above, pulse or flow-ratio maloperation, the most probable result is high fissile losses in the raffinate stream. Recovery of fissile material will be discussed under the operation of the rework system. Column maloperations are tabulated in table 9.100.

Maloperations in the Partition Cycle Feed Pump Pots and Meter Head Pots are mainly concerned with flow rates to and from the column. These are also discussed in table 9.100.

Plutonium Cycle Feed Conditioner Tank (4D-6)

9.101 Maloperations of the Plutonium Cycle Feed Conditioner Tank (4D-6) are shown in table 9.101. The maloperations are as described in paragraph 9.99.

Feed Conditioner to First Uranium Cycle (4D-9)

9.102 Maloperations of the Feed Conditioner Tank for the First Uranium Cycle (4D-9) are shown in table 9.102. The maloperations are as described in paragraph 9.99.

Second Uranium Cycle Feed Conditioner (4D-12)

9.103 Maloperations of the Second Uranium Cycle Feed Conditioner Tank (4D-12) are shown in table 9.103. The maloperations are as described in paragraph 9.99.

Plutonium Purification Cell

9.104 The operation of the Plutonium Purification Cell is discussed in paragraphs 4.73 to 4.75. Maloperations that have been considered consist in general of human errors. These include the overflowing of tanks, improper solution adjustment, improper valving, and failure to operate Plutonium Ion Exchangers 5C-1A, 5C-1B, and 5C-1C properly. These maloperations are tabulated in table 9.104.

Table 9.100 Continued
MALOPERATION OF HA COLUMN (4C-1)

	Maloperation	Result	Indication	Corrective Action
1.	Flooding.	Organic leaves the column through the normal aqueous effluent line and aqueous through the normal organic effluent line if allowed to continue. This allows product to the waste stream and fission product to the product stream. Both will require rework of material.	Interface controller LRC-29 will first become erratic then will decrease loading pressure to pot 4Y-15 significantly allowing organic to flow out HAW line. DR-23 (extraction section density) will increase indicating layer build-up of aqueous in the column. The layer of aqueous may break occasionally showing a sharp return to near normal of DR-23 reading with a following gradual build-up. PR-8 (column static pressure) will be erratic but will show a substantially higher reading, indicating increased aqueous in the column. DR-22 (density in top disengaging head) will increase significantly when aqueous replaces the organic in this section. When aqueous flows to surge pot 4Y-5 and thence to HBX column 4C-2, the interface controller, LRC-33 will be unstable due to increase in aqueous flow to that column.	Reduce column through-put rates and/or pulser frequency and amplitude. Rework material as necessary. Organic which left through the HAW line will be separated in the decanter 4Y-1 and returned to the No. 1 solvent system.

Table 9.100 Continued
MALOPERATION OF HA COLUMN (4C-1)

	Maloperation	Result	Indication	Corrective Action
1a.	Flooding caused by high flow rates.	Same as item 1.	Same as item 1.	Reduce flow rates.
1b.	Flooding caused by poor disengaging time of organic.	Same as item 1.	Indication will be same as item 1 in column. If organic disengaging time is the cause, analytical samples will indicate poor disengaging time or organic degradation.	Stop flooding as in item 1. Correct organic problem by solvent wasting or replace solvent.
1c.	Flooding caused by pulser amplitude-frequency.	Same as item 1.	Same as item 1 for column instrumentation. Pulser frequency can be counted on oscillations of PR-8 or by counting RPM of pulser poppet cam shaft. Pulser amplitude determined by maximum pressure on pulser surge tank (pulse stroke).	Adjust RPM of pulser motor or adjust pulser surge tank pressure.
2.	Cyclic flooding.	Probable larger amounts of entrained organic in HAW stream. Excessive product loss to HAW and poor decontamination in column.	Interface controller LRC-29 will be erratic, caused by a repeated build-up and breaking of an aqueous layer in the extraction section of the column. This will reflect an erratic behavior of DR-23 also. PR-8 will increase slowly as the aqueous layer builds up, then drops sharply to normal as it breaks.	Reduce flow rates or reduce pulser frequency-amplitude. Check analytical data for organic disengaging time.

Table 9.100 Continued
MALOPERATION OF HA COLUMN (4C-1)

	Maloperation	Result	Indication	Corrective Action
3.	Pulser stops.	Column will immediately go into a total flooded condition as in item 1.	XA-19 pulser alarm will sound. Oscillation effect of pulser on instruments PR-8, LRC-29 will stop. Erratic behavior of instruments described in item 1 will not occur. PR-8 will show increase as aqueous builds up in column displacing organic. DR-23 will increase, finally showing total aqueous. Organic flow to Surge Pot 4Y-5 will decrease to approximately 1/2 since flow will be equal to aqueous influent only. LRC-29 loading pressure will decrease significantly to allow organic to flow out HAW line.	Shut down partition cycle columns immediately. Restart after pulser trouble is corrected. Rework material as necessary.
4.	Loss of HAF.	Loss of product in normal stream. Possible carry-over of excess fission product to subsequent cycles.	Zero reading on LR-28; Interface Controller LRC-29 will decrease sharply until controller adjusts to bring level back to desired point. DR-23 will decrease; DR-22 will decrease; PR-8 will decrease.	If not restored within five minutes, shut down partition cycle.
5.	Loss of HAX.	Loss of product to waste system.	FAL-9, FRC-22 on HAX; flow to Surge Pot 4Y-5 stops; LIC-30; DR-23 and PR-8 will increase.	Shut down partition cycle immediately. Rework as necessary.

