Appendix 9.9

Curriculum for Process Operators and Senior Process Operators

A. Chemical Process Operators

1. Introduction-for all trainees

   a. History of plant
   b. Site description
   c. Protection of plant personnel
   d. Protection of public
   e. Licenses and permits required
   f. Purpose of plant
   g. Reason for training
   h. Requirements of trainees
   i. Type of training
   j. Results of training
   k. Industrial relations

2. Lay nuclear physics and chemistry-for all trainees

   a. General description of reactors
   b. Different types of reactors
   c. Nuclear reactors--broadly
   d. Results of reactions
   e. Physical description of various fuels
   f. Significance of fission products and their build up
   g. Reasons for recovery of Source and Fissionable material

3. Process description-for all trainees

   a. Pictures of plant
   b. Model inspection
   c. Input material--form and content
   d. Stepwise handling procedure through process
   e. End product
   f. Packaging and shipping
   g. Waste treatment

4. Reading-for all trainees

   a. Schematics
   b. Instruments
   c. Definition of terms
   d. Data recording

5. Health and Safety program-for all trainees

   a. Elementary radiation theory

      1. Types of radiation
      2. Radiation in perspective
      3. Permissible limits

b. Sources of radiation

1. Natural radioactivity
2. Fall out
3. Man-made sources
4. Fuel elements
5. Normal distribution of radioactive materials in the plant
6. NFS zone designations
7. Potential for accidents involving radioactive materials

c. Criticality

d. Radiation control methods I

Administrative control

e. Radiation control methods II

1. External exposure control
2. Internal exposure control

f. Radiation control method III

Contamination control

g. Scope of the radiation monitoring program

1. The purpose of a fuel processing plant is to make a 3-way split of incoming fuel elements (plutonium, uranium, fission products)
2. Radiation goals to be met
3. General policies used in meeting these goals
4. Services provided by Health & Safety
5. Summary

h. Aids to a good radiation zone job

1. Before start of work
2. During and after the job

i. Use of monitoring instruments for self monitoring

1. Portable alpha counter
   Alpha station monitor
2. Portable beta-gamma counter
   Beta-gamma station monitor
3. Cutie Pie
4. Self reading dosimeters

j. Advanced timekeeping training

1. Simulated maintenance work with operator keeping time
2. Practice session with small groups

k. Radiation arithmetic

l. Plant controls and problems

1. Control features
2. Special problems

m. Medical program

1. Physical examination
2. First aid

n. Chemical safety

1. Types of chemicals handled
2. Special hazards
3. Protective clothing and equipment

o. Fire safety

1. Description of fire systems
2. Fire brigade organization
3. Fire prevention

p. Safe operations of cranes and hoists

1. Inspection and preventative maintenance
2. Controls and limit switches
3. Safe operating techniques

q. Safe operation of vehicles

1. Heavy equipment
2. Automobiles and light trucks
3. Snow removal equipment

6. Equipment descriptions and uses by major area--for all trainees

a. Fuel Receiving and Storage (FRS)
b. General Purpose Cell (GPC)
c. Process Mechanical Cell (PMC)
d. Equipment Decontamination Room (EDR)
e. Chemical Process Cell (CPC)

    f. Product Packaging and Handling (PPH)
    g. Cold Chemical (CC)
    h. Control Room (CR)

7. Mechanical manipulation-for selective trainees

    a. Fuel Receiving and Storage (FRS)
    b. General Purpose Cell (GPC)
    c. Process Mechanical Cell (PMC)
    d. Equipment Decontamination Room (EDR)
    e. Chemical Processing Cell(CPC)
    f. Scrap Removal (SR)

8. Chemical processing steps-for selective trainees

    a. Sampling
    b. Cold Chemical (CC)
    c. Product Packaging and Handling (PPH)
       Product Packaging and Shipping (PPS)
    d. Acid Recovery (AR)
    e. Waste evaporation
    f. Waste tank farm operations

9. Control room operations-for selected trainees

   To include all of item 8 plus control room operations

10. Process maloperation--generally broad--for all trainees

    a. Utilities
    b. Judgment
    c. Other e.g. (fire)
    d. Equipment malfunction

11. General decontamination procedures--for all trainees

    a. Personnel
    b. Equipment

12. Waste treatment-for all trainees except control room trainees

    a. Equipment
    b. Low level
    c. High level

13. General emergency measures--for all trainees

    a. Loss from tankage
    b. Criticality emergencies

c. Chemical explosions
d. Equipment failure
e. Process emergency procedure

14. Accountability-for all trainees

a. Economic consideration
b. Criticality consideration

15. Ancillary service

a. Utilities
b. Maintenance and shops
c. Warehouses
d. Security

B. Senior chemical process operators. All of the above and in addition:

1. Conditions and limitations in facility license (or authorization)
2. Design and operating limitations in technical specifications
3. Procedures for any changes in (1) and (2) above
4. Somewhat more advanced chemistry and physics
5. Relations with utilities--AEC--ESADA--ASDA
6. Somewhat more advanced radioactivity
7. Somewhat more advanced criticality

Appendix 9.17

Protective Clothing and Safety Equipment

Following is the startup supply of protective clothing and equipment available at the plant

a. 20 dozen work shirts
b. 20 dozen pair work trousers
c. 20 dozen pair coveralls
d. 5 dozen laboratory coats
e. 20 dozen pair cloth boots
f. 20 dozen surgical type cloth hats
g. 5 dozen cloth hoods
h. 24 MSA Ultra Filter Masks
i. 18 MSA Air Line Respirators
j. 12 MSA Air Masks
k. 12 MSA Face Shields
l. 144 MSA Softsides Goggles
m. 12 MSA Plastic Suits
n. 500 dozen pair 6 mil PVC gloves
o. 36 dozen pair lined latex gloves
p. 12 dozen pair dry box gloves
q. 12 dozen pair leather palm gloves
r. 2 Safety harness
s. 3 Stretchers
t. 3 Fire Blankets
u. 144 Hard Hats
v. 1 pair Safety shoes for each production employee
w. 20 dozen pair shoe covers

Maintenance and Inspection of Protective Clothing and Equipment

Coveralls, shoe covers, gloves and related items of apparel will be collected, monitored, sorted according to levels of contamination, and laundered after each days use. Any clothing contaminated to greater than 50 mrad/hr beta-gamma or 50,000 d/m alpha will be packaged for burial. No attempt will be made to launder these items. All clothing will be spot checked after laundering for residual contamination. Contamination in excess of 0.2 mrad/hr beta-gamma or 1000 d/m alpha will require that the clothing be re-laundered and resurveyed. Items which can not be cleaned below these levels will be discarded. After each use, masks will be surveyed and released if contamination levels are less than 500 d/m alpha and 100 c/m beta-gamma. If contamination exceeding these levels is detected, the masks will be set aside for special decontamination. The contaminated areas will be cleaned by hand, taking special care to prevent spread of contamination to the inside of the mask. When released, the masks will be washed in a solution of MSA cleaner-sanitizer, rinsed in clean water, dried, and packaged in plastic bags. Filter canisters will be handled separately. Canisters will be surveyed, cleaned if necessary and stored apart from the masks. Contamination limits for non smearable contamination on canisters are 100 d/m alpha and 0.2 mrad/hr beta-gamma.

Appendix 9.17

Hand and Foot Counters

Two beta-gamma hand and foot counters are provided. They are to be located in the Main Entrance Lobby to serve as a final contamination check before entering the lunch room or before leaving the plant. The counters are supplied by Eberline Instrument Corporation, Santa Fe, New Mexico and are described below:

> 2-Model HFM-2 Beta-Gamma Hand and Foot Monitors with external probe for clothing survey. The system operates continuously using 4 Amperex 90NB GM tubes in each hand and foot cavity. Cavity shielding is equivalent to 1 inch of lead. The external probe is a halogen quenched GM tube mounted in a Model HP-177 side window hand probe. Four 100 ua relay type meters are used to accept the output from the nand and foot cavities. One four inch edge reading meter is used for the external probe. Meter ranges are 0-500, 0-2000, 0-5-000 and 0-20,000 cpm with scale selector switch mounted internally. A single speaker with variable volume control provides an audio indication of count rate. If the count rate exceeds a preset level, a buzzer alarm sounds and warning lights indicate the source of the contamination.

Testing of Hand and Foot Monitors

The detectors in the hand and foot counters will be checked for response daily by positioning a beta source over each.

Appendix 9.33

Air Sampling and Air Monitoring Equipment

Appendix 9.33

Air Sampling and Air Monitoring Equipment

Site Perimeter Air Monitor

Continuous Air Monitors are located at three points around the perimeter of the service center. The units are supplied by Tracerlab, a division of Laboratory for Electronics, Inc., Richmond, California and are described below:

3-Model MA-5B Fixed Filter Air Particulate Monitors with specially designed, heated, ventilated, enclosure and filter holder modified to hold one particulate and one charcoal filter in series.

3-MM-6B Log Ratemeter with 2½ inch meter indicating from 20 to 200,000 cpm and a switch selected scale for monitoring high voltage. Time constants vary with counting rate from 60 seconds at 20 cpm to 50 milliseconds at 200,000 cpm.

3-Model MD-1B End Window Beta-Gamma G. M. Detector, a 2½ inch O.D. cartridge containing an Amperex 100-NB halogen quenched GM tube. Following the GM tube is a trigger circuit that gives a 4 volt-2 microsecond pulse into a terminated 93 ohm output cable.

3-L and N model S Continuous Strip Chart Recorders.

Each monitoring unit is placed on a ten foot high platform to keep it above the maximum anticipated snow level.

Plant Site Air Sampler

An air sampler is available for sampling air around the plant site. The unit is supplied by Gelman Instrument Company, Chelsea, Michigan and is described below:

1-Model 26001 Nuclear Air Sampler capable of sampling continuously at a constant rate of 1 CFM. The flow is controlled by a limiting orifice installed in the sampling line between the filter bowl and intake of a vacuum pump. The amount of air sampled is recorded on a dry gas meter and a vacuum gauge is included to correct the indicated flow for error due to pressure drop across the filter. A running time meter indicates cumulative operating time in hours and tenths. Samples are collected on two 2-inch in-line type filter holders. The entire assembly is housed in a heavy gauge steel cabinet fitted with louvers for ventilation.

Plant Air Particulate Sampling System

An in-plant air sampling system is available utilizing a central vacuum pump and vacuum headers to all building occupied areas. There are 54 area air sampling stations and 19 in-cell remote air sampling stations available for use.

Each area air sampling station consists of a line to the vacuum header with a valve, a Gelman Model 8224, 10-84 lpm air flow meter and a Gelman Model 1200-A, 2 inch diameter open filter holder.

Each remote air sampling station consists of a line to the vacuum header with a valve, a Gelman Model 8224, 10-84 lpm air flow meter, a Gelman Model 1200-C 2 inch diameter closed filter holder, another valve and an offset penetration to the cell or remote area.

Continuous Air Monitors

Seven continuous air monitors are provided. The units are supplied by Nuclear Measurements Corporation, Indianapolis, Indiana and are described below:

1-Model PAPM-1 Programmed Alpha Plutonium Monitor including two ASC-1 alpha scintillation detectors utilizing ZnS phosphor and one LCRM-55 dual logarithmic count-ratemeter with two 5-cycle meters range 10 to 1,000,000 cpm and power supply. Each ratemeter has a dual contact meter manually set at a chosen scale for alert or fail-safe and alarm condition. One continuous duty positive displacement industrial air pump driven by a belt coupled, sealed ball bearing motor with an automatic switching valve which shifts collection from one collector to the other. The time cycle is controlled by a programmer with 1 through 24 hour cycles available. The count-ratemeter output is recorded on a two pen continuous strip chart recorder. During the last hour of off-collection time, the activity remaining on the filter is counted and the total count is printed out on paper tape. Assuming a 10 cfm sampling rate and a concentration of plutonium in air of 10^{-12} μc/cc, the build-up activity on the filter paper would be 37.8 cpm per hour of which 37% or 13.8 cpm would be detected. At the end of 12 hours the detector would see 165 cpm above background, not enough to cause an alarm. The air pump would then cycle to the other collector and the natural activity on the first collector would be allowed to decay for 11 hours. Then, from the 23rd to the 24th hour following the initial collection, the total count on the first collector would be recorded. The natural activity background should be about 300 to 500 counts per hour and the plutonium count would be about 9,900 for the one hour count. The unit then would alarm after 24 hours in a

concentration approaching the 40 hour M.P.C. If the concentration was 10^{-11} μc/cc the first detector would see 1100 cpm above background after 8 hours of collection and this would probably cause an alarm in the counting ratemeter. The unit will detect either a low level build up or a sudden burst of plutonium contamination and will alarm before the exposure of personnel exceeds the limits specified in 10 CFR-20.

1-Model AM-2A Fixed Filter Air Particulate Monitor. One ASC-1 alpha scintillation detector with ZnS phosphor. One LCRM-2M count ratemeter with one 3 cycle logarithmic scale of 50-50,000 cpm. Detector is shielded by 2 inches of lead equivalent. The air pump is a continuous duty positive displacement industrial type driven by a belt coupled, sealed ball bearing electric motor. Manually set alarm points with alert and alarm settings. Count-ratemeter output is recorded on a continuous strip chart recorder. Alpha air contamination of 10^{-12} μc/cc and sampling rate of 5 cfm will result in 7 cpm build-up per hour.

5-Model AM-2A Fixed Filter Air Particulate monitor identical to the unit described above except that the detector is a DGM-2 end window GM and the filter holder is modified to accept two filters in series, one particulate and one activated charcoal for collection of iodine-131. A concentration of 10^{-10} μc/cc and a sampling rate of 5 cfm will result in 350 cpm build-up per hour.

Calibration and Maintenance of Continuous Air Monitors

All the continuous air monitors will be calibrated monthly by analyzing the filters in the counting room and comparing the results with the count rate observed at the air monitors. Response of each unit to radiation will be apparent because of the natural activity filtered out of the air.

Medical Monitoring Equipment

Thyroid Monitor

A thyroid monitoring system is available for detecting iodine-131 deposited in the thyroid. The system is supplied by Nuclear-Chicago Corporation, Des Plaines, Illinois and is described below:

1-Model 612 Collimated scintillation detector with 3 inch diameter by 1½-inch thick sodium iodide, thallium activated crystal and DuMont 6363 photomultiplier;

1-Model 1720 Support Stand with arm. The arm can be automatically positioned at any height from 12 to 66 inches above floor level with a reversible electric motor which drives a

precision ball-screw inside the vertical column. The motor control switches are located at the end of a 30-inch coil cord.

1-Model 132-B Analyzer Computer. The 132-B combines a precision single channel pulse height analyzer, regulated high voltage supply, a binary scaler and a computing-circuit.