Table 9.100 Continued
MALOPERATION OF HA COLUMN (4C-1)

	Maloperation	Result	Indication	Corrective Action
6.	Loss of HAS.	Decontamination will reduce by a factor of 10 to 100. Fission products will be carried to downstream cycles.	FAL-7, FRC-1 on HAS; LRC-29 will decrease sharply until controller adjusts for reduced aqueous flow. DR-23 and PR-8 will decrease.	If not restored within 5 minutes, shut down partition cycle.
7.	High HAF flow rate.	Loss of product to HAW.	LR-28 increase (HAF measuring pot). PR-8, DR-23, and DR-22 increase; LRC-29 lower loading pressure.	Lower HAF feed rate (FRC-16). Rework material as necessary.
8.	Low HAF feed rate.	Possible stripping of excess fission product and carry-over to subsequent cycles.	LR-28 decrease (HAF measuring pot). PR-8, DR-23, and DR-22 decrease; LRC-29 higher loading pressure.	Increase HAF feed rate (FRC-16).
9.	High HAX feed rate.	Same as item 8	FRC-22 (HAX) increase; PR-8, DR-23, DR-22 will decrease.	Decrease HAX rate with FRC-22.
10.	Low HAX flow rate.	Same as item 7.	FRC-22 (HAX) decrease; PR-8, DR-23, DR-22 will increase.	Increase HAX rate with FRC-22.
11.	High HAS flow rate.	Increase waste volume of HAW. Possible loss of product to waste.	FRC-1 on HAS; PR-8, DR-23 will increase; LRC-29 loading pressure will decrease.	Reduce HAS flow with FRC-1. Rework material as necessary.
12.	Low HAS flow rate.	Fission products will not be scrubbed from organic in scrub section of column.	FRC-1 on HAS; PR-8, DR-23 will decrease; LRC-29 loading pressure will increase.	Increase HAS flow with FRC-1.

Table 9.100 Continued
MALOPERATION OF HA COLUMN (4C-1)

	Maloperation	Result	Indication	Corrective Action
13.	Loss of salting agent from HAS.	Same as item 12. Will also cause refluxing in column and loss of product to waste stream.	DI-1 and lab analysis on 14D-17; PR-8, DR-23, and DR-22 will decrease.	Certification of HAS make-up solution before use.
14.	No cooling water on HA column 4C-1 jacket.	Depending on temperature of influent streams, may cause less efficient decontamination factor and waste loss.	Cooling water valves closed. Sample analysis of effluent streams.	Open cooling water valves.
15.	Excess interface crud.	Increase disengaging time. Possible poor decontamination of Zr and Nb.	Sample analysis of effluent streams. HAW and uranium and plutonium streams from subsequent columns.	If severe enough to affect product specifications, increase solvent clean-up to improve disengaging time. If trouble still prevails, displace interface to HAW system by Standard Operating Procedure.
16.	Fouling of column nozzle plates.	Reduce contact of organic aqueous and number of column stages with resulting loss of column efficiency.	Can only be determined by critical analysis of all factors affecting column operation.	Clean out system and try to remove fouling material by chemical flushes. If unsuccessful, replace column.

Table 9.100
MALOPERATION OF PARTITION CYCLE FEED PUMP POTS (4C-13A - 13B)

	Maloperation	Result	Indication	Corrective Action
1.	Air supply is high.	Cause high flow of HAF stream.	LR-28 on Meter Head Pot 4Y-14 and FRC-16 on air supply.	Correct settings on LR-28 and FRC-16 instruments.
2.	Low air supply.	Cause low flow of HAF stream	LR-28 on Meter Head Pot 4Y-14 and FRC-16 on air supply.	Correct setting on LR-28 and FRC-16 instruments.
3.	Loss of pot due to crud in check valves.	Low or loss of HAF stream.	LR-28; FRC-16.	Switch to air lifts for HAF feed.

Table 9.100
MALOPERATION OF METER HEAD POT (4Y-14)

	Maloperation	Result	Indication	Corrective Action
1.	High level in pot.	The solution will go through the overflow line to Tank 4D-1 until maloperation is corrected.	LRC-28; FRC-16.	LRC-28 will adjust air flow to pump pots 4C-13A and 13B; reset instruments if necessary.
2.	Low level in pot.	Low flow to HA column.	LRC-28; FRC-16.	LRC-28 will adjust air flow to Pump Pots 14C-13A and 13B; reset instruments if necessary.