A plutonium gamma detector is available for detecting plutonium contamination in wounds. The detector-ratemeter system is supplied by Nuclear-Chicago Corporation, Des Plaines, Illinois and consists of the following:

1-Model 644 (DS8-21) gamma scintillation detector with a ½-inch diameter by 2 mm thick sodium iodide crystal. The crystal is coupled to the photocathode of a ten stage photomultiplier tube through a short light pipe. The crystal projects through a tight flange and has a ½-inch diameter by 0.0005 inch thick beryllium window to allow detection of low energy radiation without appreciable loss. Efficiency is about 90 per cent for gamma rays of less than 35 kev. Unshielded background is 5 to 10 cpm.

1-Model 8619 Labitron Ratemeter with 4½-inch meter, speaker with volume control and ranges of 0-500; 2,000; 5,000; and 20,000 cpm.

Equipment for Detection of Gases and Vapors

1-Universal Testing Kit, Model 2. Kit includes a piston type pump with a turret head and four orifices sized for optimum sampling rates, a calibrated handle to permit sampling volumes of 25, 50, 75, or 100 cc. and a remote sampling attachment for hard-to-reach spots. Kit provides capability for sampling carbon monixide, hydrogen sulphide, chlorine, mercury vapor, nitrogen dioxide, carbon dioxide, unsaturated hydrocarbons, phosgene, hydrocyanic acid gas, aromatic hydrocarbons, sulphur dioxide, halogenated hydrocarbons, lead-in-air, chromic acid mist, hydrogen fluoride, arsine, boranes-in-air and unsymmetrical dimethyl hydrazine.

1-Model 53 Gascope for detection of natural gas in air. The instrument has a dual range with one scale graduated from 0-100% of the lower explosive limit of natural gas in air and the second scale graduated from 0-100% by volume natural gas.

Appendix 9.36

Portable Monitoring Equipment

Appendix 9.36

Portable Monitoring Equipment

Alpha Detectors

The equipment provided for the detection of surface alpha contamination includes four portable alpha counters and one alpha floor monitor. These instruments are supplied by Eberline Instrument Corporation, Santa Fe, New Mexico, and are as described below:

4-Model PAC-3G Portable Gas Proportional Alpha Counters. Instrument grade propane flows through the probe at 30 cc per minute. The probe has an active surface area of 61 square centimeters. The instrument has three ranges, 0-1000, 0-10,000 and 0-100,000 cpm. Phones for aural monitoring and a uranium oxide check source are included.

1-Model FM-3G Gas Proportional Alpha Floor Monitor. Active probe area of 68 square inches for faster surveying of large, open floor areas. Three ranges, 0-1000, 0-10,000 and 0-100,000 cpm. Speaker and phones supplied for aural monitoring. The unit is mounted on wheels and the probe height from the floor is adjustable for 1/8 to 1/4 inches with additional adjustment to 2 inches for safe transportation.

Calibration and Maintenance of Portable Alpha Counters

The bi-monthly calibration procedure for portable alpha counters is as follows:

a. Check each scale using the calibrated plutonium-239 sources provided and adjust to the proper response.

b. Check the response of the instrument to the uranium check source.

c. Hold the instrument probe against the radium source container and, using the gain adjustment, tune out any response to the gamma radiation.

d. Recheck each scale with the plutonium-239 sources if a gain adjustment was necessary.

Appendix 9.36

Calibration and Maintenance of Alpha Floor Monitor

Twice each month the response of the alpha floor monitor will be tested using the uranium check sources.

Beta-Gamma Detectors

Beta-Gamma detection equipment includes: four GM Meters supplied by Victoreen Instrument Company, Cleveland, Ohio; one deep hole monitor supplied by Nuclear Chicago Corporation, Des Plaines, Illinois; and one floor monitor supplied by Eberline Instrument Corporation, Santa Fe, New Mexico. This equipment is described below:

4-Victoreen Model 489 Thyac II GM Survey Meter with Model 489-4 probe. The detector has a sliding metal window for beta discrimination and a 360 degree window for maximum beta-gamma sensitivity. The meter has three ranges of 0-800, 0-8,000 and 0-80,000 cpm and a built-in check source and phone for aural monitoring.

1-Nuclear Chicago Gamma Radiation Monitor for deep holes. The unit consists of a gamma scintillation detector in a waterproof, shock resistant housing, 150 feet of cable, Model 8619 ratemeter and a strip chart recorder.

1-Eberline Model FM-1 beta-gamma floor monitor. The detectors, Amperex 912NB GM tubes, are mounted in a steel encased lead shielded housing with an effective monitoring width of 21 inches. The shield can be rotated 45 degrees to check base-boards and other vertical surfaces close to ground level. The electronic, Model E-112B-1, has three ranges, (0.2, 2.0 and 20.0 mr/hr. full scale) with ratemeter, hand probe and phones for aural monitoring.

Calibration and Maintenance of Portable GM Counters

Before each use the response of the GM meter will be tested using the source supplied with each unit. After any maintenance has been performed on a unit, it will be calibrated using the calibrated 10 millicurie cobalt-60 source.

Calibration and Maintenance of Deep Hole Monitor

Before each use the response of the deep hole monitor will be checked using the radium source.

Appendix 9.36

Calibration and Maintenance of Beta-Gamma Floor Monitor

Twice each month the response of the beta-gamma floor monitor will be tested using beta check sources.

Appendix 9.37

Counting Room Equipment

Appendix 9.37

Counting Room Equipment

Liquid Scintillation Counting System

A Liquid Scintillation counting system is provided for the detection of tritium in samples. The system is supplied by Packard Instrument Company, Inc., La Grange, Illinois. The Model 314-EX2, as supplied, includes the following:

1-Tri-Carb Spectrometer, a two channel unit with two scalers, red and green, and an electronic timer. All three units have glow tube decade readout. Each channel has discriminator controls providing separate channels of pulse height analysis. Preset time control is in 20 steps from 3 seconds to 100 minutes. Preset counts may be selected on either scaler in increments from 10^2 to 10^6. Preset time and both preset count settings interact so that whenever any limit is reached the count will stop;

1-Model 500-C Automatic Control Unit and 100 sample automatic changer, with two photomultiplier detectors, a monitor detector and an analyzer detector monitoring the sample well. The automatic changer and detectors are mounted in an eleven cubic foot freezer for controlled temperature counting. The automatic control unit programs operation of the sample changer. Controls may be set to count anywhere from 1 to 100 samples and the unit will recycle continuously if repeat data are required on a batch of samples. The unit may also be set for repeat counting of a single sample. If power failure should occur while a count is in progress, the control unit will clear and repeat the count automatically when voltage is restored. A manual over-ride button allows the operator to select any sample for a special count;

1-Model A Digital Printer provides a printed record of counting data on a strip of paper tape. For each sample, the printer records sample number, elapsed time and counts on both scalers.

In the operation of the liquid scintillation counting system, radioactive decay events occurring in the sample cause scintillations which are seen simultaneously by both photomultiplier tubes, giving rise to pulses at the phototube output. Pulses from the photomultipliers pass through preamplifiers and into three separate amplifiers. Pulses from the "Analyzer" phototube then go to the discriminator pairs A-B and C-D for pulse-height analysis. The "Monitor" phototube functions only to determine whether a pulse is the legitimate result of a decay event or whether it arises from photomultiplier tube noise. Pulses falling between A and B are fed to the red scaler and pulses falling between C and D are fed to the green scaler. Output pulses from all of the discriminators pass through the coincidence circuitry and only pulses occurring simultaneously in both photomultipliers are counted. This results in some loss of

efficiency but effectively eliminates phototube noise. The two channels may be used to estimate the amount of quenching in a sample so that appropriate correction factors may be applied to the count. The disintegration rate of an unknown sample may be determined by counting the sample with the two channels operating first separately and then in coincidence. Based on the approximation that coincidence counting efficiency is a product of the two single-channel efficiencies, the disintegration rate is found from the equation:

$$\text{dpm} = \frac{\text{Counts (red)} \times \text{Counts (green)}}{\text{Counts (coincidence)}}$$

Calibration and Maintenance of Sample Counters

The gas proportional alpha and beta sample counters will be calibrated and source checked according to the following procedure after any maintenance has been performed on the units.

a. From a series of twenty-five minute counts of a calibrated alpha or beta source determine:

1. Chi-square

$$\text{Chi-square} = \frac{\sum (x - \bar{X})^2}{\sum x}$$

2. Geometry

$$G = \frac{\bar{X}}{\text{Source d/m}}$$

3. Standard Deviation

$$\text{S.D.} = \sqrt{\frac{(X - \bar{X})^2}{n-1}}$$

4. Error

$$E = \frac{k\ (\text{S.D.})}{\sqrt{P}} \qquad P = \frac{\text{Time of sample count}}{\text{Time of control count}}$$

b. From the data derived above, establish a maximum and minimum counting rate for the 90% and 95% confidence intervals.

c. Each day check the response of the sample counters to the calibrated source. If more than one count in ten exceeds the 90% limits or more than one count in twenty exceeds the 95% limits, the unit is removed from service until repaired and recalibrated.

Calibration and Maintenance of Liquid Scintillation System

The calibration and source check procedure for the liquid scintillation system will be identical to that outlined above using a calibrated tritium source.

Gamma Spectrometer

A continuous scan gamma energy analyzer is provided for analysis of the activity and gamma energy distribution of any gamma emitting sample. The system, supplied by Nuclear Measurements Corporation, Indianapolis, Indiana, is designated Model GSS-1B and consists of the following components:

1-Model WSC-3S Well Scintillation Detector with 3 x 3-inch sodium iodide, thallium activated crystal, spectrometer grade. The well has 100 cc volume.

1-Model US-11 Super Shield providing 4½ inches of lead shielding around the detector and a counter-balanced lid.

1-Model PHA-1B Pulse Height Analyzer with linear count-ratemeter auto scanner and binary scale factor selector. Standard energy range is 30 kev to 3 mev. Count-ratemeter ranges are 0-300, 1000, 3,000, 10,000, 30,000, and 100,000 cpm. Time constants are 0.3, 1, 3, 10, and 30 seconds. Spectrometer window width is variable in ten steps from 0 to 30%. Three position scan speed selector, 10, 25, and 60 minutes.

1-Model GR-5 X-Y Spectrometer Graphic Recorder. Chart size is 8½ inches x 11 inches. Maximum pen speed is 7.5 inches per second.

1-Model SDS-1B Slave Decade Scaler with timer.

The NMC Model GSS-1B is an automatic scan pulse height analyzer system which provides a graphic record of the activity and energy distribution of any gamma emitting sample. A constant percentage of each gamma energy peak is analyzed. The fixed window counts only those pulses brought to it by the amplifier. The system uses a sliding pulse amplification technique and is capable of scanning the gamma spectrum in a range of 0.1 kev to 6 mev. Special recorder paper is available for nonstandard ranges. Both automatic and manual scan control are provided. Individual peak monitoring may be accomplished directly on the graph paper using the slave scaler to integrate the total count under the peak.

Calibration and Maintenance of Gamma Spectrometer

The response of the gamma spectrometer to a calibrated source will be checked daily as outlined above. Pulses will be fed into the X-Y recorder from a pulse generator. The recorder will be adjusted to the exact pulse height and input rate. This will be performed when the daily source checks indicate that the instrument response has shifted.

Appendix 9.37a

Determination of Beta Emitters in In-Plant Air Samples

Appendix 9.37a

Determination of Beta Emitters in In-Plant Air Samples

The concentration of beta emitters in in-plant air samples is determined as follows:

$$\mu c/ml = \frac{c/m\ (\text{Factor})}{M^3}$$

$\mu c/ml$ = Microcuries per milliliter

c/m = Beta counts per minute on sample corrected for background.

M^3 = Total cubic meters of air sampled

$$\text{Factor} = \frac{1}{c\ g\ a\ K_1\ K_2}$$

c = Collection efficiency = 98%

g = Geometry of counter = 50%

a = Absorption correction = (not applicable -- see paragraph 9.34)

K_1 = $d/(m)/(\mu c)$ = 2.22×10^6

K_2 = Milliliters per cubic meter = 10^6

$$\text{Factor} = \frac{1}{(.98)\ (.50)\ (2.22 \times 10^6)}$$

$$\text{Factor} = 9.2 \times 10^{-13}$$

$$\mu c/ml = \frac{\mu c/m\ (9.2 \times 10^{-13})}{M^3}$$

Since, at 60 l/m a 24-hour sample represents $86.4 M^3$ sampled and the counting error for a one-minute count at 95% confidence level is ± 10% at 400 c/m, the minimum detectable concentration is:

$$\frac{(400)\ (9.2 \times 10^{-13})}{86.4} = 4.3 \times 10^{-12}\ \mu c/ml$$

with ± 10% accuracy.

Appendix 9.37b

Determination of Long-Lived Alpha Emitters in In-Plant Air Samples

Appendix 9.37b

Determination of Long-Lived Alpha Emitters in In-Plant Air Samples

The concentration of long-lived alpha emitters in in-plant air samples is determined as follows:

$$\mu c/ml = \frac{C_p\ (\text{Factor})}{M^3}$$

C_p = Calculated c/m due to product

$$= \frac{C_{24} - C_6 e^{-\lambda \Delta t}}{1 - e^{-\lambda \Delta t}}$$

C_{24} = 24-hour count

C_6 = 6-hour count

Δt = Time of 24-hour count minus time of six-hour count

M^3 = Total cubic meters sampled

$$\text{Factor} = \frac{1}{c\ g\ a\ K_1\ K_2}$$

c = Collection efficiency = 98%

g = Geometry of counter = 50%

a = Absorption correction = 70%

K_1 = d/(m)/(μc) = 2.22×10^6

K_2 = Milliliters per cubic meter = 10^6

$$\text{Factor} = \frac{1}{(.98)\ (.50)\ (.70)\ (2.22 \times 10^6)\ (10^6)}$$

$$\text{Factor} = 1.3 \times 10^{-12}$$

$$\mu c/ml = \frac{C_p\ (1.3 \times 10^{-12})}{M^3}$$

Since the counting error for a five-minute count at 95% confidence level is ± 10% at 75 c/m, the minimum detectable concentration on a 24-hour sample is:

$$\frac{(75)\ (1.3 \times 10^{-12})}{86.4} = 1.1 \times 10^{-12}\ \mu c/ml$$

with ± 10% accuracy.

Appendix 9.39a

Low Background Counting System

Appendix 9.39b

Determination of Beta Emitters in Perimeter Samples

Appendix 9.39b

Determination of Beta Emitters in Perimeter Samples

The concentration of beta emitters in perimeter samples is determined as follows:

$$\mu c/ml = \frac{(\text{Net Count})\ (\text{Factor})}{M^3}$$

Net Count = Total count for 60 minutes less 60-minute background count.