Table 9.101
MALOPERATION OF PLUTONIUM-CYCLE FEED CONDITIONER TANK (4D-6)

	Maloperation	Result	Indication	Corrective Action
1.	High level in tank.	Cause overflow to 6D-3.	LRC-1; sample in Vent System Catch Tank 6D-3.	Correct flows in and out of tank and recycle product from vent system to rework.
2.	Low oxident concentration of cold chemicals.	Results in insufficient oxidation of plutonium, which causes the plutonium product to go with the IIAW stream.	FR; FAL on cold chemical feed tank; sample 9C; DR-1.	Add oxident to correct concentration and recycle IIAW from 4D-8 to rework.
3.	No air sparging; poor mixing.	Poor tank mixing; poor sample.	Air Supply Valve HC-1; thin line on LRC-1.	Open HC-1 1/2 hour prior to sampling; check and log opening of spare valve.

Table 9.102
MALOPERATION OF FEED CONDITIONER TO FIRST URANIUM CYCLE (4D-9)

	Maloperation	Result	Indication	Corrective Action
1.	Wrong cold chemical addition.	Cause wrong feed concentration to Uranium Cycle and loss of product to IAW or poor df.	DRC-3; sample 22C.	Correct concentration and recycle IIAW to the rework system.
2.	Low cooling water on cooler 4E-4.	Poor temperature control may cause poor column efficiency.	Valves closed on cooler; column effluent samples.	Open valves on cooler.
3.	Air sparger off.	Poor mixing, resulting in a bad sample and poor concentration control on IAF.	HC-4 off; sample 22C; DRC-3.	Insure sparger on for 1/2 hour prior to sampling.

Table 9.103
MALOPERATION OF SECOND URANIUM CYCLE FEED CONDITIONER (4D-12)

	Maloperation	Result	Indication	Corrective Action
1.	Incorrect cold chemical addition to 4D-12.	Wrong feed concentration, resulting in poor extraction and loss of product to IDW or poor df.	FR on Cold Chemical Feed Tank; sample 26B; DR-7 on 4D-12.	Correct concentration in tank and recycle IDW from 4D-13 to rework.
2.	High level in tank 4D-12.	Overflow of tank; loss of product to 6D-3.	LR-22; LAH-6 in Tank 4D-12.	Adjust flows into and out of tank and recycle from off-gas system to rework.
3.	Low level in Tank 4D-12.	Loss of IDF flow.	LR-12 in Tank 4D-12.	Adjust flow into and out of Tank 4D-12.
4.	Low cooling water to Cooler 4E-5.	Poor IDF temperature control.	Valves closed on cooler; column effluent samples.	Open valves on cooler.
5.	No air sparging.	Poor mixing of IDF.	HC-8 off; sample 26B.	Turn on HC-8.

Table 9.104
MALOPERATION IN PLUTONIUM PURIFICATION CELL (PPC)

	Maloperation	Result	Indication	Corrective Action
1.	Plutonium Ion Exchange Feed Conditioner 5D-1 has been allowed to overflow.	Overflow goes to Ion Exchange Recycle Waste Tank 5D-2 and then to the Plutonium Feed Conditioner Tank 4D-6 for rework.	LAH-12 and LR-14 on 5D-1; LR-1 on 5D-2.	Start flow through one of the Plutonium Ion Exchangers 5C-1A, 5C-1B, or 5C-1C.
2.	Improper Plutonium Ion Exchange Feed Conditioner 5D-1 temperature and/or temperature at Plutonium Ion Exchangers 5C-1A, 5C-1B, and 5C-1C due to pump 5G-7 not operating or improper heating of hot water tank 5D-20.	Maximum plutonium absorption by the anion resin will not be accomplished if the 60 C $\pm$ 10 C plutonium Ion Exchanger temperature is not maintained. At higher and lower temperatures, resin exchange efficiency is lost.	TIC-3 on 5D-1; TRC-4 on 5D-20.	Readjust temperature and refer to Standard Operating Procedures if necessary; check 5D-20 for necessary water level; adjust proper temperature with TRC-4.
3.	Improper Plutonium Ion Exchange feed concentration (5D-1) due to poor sparging or improper feed adjustment of HNO_3 and $NaNO_2$.	Without proper sparging, proper adjustment of feed in 5D-1 cannot be obtained. If HNO_3 is not adjusted to 7.2 M or the plutonium is not oxidized by sodium nitrite, some plutonium will pass through the Ion Exchangers (5C-1A, 5C-1B, or 5C-1C) during the loading cycle, to the Ion Exchange Waste Tank 5D-2 and will have to be returned to the Plutonium Feed Conditioner Tank (4D-6) for rework.	13B, 14B, 15B, and 16B samplers give effluent concentration; sparging indicated by variation in level recorder; failure to add HNO_3 indicated by FR-9; $NaNO_2$ by LR-14.	Adjust $NaNO_2$ and HNO_3 addition to tank 5D-1 if product does not meet specifications.