M^3 = Total cubic meters of air sampled

$$\text{Factor} = \frac{1}{60\ c\ g\ a\ K_1\ K_2}$$

60 Converts counts per 60 minutes to counts per minute

c = Collection efficiency = 98%

g = Geometry of counter = 50%

a = Absorption correction (not applicable, see Paragraph 9.34)

K_1 = $d/(m)/(\mu c) = 2.22 \times 10^6$

K_2 = Milliliters per cubic meter = 10^6

$$\text{Factor} = \frac{1}{(60)\ (.98)\ (.50)\ (2.22 \times 10^6)\ (10^6)}$$

$$\text{Factor} = 1.5 \times 10^{-14}$$

$$\mu c/ml = \frac{(\text{Net Count})\ (1.5 \times 10^{-14})}{M^3}$$

Since the counting error for a 60-minute count at 95% confidence level is ± 10% at 6.5 net counts per minute, the minimum detectable concentration of beta emitters on a weekly sample is:

$$\mu c/ml = \frac{(390)\ (1.5 \times 10^{-14})}{604.8}$$

$$\mu c/ml = 9.9 \times 10^{-15}$$

With ± 10% accuracy.

Appendix 9.39c

Determination of Alpha Emitters in Perimeter Samples

Appendix 9.39c

Determination of Alpha Emitters in Perimeter Samples

The concentration of alpha emitters is determined as follows:

$$\mu c/ml = \frac{(\text{Net Count})\ (\text{Factor})}{M^3}$$

Net Count = Total count for 60 minutes less 60-minute background count.

M^3 = Total cubic meters of air sampled

$$\text{Factor} = \frac{1}{60\ c\ g\ a\ K_1\ K_2}$$

60 Converts counts per 60 minutes to counts per minute.

c = Collection efficiency - 98%

g = Geometry of counter = 35%

a = Absorption correction - 70%

K_1 = d/(m)/(μc) = 2.22×10^6

K_2 = Milliliters per cubic meters = 10^6

$$\text{Factor} = \frac{1}{(60)\ (.98)\ (.35)\ (.70)\ (2.22 \times 10^6)\ (10^6)}$$

Factor = 3.1×10^{-14}

$$\mu c/ml = \frac{(\text{Net Count})\ (3.1 \times 10^{-14})}{M^3}$$

Since the counting error for a 60-minute count at 95% confidence level is ± 10% at 6.5 net counts per minute, the minimum detectable concentration of alpha emitters on a weekly sample is:

$$\mu c/ml = \frac{(390)\ (3.1 \times 10^{-14})}{604.8}$$

$\mu c/ml = 2.0 \times 10^{-14}$

With ± 10% accuracy

Appendix 9.43

Exposure Record Card

Appendix 9.43

Exposure Record Card

Exposed From - To	Dosimeter Readings								Badge Readings				Total
	M	T	W	T	F	S	S	Total	G	B	N	Total	

Recorded For	Body Status	Prev. Total	This Card	Acc. Dose	5 (n-18)	Unused Dose

Badge	Name (Last, First, Middle)	S. S. Number	Birth Date	Nuclear Fuel Services, Inc. West Valley, New York

Appendix 9.47

Routine Survey Form

Appendix 9.47

Routine Survey Form

ROUTINE SURVEY LOG
NUCLEAR FUEL SERVICES, INC.
SPENT FUEL REPROCESSING PLANT

Survey Number: Shift Assigned:

Frequency: Time Allotted:

Title:

MATERIALS AND EQUIPMENT REQUIRED:

DESCRIPTION OF SURVEY:

SPECIAL SAFETY INSTRUCTIONS:

PREPARED BY: REVISED BY: DATE:

Appendix 9.49

Environmental Monitoring Program

Appendix 9.49

Environmental Monitoring Program

Phase I - Atmospheric Monitoring

Three air-sampling stations have been established at the site perimeter. These stations consist of a vacuum pump drawing air through a filter, a beta-gamma detector to measure the activity deposited on the filter, a log-count ratemeter and strip-chart recorder to provide a permanent record of activity at each location. These air monitors are serviced weekly. One air-sampling station has been established near the plant site. This station will consist of a vacuum pump pulling air through a filter paper to collect particulates. The filter will be changed and monitored weekly for gross alpha and gross beta activity.

Water Monitoring

A rain and snow collection station has been established at the plant site. Samples of water from this station are collected and monitored as available for gross alpha and gross beta activity, iodine-131, and strontium-90. Surface water samples and mud and silt samples are collected monthly and monitored for gross alpha and gross beta-gamma activity. Samples will be collected from the following locations:

1. Erdman Brook near Buttermilk Creek;
2. Buttermilk Creek near the Emerson Road crossing;
3. Cattaraugus Creek near the Nagel Road crossing.

A well water sample is obtained from the site monthly and monitored for gross alpha and gross beta-gamma activity.

Earth and Biota Monitoring

Vegetation samples are collected near the three perimeter monitoring stations in the spring and fall and will be monitored for gross alpha, gross beta-gamma, iodine-131, and strontium-90.

A milk sample is collected from a neighboring farm weekly and is monitored for gross beta-gamma. Samples collected once each month are analyzed for iodine-131 and strontium-90.

In the spring and fall a rabbit or other small game from the site will be analyzed for gross beta, gross alpha and iodine-131 activity.

Phase II - Atmospheric Monitoring

The three air-monitoring stations at the site perimeter, as described in Phase I, will be used and serviced weekly.

Appendix 9.49

The Plant site air-sampling station, as described in Phase I, will be used and serviced weekly.

Samples may be autoradiographed on x-ray film to determine number and relative intensity of particulates collected.

Water Monitoring

A rain and snow collection station is established near the plant site. Samples of water from this station will be collected and monitored as available for gross alpha, gross beta and tritium. A strontium-90 determination will be made twice each year.

Surface water, mud, and silt samples will be collected monthly from the locations specified in Phase I. These samples will be monitored for gross alpha, gross beta-gamma, and tritium. Each month one or more of the samples will be gamma scanned if sufficient activity is present. Well water samples will be collected monthly from the site. These samples will be analyzed for gross alpha, gross beta-gamma, and tritium activity.

Earth and Biota Monitoring

Vegetation samples will be collected in the spring and fall near the three perimeter stations. These samples will be analyzed for gross alpha, gross beta-gamma, and iodine-131. One or more of the samples collected in the spring and fall will be analyzed for strontium-90.

Milk samples will be collected weekly from the plant site and analyzed for gross alpha, gross beta-gamma. and iodine-131. In the spring and fall strontium-90 determinations will be made.

Twice each year, in the spring and fall, fish and shellfish specimens will be collected from Buttermilk Creek and Cattaraugus Creek. These specimens will be analyzed for gross alpha, gross beta-gamma, and iodine-131.

In the spring and fall a rabbit or other small game from the site will be analyzed for gross alpha, gross beta-gamma, and iodine-131 activity.

Appendix 9.51

Stack Monitoring System

Appendix 9.51

Stack Monitoring System

The stack monitoring system consists of two channels of monitoring; the first channel for beta-gamma emitting particulates, and the second channel for iodine-131 with readout and alarm locally and at the Control Room Panel. The system is supplied by Tracerlab, a division of Laboratory for Electronics, Inc., Richmond, California. The following equipment is included:

1-Isokinetic nozzle;

1-Model MX-14C Pumping System with a 10 cfm sliding dry vane pump driven by an electric motor through double V-belts, a control valve, a calibrated fixed orifice, flow gauge, and necessary piping;

1-Model MA-1B Filter Tape Transport Mechanism, an advanced version of the Brookhaven design. A solid capstan with milled slots rides on a Teflon shear valve which limits the air bypass around the filter paper to less than 2 percent. The filter paper is held against the rotating capstan by the pressure differential across the paper and is moved by the rotating capstan. Two filter tape speeds are provided; one inch per hour for normal operation, and 28 inches per minute for fast advance to clear contaminated tape from the detector areas;

1-Model MD-1B Beta-Gamma GM Detector, a halogen-quenched end window detector, $2\frac{1}{2}$ inches in diameter. The window is mica -- less than 4 mg/cm^2 thickness. The detector is shielded by two inches of lead;

1-Model RM-20B Precision Log Ratemeter with a $4\frac{1}{2}$-inch panel meter indicating the counting rate directly in counts per minute on a switch selected three decade (10 to 10^4 cpm) or five decade (10 to 10^6 cpm) scale. One additional scale indicates high voltage. The ratemeter has an adjustable alarm point and a manual reset to provide "memory". The meter relay automatically resets to permit meter to read cpm below the alarm point;

1-Model RM-40B Dual Power Supply with main power switch, high voltage switch, two high voltage adjustment screws and alarm reset. Unit supplies high voltage for the system detectors;

1-Model MI-5B Iodine Sampler and Shield Assembly, with a holder for a two-inch diameter activated charcoal filter and a three-inch thick lead shield for the detector;

1-Model MD-5B Gamma Scintillation Detector, with a $1\frac{1}{2}$-inch diameter x 1-inch sodium iodide, thallium-activated crystal, a Dumont 6292 photomultiplier and a 100-gain preamplifier.

1-Model RM-20BS Precision Log Ratemeter, identical to the RM-20B described above plus a spectrometer input circuit for pulse height discrimination. Window width adjustable from 2 percent to 100 percent and threshold adjustable from 5 percent to 100 percent of full scale.

1-De Var Series R 300 two-pen recorder, Control Room Panel mounted to record output from particulate and radioiodine stack monitors and to alarm if count rate of either unit exceeds the preset level.

The beta-gamma particulate monitor, with two inches of lead shielding around the detector, has a background of about 25 cpm. A counting rate of twice background is obtained at a concentration in the stack of about 1×10^{-11} $\mu c/cc$ of mixed fission products.

The Gamma Scintillation Detector, with three inches of lead shielding around the detector, has a background of about 175 cpm for a counting threshold of 100 kev. The detector will show 100 net cpm after an exposure of 30 minutes to a concentration of 10^{-10} $\mu c/cc$ of iodine-131.

Calibration and Maintenance of Stack Monitor

The response of the stack particulate monitor to radioactivity will be apparent from natural activity as well as activity from the stack air stream which will be trapped by the filter paper. Calibration of the particulate monitor, relating detector counts per minute to microcuries per milliliter in the air stream, will be accomplished by analyzing a section of the filter in the counting room and comparing the results to the count rate indicated by the stack sampler. After the initial calibration, this check will be made only as the need is indicated but not less than twice annually.

The iodine monitor will be calibrated quarterly by analyzing the activated charcoal filter in the counting room and comparing the results with the count rate indicated by the stack sampler. The collection efficiency of the charcoal filter will be checked by collecting a caustic scrubber sample independent of the stack monitor and comparing the results with the activity of the charcoal filter. This check will be made on each batch of filter paper received.

Appendix 9.53

Weather Monitoring Station

Appendix 9.53

Weather Monitoring Station

Two weather-monitoring stations are provided, one at 60 feet and the second at 200 feet above ground level. Each station continuously records wind direction, velocity, and ambient temperature. The weather-monitoring stations are supplied by Science Associates, Princeton, New Jersey and each station consists of the following:

1-No. 4-120 Aerovane transmitter, a combined anemometer and wind vane in one unit. A three-bladed plastic rotor with a starting speed of 2.5 mph drives a magneto which generates a voltage directly proportional to wind speed. The streamlined vane houses a synchro whose rotor position is determined by the vane. The transmitter includes a filter to prevent radio interference and is permanently lubricated.

1-No. 4-141-5 Aerovane Recorder provides instantaneous readout of wind direction and velocity on the same chart. Direction data from 0 to 360 degrees is recorded on one side of the chart and speed data from 0 to 100 mph is recorded on the other side of the chart. Each recording area is 4½ inches wide.

1-No. 170 Stainless Steel sheathed temperature bulb and temperature recorder. Recorder is two pen with range of-50 to 110 F in one degree divisions. The temperatures from both stations record on one chart.

1-No. 174 Aspirated Solar Radiation Shield to house the temperature bulb. Heat from the sun and from surrounding objects is excluded by the dome-shaped shield, by an inner and outer shield and by a surface oriented baffle. A motor and blower, located at the remote end of the mounting arm, induce a forced ventilation.

The recording charts for the two weather stations are located in the Control Room Panel.

Appendix 9.56

Stream Gauging and Sampling

Appendix 9.56

Stream Gauging and Sampling

Stations are provided for gauging and sampling the flow of Franks Creek and Cattaraugus Creek.

The gauging stations each consist of a calibrated level detector and continuous recorder.

The sampling stations each consist of a proportioning pump to take a maximum size sample of 10 gallons per week. The samplers are each housed in an electrically heated, weatherproof enclosure.

Appendix 9.93

Format for Standard Operating Procedures
and
General Index of Standard Operating Procedures

Appendix 9.93

Format for Standard Operating Procedures

Date
Name
Draft No.

1. Purpose - (Merely a repetition of title.)

2. Scope

   a. Area
   b. Major Equipment
   c. Startup
   d. Operations
   e. Shutdown

3. General

   a. Criteria of Operations (functions), e.g. Batch, Surge Tank, Feed Tank, etc.
   b. Interfacial Effects, i.e. Equipment on Upstream and Downstream Side of Subject Equipment

4. Special Precautions

   a. Administrative - Need for approval of Shift Supervisor
   b. Criticality
   c. Accountability

5. Process Streams

   a. Influent
   b. Effluent (overflows included)

6. Operations

   a. Start Up
   b. Operate
   c. Shut Down
   d. Regenerate
   e. Emergency Procedures

7. References

NRC .0581

DOCKET NO. 50-201

~~DR00, TISE~~ T. I.

acc. 1201.11
NRC 9064

S A F E T Y A N A L Y S I S

SPENT FUEL PROCESSING PLANT

Part B

of

License Application

Volume I

Copy No. 79

NUCLEAR FUEL SERVICES, INC.

July 1962

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<u>Appendices</u>

Continued

I INTRODUCTION

1.11 This document, which consists of nine sections plus appendices presented in two volumes, represents a description and safety analysis of the Spent Fuel Processing Plant which Nuclear Fuel Services, Inc. wishes to build on the Western New York Nuclear Service Center near Riceville, New York. It is the purpose of this introductory section to provide a summary of the information contained in the body of this report. Throughout the report the location of material is identified by numbering paragraphs consecutively within each section; in this introduction the numbering relates to the particular section being described.

1.12 Sections II, III, IV, V, and VI describe the site plant, process, equipment, and supporting engineering systems, respectively. These descriptive sections form the basis for the safety analysis contained in Sections VII, Protection of the Public, and Section VIII, Protection of Plant Personnel. Section IX describes the health and safety programs and the start-up plans for the plant.