Table 9.104 Continued

MALOPERATION IN PLUTONIUM PURIFICATION CELL (PPC)

	Maloperation	Result	Indication	Corrective Action
4.	Improper valve open during elutriation cycle of Ion Exchangers 5C-1A, 5C-1B, and 5C-1C.	Excess plutonium will be carried to the Recycle Waste Tank 5D-2.	Sample 5Y-14, 5Y-16, or 5Y-18.	Double check correct valve upon start of cycle.
5.	Improper valve open during loading or wash cycle of Ion Exchanger (5C-1A, 5C-1B, 5C-1C).	Impurities and fission products will be carried to the Plutonium Product Feed Evaporator Tank 5D-4. This material can be sent back to the Plutonium Ion Exchange Feed Conditioner Tank (5D-1) for rework.	LAH-13, LAH-14, LAH-15 on Ion Exchange Columns; LR-19 on 5D-4.	Correct valve positions.
6.	Omit wash cycle of Plutonium Ion Exchangers 5C-1A, 5C-1B, 5C-1C.	Off product specification.	Sample 14B, 15B, or 16B on 5C-1A, 5C-1B, or 5C-1C and Sampler 17B on tank 5D-4.	Rework product to tank 5D-1.
7.	No HNO_3 or less than 0.25<u>M</u> HNO_3 elutriant used in elutriation cycle Plutonium Ion Exchange Recycle Waste Tank.	Formation of plutonium polymers which might plug resin bed.	Tank 14D-46 analyses; no flow by LI-27 and LR-28.	Certification of acid concentration before use.
8.	Overflow of Plutonium Ion Exchange Recycle Waste Tank (5D-2).	Overflow will be carried through vent line to the Vessel Off-Gas Catch Tank (6D-3) where it can be reworked or sent to waste.	LAH-1 or LR-1 on Tank 5D-2.	Steam Jet 5H-32 to the Plutonium Waste Catch Tank 4D-8 or by gravity flow to 4D-6.
9.	Improper use of Steam Jet 5H-32 (Pump-Out Eductor on 5D-2).	May result in transferring plutonium product into Plutonium Waste Catch Tank 4D-8.	LR-22 on Plutonium Waste Catch Tank (4D-8) and sample analysis of 4D-8.	Shut off 5H-32 and rework 4D-8; send to tank 7D-8.

Table 9.104 Continued
MALOPERATION IN PLUTONIUM PURIFICATION CELL (PPC)

	Maloperation	Result	Indication	Corrective Action
10.	Plutonium Product Evaporator Feed Tank 5D-4 overflow.	Plutonium carried to PPC sump and to Solvent Waste Tank (13D-8) by 15H-8 Steam Eductor. Sump and floor are sized to be safe for largest vessel in PPC. Tank 13D-8 has boron Raschig rings and is critically safe.	LR-19 on 5D-4; LAH-16 on sump.	Start Pump 5G-10 to evaporator or stop flow into 5D-4.
11.	Plutonium Product Evaporator 5C-2 is allowed to overflow.	Liquid is returned to Tank 5D-4; some liquid may carry over through condenser to 5D-6.	DR-17 and LRC-20 on 5C-2 and 5G-10 respectively.	Stop pump 5G-10; return 5D-6 solution to 5D-4 with HC-41.
12.	Product boil-down to a high concentration in Evaporator 5C-2.	Plutonium concentration is too high.	LRC-20, TI-2-31, and DR-17 on 5C-2.	Watch DR-17 closely; dilute with dilute acid in 5C-2.
13.	Plutonium Evaporator Condensate Tank 5D-6 overflow.	Condensate is carried through overflow vent to Vessel Off-Gas Catch Tank 6D-3. It can be handled at that point as required.	TI-2-32, LAH-16, and LR-21 on 5D-6; LR-2 on 6D-3.	Route to rework 7D-8 or waste 7D-2.
14.	Insufficient HNO_3 in 5D-4.	May form plutonium polymer in 5C-2.	5D-4 sample analysis.	Add HNO_3 if polymer has formed in 5C-2 and digest until in solution.
15.	Excess fission products in 5D-4.	Won't meet product specifications.	5D-4 sample.	Return to 5D-1 with pump 5G-10 for rework.

Table 9.104 Continued
MALOPERATION IN PLUTONIUM PURIFICATION CELL (PPC)

	Maloperation	Result	Indication	Corrective Action
16.	Resin degradation 5C-1A, 5C-1B, 5C-1C.	Excessive product in 5D-2.	5D-2 sample.	Replace resin as specified in Standard Operating Procedure covering ion exchange column operation.
17.	Improper discharge of contents of Plutonium Evaporator Condensate Tank (5D-6).	Solution directed to wrong tank.	LAH-16 on Tank 5D-6.	Ensure that tank contents are known prior to discharge.

Uranium Product Purification

9.105 Uranium Product Purification is discussed in paragraphs 4.67 to 4.72. This discussion includes the operation of the Uranium Product Evaporator, the Silica-Gel Beds, and the storage of uranium product. Again, the maloperations discussed concern primarily those associated with human errors. These include high and low levels of solutions in tanks, improper valving, improper evaporator operation, and improper sampling. These maloperations are listed in table 9.105.

Product Packaging and Shipping Area

9.106 In the Product Packaging and Shipping Area, product plutonium solution is placed in small bottles for shipment. High-enriched uranium product is also packaged in this area and low-enriched uranium is transferred to tank trailers from this area. Due to the possibility of hazard from alpha contamination in the Product Packaging and Shipping area, much of the equipment is enclosed in glove boxes and electrical interlock controls are installed to insure proper operator procedure and ventilation control. Maloperations in the Product Packaging and Shipping Area include any spillage of more than a minute quantity of plutonium solution, cross contamination of the products with any foreign material, and any act that could cause a critical array. All equipment used for high-enriched uranium and plutonium is geometrically safe, including the sumps in the handling area. Here again, maloperations involve human errors and are discussed in table 9.106.

Rework Evaporator System

9.107 The rework system consists of an evaporator, condenser, feed tank, and associated piping. The rework system is used to boil down and adjust any one of the aqueous waste streams that are sampled and found to be too high in product to discard before rerunning through the solvent extraction system. Organic streams are not run through the rework system.

The streams reaching the rework system will vary from very dilute solutions approaching water, to stronger solutions containing up to 6.0 M HNO_3. Some streams will have only a few grams per liter uranium in them; others will be of much higher concentration, and plutonium may also be present. When high-enriched fuel is processed, these streams may contain some of the structural alloys of the fuels, such as aluminum and zirconium. Thorium may also be present during thorium fuel processing.

Since the feed material entering the rework system will vary widely in composition, each batch will require special consideration and operating instructions. Any serious deviation from these instructions would constitute a maloperation and would result in a product stream unsuitable or less than optimum in composition for return to the extraction system. Off-specification feed to the extraction system will result in loss of product and/or further rework operations. If solutions should be overconcentrated in the rework system, a nuclear criticality incident could result. Prevention of such incidents, however, is assured by certain

Table 9.105
MALOPERATION OF URANIUM PRODUCT PURIFICATION

	Maloperation	Result	Indication	Corrective Action
1.	High level in Uranium Product Evaporator Feed Tank 5D-7.	Tank overflows to 6D-3; tank may boil; no adverse effect unless ignored for long period. This tank is not normally heated.	LAH-19; LRC-26.	Shut down extraction until excess solution in 5D-7 can be processed.
2.	Low enriched uranium transferred from 5D-7 to 5D-9 by mistake.	Possible degradation of high enriched uranium product solution.	Tank inventory; LAH-24 in 5D-9.	Lock out high enriched uranium transfer airlifts when processing low enriched uranium.
3.	High enriched uranium product misdirected to Low Enriched Uranium Product Evaporator 5C-4.	Possible to approach critical concentration (See section on Nuclear Safety).	LRC-27 on 5C-4.	When processing high enriched uranium in 5C-4, steam will be locked out of service; air lift supply will be blanked.
4	High level in product evaporators.	Poor operating behavior of evaporators.	High readings on LRC-27 (low enriched uranium) and LRC-28 (high enriched uranium).	Reset control point to lower value on LRC.
5.	High density in product evaporator.	Possible freeze-up of evaporator.	High DRC-20 reading; high TR-1-3 reading (low enriched); DRC-21 and TR-1-1 (high enriched).	Reset DRC to lower control point. DRC automatically dilutes high density product in evaporator.
6.	Low density product in evaporator.	Low product concentration.	Low DRC-20 reading; low TR-1-3 reading (low enriched) high product volume; DRC-21 and TR-1-4 (high enriched).	Reset DRC to higher control point.

Table 9.105 Continued
MALOPERATION OF URANIUM PRODUCT PURIFICATION

	Maloperation	Result	Indication	Corrective Action
7.	Too much cooling water to evaporator discharge line jacket.	Plugging of evaporator product discharge line if over concentration of uranium.	High evaporator level; product volume; LRC-27 (low enriched); LRC-28 (high enriched).	Warm product line with steam or hot water via temporary connection. Operate evaporator at lower concentration.
8.	Too little cooling water to product evaporator condensers.	Vapor to vent system; possible uranium loss to vent system.	High water temperature on Condenser TRC-5 (low enriched) and TRC-9 (high enriched); high temperature in 5D-8 (TI-2-36).	Reset TRC to lower temperature.
9.	High level in Uranium Product Evaporator Condensate Tank 5D-8.	Overflow to vent system; loss of uranium.	LAH-20 on 5D-8; LRC-29.	Stop evaporator; sample analysis will determine disposition.
10.	Low level in 5D-8.	Lack of strip feed for first uranium cycle.	LAL-21; FAL-28 on ICX feed.	Supply solution from cold make-up area.
11.	High level in Uranium Product Surge Tank 5D-9.	Overflow to vent system to 6D-3.	LAH-24 in 5D-9; LR-2 on 6D-3.	Increase rate setting of pumps 5G-2 and 5G-2A and/or stop influent flows.
12.	Low level in 5D-9.	Tank runs dry; no adverse results.	LAL-25 in 5D-9.	Adjust pump rate on 5G-2 or 5G-2A at lower setting or stop pump.
13.	High temperature in 5D-9.	Improper feed temperature to silica gel units.	TRC-11 high on 5D-9.	Reset TRC-11; use cooling water if necessary; check cooling water to 5E-10.
14.	High feed rate to silica gel beds 5C-6A and 5C-6B.	Excess solution flows back to 5D-9; no adverse effect.	High reading on PR-9 or PR-10 on Head Pots 5Y-29 or 5Y-30.	Decrease Feed Pump 5G-2, 5G-2A rate setting.