II Site Description

Geography

1.21 The facility will be located on the Western New York Nuclear Service Center in the Town of Ashford, near Riceville, Cattaraugus County, New York, about thirty miles southwest of Buffalo and will be described as the Riceville Site. The site contains 3,331 acres and the processing plant and waste storage facilities are located 3,000 to 4,000 feet from the nearest site boundary. The site is in the middle of a rural area of low population density - an average of 90 persons per square mile within a 25-mile radius. The population has not changed within a 10-mile radius over the past 50 years, and the character of the land and community are such that it should not change materially over the next 15 years. There is no town within 25 miles of the site with a population in excess of 10,000. The nearest village is Springville, 4-1/2 miles to the north with a population of 3,852, and the nearest major population center is the city of Buffalo, the city limits of which are 26 miles north of the site. The immediate area within four miles around the site is divided between unusable rugged terrain and level fertile land used for farming. All roads through the site will be used solely for access purposes and will be controlled by the applicant. There is a spur of the Baltimore and Ohio Railroad Company railroad used solely for freight traffic running through the site at a distance of 1,800 feet at its closest point to any facility.

1.22 It is suggested that the geographical factors are favorable. The exclusion area, as is demonstrated in Section VII, is more than adequate to assure that the health and safety of the public will not be endangered by normal operation of the facility or by any credible accident. The population density beyond the exclusion area and population

within a radius of 25 miles is small, thus assuring a minimum exposure of the general public, if as a result of an unforeseen accident, radioactivity should not be contained within the area of the site.

Meteorology

1.23 The area has a mean annual temperature of 45F, an annual rainfall of 40 inches, and an annual snowfall of 80 to 100 inches. The prevailing wind directions are from the northwest in the winter and from the southwest in the summer. The area to the northeast and southeast are even more sparsely populated than the average set forth in 1.21 above and the closest major population areas in these directions are approximately 80 miles from the site. The area around the site is seldom subject to persistent stagnant high pressure areas and poor diffusion conditions. Thus, the prevailing wind and diffusion conditions are favorable.

Geology

1.24 The plant and the waste storage facilities are located on a plateau between two of the ravines which form tributaries flowing into Buttermilk Creek. The geological structure is bedrock overlain by glacial deposits consisting of a permeable glacial till, a much less permeable silty till, with sandy tills and various shales underneath. All layers have good ion exchange capacity for cesium and strontium.

Hydrology

1.25 The site is an elongated rolling plain cut by ravines with tributaries leading into Buttermilm Creek. All of the tributaries on the site and, therefore, all ground water on the site feed into Buttermilk Creek within the portion of that creek contained wholly within the site. Applicant thereby has control over all surface drainage for the entire site by its control over Buttermilk Creek. At the site boundary, Buttermilk Creek empties into Cattaraugus Creek, which in turn flows into Lake Erie, 39 stream miles from the site. No cities or villages downstream from the site rely on Cattaraugus Creek for their water supply, and there are no potable water sources or large water supplies in the immediate area of the site.

1.26 Buttermilk Creek supplies dilution water at an average rate of 41 cfs. Cattaraugus Creek has an average flow at the site of 358 cfs.

1.27 There are three aquifers on the site. One is in the surficial glacial till. Ground water movement in this formation is from 1 to 2 feet per day. On some parts of the site there is an aquifer located in sandy tills underneath the silty till. This does not exist on the plateau selected for the plant facilities. Finally, there is a deep bedrock artesian aquifer which is situated well below impermeable layers at the facility location. The silty till, in which the waste tanks and the solid burial will be located, is not an aquifer

but it is water saturated. Ground water movement in this very impermeable layer is calculated to be about 5×10^{-5} ft/day. It is calculated that it would take about 40,000 years for the high level wastes and 5,500 years for the low level wastes to move through this silty till from the point of storage to the nearest ravine.

1.28 The good ion exchange capacity of the soil, the slow movement from the waste storage facilities to the ravines, the existence of the ravines, and the fact that all ground water flows to a creek within the site render the site adaptable to an excellent monitoring system and allow excellent control over radioactive wastes stored on the site.

Seismology

1.29 Western New York is an area of low seismicity and the danger of earthquakes which might rupture any of the plant's facilities is minimal. The nearest fault to the site is at a distance of 35 to 40 miles, and this is more properly classified as a minor earth structure rather than a fault. Thus, the site presents no seismological problems.

Summary

1.210 In summary, the characteristics of the site are such that the health and safety of the public should not be endangered by operation at the site of the NFS chemical processing plant or by the storage of low or high level wastes. The remoteness of the site from population centers, the low population density for 25 miles beyond the site, the large exclusion area, and the meteorology, all are favorable factors to assure protection both from normal operation of the facility and from any credible accidents. The hydrology and geology are suitable to permit control of low level and high level wastes under normal conditions and in the event of a credible accident. The ease of monitoring water movements and exercising necessary controls, if excessive radioactivity developed, is assured by the special conditions existent on the plateau on which these waste facilities will be located.

III Plant Description

1.31 The plant site area, located in the center of the 3,331-acre exclusion area, contains 500 acres. Both areas will be fenced and conspicuously posted, and access will be controlled. The facilities consist of a process building, a waste tank farm, a waste burial ground, a temporary waste storage lagoon, an office building, and a warehouse.

Office Building

1.32 The office building and parking for visitors and employees is located at the entrance of the plant site area 4,000 feet from the process building and warehouse and 3,000 feet from the waste disposal

areas. It is thus remote from the areas where nuclear materials are handled. Of the approximately 130 employees of the applicant, it is estimated that approximately 30 will be employed in the office building.

Process Building

1.33 The process building is arranged in a Z with fuel receiving and storage area on one end and purified product removal facilities on the other end. In the middle are the mechanical and chemical process cells. On one side of the center line are offices, laboratories, control room, and related facilities. On the other side are shops, a utility area, and a warm equipment aisle.

Fuel Receiving and Storage Area

1.34 The fuel receiving and storage area consists of a primary washdown area into which the fuel shipping cask is brought by rail or truck, a cask storage area, a cask decontamination pit, a cask unloading pool, a ruptured fuel isolation pool, a fuel storage pool, and an underwater process pool. The cask unloading pool is sufficiently deep to permit a minimum water cover of 11 feet over the longest fuel element contemplated. The fuel storage pool has racks and equipment for handling each type of fuel presently contemplated. The underwater process pool contains equipment for doing rough underwater cutting of non-active parts of fuel elements if necessary. Each pool can be segregated by removable gates. The spacing of the fuel and the crane and fuel handling fixtures are designed to prevent accidental criticality.

Mechanical and Chemical Process Cells

1.35 The central processing area consists of a process mechanical cell and a chemical process cell. The mechanical cell is 16 feet wide by 54 feet long by 24 feet high with wall of 6 feet of ordinary concrete or 4 feet of high density concrete. The primary purpose of the mechanical cell is to remove extraneous hardware from the fuel element and reduce it to small pieces (1 in. to 2 in.) which can be dissolved in the chemical cell. The area has viewing windows and remotely operated cranes and manipulators. The chemical cell is 16 feet wide by 107 feet long by 45 feet wide with walls of 6 feet of ordinary concrete. It has a remotely operated crane and periscopes, television, and viewing windows to aid in the use of the crane. All high level radioactive equipment requiring frequent maintenance which can be performed remotely is located in this cell. Both cells are tied into a central ventilation system. On each side of the central processing area are operating aisles containing most of the instruments and controls. Under these aisles are aisles containing sampling stations. Underneath the interior operating gallery is a warm equipment aisle consisting of a series of shielding cubicles located below the floor level of the aisle. The cubicles have removable shield covers which permit maintenance of pumps and other mechanical equipment contained therein.

Product Purification Area

1.36 At a 90 degree angle to the central processing area are the principal production purification and recovery facilities. After dissolution of the fuel element in the chemical cell to form a process fuel solution, the solutions are put through a Purex solvent extraction process which separates and recovers uranium and plutonium as nitrate solutions. This is done in a series of perforated-plate pulse columns which have the necessary equipment for metering, transferring and intermediate storage of solutions. Facilities for clean-up and recycle of solvent are also included.