Table 9.105 Continued
MALOPERATION OF URANIUM PRODUCT PURIFICATION

	Malfunction	Result	Indication	Corrective Action
15.	Line blinds and valves set wrong on silica gel unit.	Possible diversion of product to rework.	Valves are interlocked to insure proper settings; visual observation of blinds	Administrative procedure will insure correct positioning of blinds before either loading or regenerating silica gel beds.
16	High level in High Enriched Evaporator Product Surge Tank 5D-13A.	Overflow to Tank 5C-13B or 5C-13C; possible rework of product.	LAH-4 on 5D-13A.	Transfer solution to 5D-13B; shut down Product Evaporator 5C-5.
17.	Off-Specification product in 5D-13A.	Product must be reworked.	Sample analysis.	Transfer to 5C-13C.
18.	Transfer of 5D-13A to 5D-13B or 5D-13C by error before sampling.	Possible rework of product.	Level inventory on tanks; LAH-5 or 5D-13B or LA-6 or 5D-13C.	Resample and rework if required.
19.	High level in High Enriched Uranium Storage Tank 5D-13B.	Overflow to 5D-13A and 5D-13C; possible rework.	LAH-4 in 5D-13A; LAH-5 on 5D-13B or LAH-6 on 5D-13C.	Resample; rework if necessary.
20.	High level in 5D-13C.	Overflow to 5D-13A or 13B; possible rework.	LAH-6.	Resample all three tanks (5D-13A, B, and C) and rework if required.
21.	High temperature in 5D-13A or 13B.	No adverse effect; eductor transfer may be difficult.	High(TI-2-22 on 5D-13A or TI-2-23 on 5D-13B) readings; inoperable eductors or pump.	Check cooling water to 5E-11; allow tanks to cool by air sparging.
22.	High levels in Low Enriched Uranium Product Sample Tanks 5D-12A or 12B.	Overflow to 6D-3 Vessel Off-Gas Condensate Catch Tank; possible rework of solution.	LAH-7 on 5D-12A; LAH-8 on 5D-12B.	Transfer flow to empty tank; transfer full tank to 5D-15B after sampling; resample tanks involved in overflow; rework if necessa

Table 9.105 Continued
MALOPERATION OF URANIUM PRODUCT PURIFICATION

	Maloperation	Result	Indication	Corrective Action
23.	High temperatures in 5D-12A or 12B.	No adverse results; possible boiling in tank.	High reading on TI-2-25 on 5D-12A; TI-2-26 on 5D-12B.	Turn on cooling water.
24.	Failure to sparge tanks 5D-12A or 12B before sampling (See note).	Poor sample; incorrect analysis.	LR-6 on Tank 5D-12A shows tank was or was not sparged by linetrace; LR-7 on Tank 5D-12B.	Operator must follow proper sampling procedure; resample tank; turn on sparge air 1/2 hour prior to sampling.
	Note: This maloperation procedure applies to all product tanks requiring sampling.			
25.	Solution put into wrong tank (e.g. 5D-12A instead of 5D-12B.	Possible rework of product and resampling.	Level inventory on tanks; LR-6 on 5D-12A; LR-7 on 5D-12B; if too full, LAH-7 on 5D-12A or LAH-8 on 5D-12B.	Resample tanks as required.
26.	High level in Low-Enriched Uranium Storage Tank 5D-15A.	Overflow to off-specification compartment in 5D-15A.	LAH-9.	Resample and transfer solutions as required.
27.	High temperature in 5D-15A.	No adverse results; possible boiling of solution.	High TI-2-27 reading.	Turn on cooling water to coils.
28.	High level in Low-Enriched Uranium Storage Tank 5D-15B.	Overflow to 5D-15A off-specification compartment; resampling required; possible rework.	LAH-11.	Resample and take inventory; rework as required.
29.	Low level in 5D-15B.	No adverse results; automatic shutdown of product pump 5G-6.	When Pump 5G-6 stops, low level is recorded.	Wait for more solution to accumulate or transfer more solution from 5D-12A or B.
30.	High level in Low-Enriched Uranium Product Weight Tank 5V-1.	More solution than required to fill tank trailer.	LI-14; scale weight.	Transfer to next tank truck.
31.	Degradation of silica gel.	Failure to remove zirconium and niobium from uranium product.	Sample analysis of 5D-12A and 5D-12B.	Rework if necessary; regenerate or replace silica gel beds.

Table 9.106
MALOPERATION OF THE PRODUCT PACKAGING AND SHIPPING AREA (PPS)

	Maloperation	Results	Indication	Corrective Action
1.	Plutonium product bottle overfilled or fill line misconnected.	Plutonium solution will spill in bottle filling station sump.	Visual observation of spillage and/or measuring pot to a volume > 10 liters.	Close valves on filling head; move to drip container; transfer spill to 5D-4 with eductor; clean up area with decontamination washes.
2.	Enriched uranium product bottle overfilled or improper connection of fill head.	Spillage of enriched uranium in fill area.	Visual observation of spillage.	Close fill valves and transfer spill to Enriched Uranium Product Storage Tank 5D-13B.
3.	Two filled product bottles (plutonium or enriched uranium) brought together.	May approach a critical array (See section on Nuclear Safety.)	Radiation alarm.	All equipment and operating procedures have been designed to prevent more than one uncaged product bottle from being in the area at one time. If the radiation alarm sounds, area will be evacuated at once.
4.	Cross-over valves opened between plutonium and uranium spill transfer lines.	Cross contamination of products. Plutonium alpha contamination of uranium product fill area.	Radiation alarm; product analysis.	These valves will be locked at all times unless a special situation requires their use; material returned to rework.
5.	Glove rupture.	Personnel hand contamination.	Visual.	Negative pressure on glove box will prevent leakage of contamination from box. Hand decontamination as prescribed by Health and Safety. Replace glove.

Table 9.106 Continued

MALOPERATION OF THE PRODUCT PACKAGING AND SHIPPING AREA (PPS)

	Maloperation	Results	Indication	Corrective Action
6.	Improperly stoppered product bottle.	Gross contamination of the birdcage.	Monitoring prior to shipment.	Immediate evacuation of area; decontamination of birdcage under Health and Safety supervision; decontamination procedures as prescribed by Health and Safety.

procedures and administrative controls, which are discussed in the chapter on Nuclear Safety. The rework system receives solutions into the Rework Evaporation Feed Tank (7D-8) from seven other collection tanks (4D-2, 4D-8, 4D-10, 4D-13, 6D-3, 7D-10, and 13D-8). The solutions in these seven tanks have been sampled; hence, they are of known composition. These analyses determine which solutions shall be routed to Tank 7D-8. On the basis of these known compositions and extraction feed requirements, a procedure is followed for reworking each batch. If soluble neutron poison is required, as determined by analysis, it is added from Tank 14D-32 in the cold solution area. Acid, or other reagents, could be added from the same tank, if required. Solution in Tank 7D-8 is air-sparged and transferred by steam-jet eductors to the Rework Evaporator 7D-4. Because of criticality considerations, Evaporator 7D-4 is operated on a batch basis only. A low-level alarm and control prevent overconcentration in the evaporator.

Condensate from the rework evaporator flows to the Low-Level Waste Evaporator Feed Tank. This material will be very dilute acid with some activity in it. The bottoms from the rework evaporator are transferred by steam transfer eductor to the Partition Cycle Feed Tank (3D-1). Solutions may also be transferred to the Low-Level Waste Accountability and Neutralizer Tank. Various possible maloperations of the Rework Evaporator System, together with possible consequences, alarms, indications, and corrective measures, are listed in table 9.107.

High-Level Waste Evaporator System

9.108 A schematic representation of the High-Level Waste Evaporator System is shown in figure 4.81. The system consists of Tank 7D-1 (the High-Level Waste Evaporator Feed Tank), 7C-1 (the Low-Level Waste Evaporator), 7E-5 (the High-Level Waste Evaporator Condenser), and 7D-4 (the High-Level Waste Accountability and Neutralizer Tank). The system is fabricated of stainless steel except for the heat transfer tube bundle, which is made of titanium. Waste from the partition cycle or from the rework evaporator can be transferred to the High-Level Waste Evaporator Feed Tank. Solution may be transferred to the evaporator by air lift or by jet. It is intended that the evaporator bottoms be operated at an acid concentration no greater than 8M HNO_3. Maloperations in this system are detailed in table 9.108. The evaporator bottoms, after analysis, are either neutralized with caustic and pumped to the tank farm for storage or are recycled, if necessary.

Low-Level Waste Evaporator System

9.109 A schematic representation of the Low-Level Waste Evaporator System is shown in figure 4.83. The system consists of Tank 7D-2 (the Low-Level Waste Evaporator Feed Tank), 7C-2 (the Low-Level Waste Evaporator), 7E-7 (the Low-Level Waste Evaporator Condenser), and 7D-10 (the Low-Level Waste Accountability and Neutralizer Tank. The system is fabricated of stainless steel except for the heat transfer tube bundle which is made of titanium. The Low-Level Evaporator System evaporates the overheads from the High-Level Evaporator System, the aqueous waste streams from all of the solvent extraction steps except

Table 9.107
MALOPERATION SUMMARY OF REWORK EVAPORATOR SYSTEM

	Maloperation	Result	Indication	Corrective Action
1.	Transfer of too much solution from any one of seven feeds to 7D-8.	Overflow of 7D-8 to Tank 4D-10 and 4D-13, one of the seven feeds to 7D-8.	LAH-7 on 7D-8; PAH-3.	Turn off steam to transfer eductor, causing excess transfer.
2.	Transfer of insufficient solution to 7D-8.	7D-8 will run dry when evaporator is running.	LAL-8 on 7D-8.	Shut down of Evaporator 7C-4 is automatic; supply more solution to 7D-8 if available.
3.	Transfer of organic to 7D-8 (see note).	Organic will flow to 7C-4; some solvent degradation may occur.	DI; low densities in seven feeds (7D-8 and 7C-4).	Jet out organic to waste tank after using special wash solution to strip out any product from the organic.
	Note: Hydraulics of equipment and piping is designed to prevent organic reaching any one of the seven feed to 7D-8. Concentration of acid used in 7C-4 will not cause serious solvent nitration.			
4.	Transfer of wrong tank to 7D-8.	Boil down of wrong solution; incorrect rework product composition.	Sample analysis; tank level inventory will show wrong tank has been transferred.	Revise boil-down and rework procedure to compensate for different solution.
5.	Insufficient air sparge to 7D-8.	Poor mixing in 7D-8; this is only serious when widely differing compositions from two or more tanks are mixed or neutron poison is required.	HC-5 off; LR on 7D-8 will draw thin, even line.	Turn on HC-5.
6.	Failure to add neutron poison to 7D-8 when required.	LRC-4 and LAL-9 on 7C-4 will provide control and alarm to prevent possible critical condition.	Level inventory on 7D-8 and 14D-32; also administrative check and data sheet.	Administrative procedure designed to provide two or more independent checks in such cases to insure poison has been added. See section on Nuclear Safety.

Table 9.107 Continued
MALOPERATION SUMMARY OF REWORK EVAPORATOR SYSTEM

	Maloperation	Result	Indication	Corrective Action
7.	High level in 7C-4.	Solution overflows to 3D-1 before it is properly adjusted.	LAH in 3D-1.	Level control in 7C-4 set too high or steam supply too low -- reset.
8.	Level too low in 7C-4.	Concentration too high or steam coil not covered, resulting in low capacity.	LAL-9.	Dilute as necessary.
9.	Air sparger on 7C-4 turned off.	No adverse results; boiling will supply ample mixing.	None other than position of air valve.	None necessary.
10.	Cooling water to Condenser 7E-8 too low or turned off entirely.	Water and nitric acid vapor in Vessel Vent System.	High temperature on TR-1-8; high temperature in Vessel Vent System; excess condensate in Vessel Vent System.	Increase water flow to 7E-8.

Table 9.108
MALOPERATION OF HIGH-LEVEL WASTE EVAPORATOR FEED TANK (7D-1)

	Maloperation	Result	Indication	Corrective Action
1.	Feed lift to 7C-1 working too fast.	7C-1 level rises due to increased flow.	LRC-6 in 7C-1.	Automatic cutback of air flow.
2.	Feed lift to 7C-1 working too slowly.	7C-1 level drops due to decreased flow.	LRC-6 in 7C-1.	Automatic increase of air flow.
3.	Liquid level too low in 7D-1.	Liquid level will drop in evaporator 7C-1.	LAL-5.	Shut off air lift. Shut down steam to evaporator 7C-1 to avoid overconcentration.
4.	Liquid level too high in 7D-1.	If alarm is ignored and no action taken, will overflow back to 4D-2, the Partition Cycle Waste Hold Tank.	LAH-4.	Shut off steam jet from 4D-2; increase steam and air jets in 7D-1, removing liquid as much as necessary (both eventually feed 7C-1).
5.	Rate jet fails or is plugged.	7C-1 level drops.	LRC-6.	Use air lift as alternate transfer mechanism.
6.	Transfer of organic when using rate jet 7H-4.	Organic will decompose in 7C-1 with subsequent transfer to underground tank.	Sample of tank 7D-4.	No explosion will occur because steam is limited to 25 psig; the temperature is then below flash point organic; when using 7H-4, tank 7D-1 will not be completely emptied.

Table 9.108 Continued
MALOPERATION OF HIGH-LEVEL WASTE EVAPORATOR (7C-1)

	Maloperation	Result	Indication	Corrective Action
1.	Not enough steam in heating coils.	Insufficient amount of liquid boiled off; liquid level rises, which automatically shuts off air lift from high-level waste evaporator feed tank (7D-1); level in high-level waste accountability and neutralizer tank (7D-4) rises by solution traveling through overflow pipeline from 7C-1 to 7D-4 if on continuous processing.	TR-1-6 in 7C-1; LRC-6 in 7D-1; LR-9 in 7D-4; DR-5 decrease.	Increase steam flow through coils with FIC-3. Stop steam jet from 7D-1.
2.	Too much steam in heating coils.	Too much liquid boiled off; liquid level drops; liquid temperature rises; density rises; level recorder control will automatically draw more feed from High-Level Waste Evaporator Feed Tank (7D-1).	LRC-6, TR-1-6 in 7C-1; DR-5.	Turn down steam to coils with FIC-3; use batch transfer jet 7H-4 if necessary.
3.	Liquid level too high in 7C-1.	Level recorder control will automatically reduce flow from High-Level Waste Evaporator Feed Tank (7D-1).	LRC-6; check flow from 7D-6.	If automatic control not enough, shut off steam jet from high-level waste evaporator feed tank (7D-6); increase heating steam flow to 7C-1 with FIC-3.