Product Handling Area

1.37 Adjoining the product purification area are the product concentrating and packaging areas including evaporation, ion exchange and silica gel equipment for concentration, final clean-up and packaging of uranium and plutonium. The entire production purification and product handling area is 128 feet long by 43 feet high by 16 to 22 feet in width.

Warehouse

1.38 The warehouse is located near the process building and will provide storage space for bulk chemicals and other supplies, bird cages, shipping containers, equipment spare parts, and plutonium product solutions.

IV Detailed Process Description

Basic Process

1.41 The plant is a multipurpose plant capable of processing any type of fuel element from which the fuel proper can be reduced to a nitric acid solution. This includes all but one of the presently contemplated fuels from private nuclear power plants (graphite maxtrix fuels). No fuel will be processed before it has been cooled for 150 days. The base line process is a Purex solvent extraction system designed for processing of low enriched NO_2 in stainless steel or zirconium alloy tubes with a maximum throughput of 1,000 kg of uranium per day. In addition, there will be:

1. A head end dissolution treatment for the dissolution of zirconium clad fuels in HNO_3-HF mixtures, permitting a throughput of 600 kg of zirconium per day. Dissolution is performed in stainless steel dissolvers with controlled additions of HF and HNO_3. Aluminum nitrate is added to permit extraction of the uranium and to minimize corrosion. Stainless steel tankage is provided for storing the wastes in acidic condition.

2. A total dissolution scheme (Darex) for stainless steel cermet fuels, using mixtures of hydrochloric and nitric acids with a throughput of 230 kg of stainless steel per day. Special titanium equipment is required in this head-end step which contains facilities for distillation and recycle of the HCl. The dissolver is located in a special cell over the process mechanical cell and the remainder of the Darex equipment is located in a contact-maintained cell adjacent to the first extraction cell. The Darex head-end may be replaced with electrolytic dissolution which is simpler. The use of electrolytic dissolution will introduce no new safety questions.

3. A direct nitric acid chemical dissolution process for aluminum or molybdenum alloy fuels.

4. A deactivation process prior to dissolution for uranium carbide fuels or for those in which sodium is present as a bonding agent.

Receipt and Storage

1.42 The fuel is received in shielded, water-cooled casks and is hosed down in the primary washdown area. After temperature reading, sampling of cask coolants and purging of gases into the ventilation system, the cask is placed underwater in the 44-foot deep unloading pool by a hand-operated overhead crane. The fuel is removed and placed in storage baskets by remotely-operated equipment and the cask is transferred to a decontamination pit. The storage baskets are transferred by the storage pool crane to the fuel storage pool and placed in safe geometry racks. Any ruptured elements will be stored in sealed canisters.

Mechanical Processing

1.43 When the fuel is ready to be processed, it is transferred by the storage pool crane to the underwater process pool from where it is transferred through a conveyor and crane to the process mechanical cell. It is removed from the basket by remote equipment and dried. The end hardware is then cut off and the fuel pushed out of its casing. After inspection it is chopped into small pieces in the bundle shear. This operation is carried out under an inert atmosphere such as CO_2. The resulting pieces of fuel are collected in chopped fuel canisters. If sodium is involved, deactivation of the sodium is accomplished before removal of the chopped fuel from the CO_2 atmosphere. Then the chopped fuel canisters are removed to the chemical processing cell on a transfer cart through an airlock.

Chemical Processing

1.44 In the chemical processing cell, the chopped fuel cannisters are placed into one of the dissolver barrels. Nitric acid and water are metered into the dissolver from the solution makeup area so that the final solution contains no more than 7.5 grams per liter of U-235, a critically safe concentration in all geometries and quantities. Complete dissolution is expected to take about 12 hours. The off-gas treatment includes a down-draft condenser on the dissolver, a secondary condenser, a scrubber, iodine removal on a silver reactor, and filtration through parallel filters. The off-gas is then added to the general ventilation system for further filtration before discharge to the stack.

1.45 When the dissolution of the fuel is complete, the solution is cooled and jetted to a 304-L stainless steel accountability and feed adjustment tank. The dissolver is then heated to dry off the hulls, which are returned to the process mechanical cell. The hulls are inspected and packaged and sent to the solid waste storage area. The accountability and feed adjustment tank is equipped with heating coils, a condenser, air sparger, liquid level and specific gravity measurement, circulating sampler, and temperature measurement. After analysis and adjustment of the concentration and acidity of the feed, it is jetted to the partition cycle feed tank from which it is fed to the extraction columns.

Solvent Extraction

1.46 Solvent extraction is done by a Purex-type process, which is performed in the contact process area. The base-line fuel is put through a partition cycle, in which a TBP-kerosene solvent is used to extract the uranium and plutonium from the feed stream, leaving the bulk of the fission products ($>$99.9%) in an aqueous stream which becomes the major fission product waste stream of the plant. The plutonium and uranium are also separated in this first extraction cycle into two separate, partially decontaminated, aqueous product streams. These two product streams are then separately put through additional solvent extraction cycles to complete the removal of remaining fission products.

1.47 The uranium and plutonium product streams are first collected in the feed conditioner tanks for sampling, analysis, and adjustment of acid concentration. The streams are then put through additional solvent extraction cycles in which the product is extracted into an organic phase in one column and then returned to an aqueous product stream in a second column. The uranium stream goes through two such cycles and the plutonium through one.

Product Purification and Concentration

1.48 The uranium product stream from solvent extraction is collected in a product evaporator feed tank from which it is jetted into one of two evaporator tanks for concentration. The condensate is collected in one tank and the concentrate in another. The concentrate is subjected to a silica gel treatment for final decontamination. The product is then placed in one of two sampling tanks, and after sampling and analysis it is transferred to one of a series of storage tanks. Highly enriched uranium is drawn from these tanks in small quantities and mixed with water to a concentration critically safe for shipment in tank trucks; the low enriched uranium is already at an acceptable concentration from a criticality standpoint.

1.49 The plutonium product stream is collected in an ion exchange conditioner tank from which it is pumped into one of three anion exchange columns for concentration and final decontamination. It is eluted from the columns and evaporated in a titanium vessel. The condensate is pumped back to the feed adjustment tank and the concentrate is collected in one of three plutonium storage tanks, from which it is packaged for shipment. All of the packaging and shipping equipment is enclosed in separately ventilated glove boxes. The shipping bottles are placed in secondary containers and stored in the product storage area in bird cages awaiting shipment.

Solvent Recovery

1.410 The plant is designed to reuse the TBP-kerosene solvent, which must be cleaned of fission products prior to reuse. To accomplish this, the solvent is first washed with sodium bicarbonate and then with dilute nitric acid.

Acid Recovery

1.411 All of the aqueous waste streams will contain nitric acid which will be recovered to reduce the solid loading on the waste tanks. Acid recovery is accomplished through the use of two waste evaporators following which the acid is subjected to an acid fractionation step to concentrate it into a reuseable condition.

Rework System

1.412 All waste streams will be sampled and analyzed prior to being discarded to the waste disposal system. In the event that the product in the waste stream is above specification, facilities are provided to rework the wastes. They are recycled through a feed tank and a rework evaporator. The bottoms from this evaporator are pumped back to the feed adjustment tank to be subjected to further solvent extraction.

Waste Handling

1.413 Liquid wastes are placed in tanks designed to contain approximately 500,000 gallons each. The tanks are constructed in the "cup-and-saucer" design used at Savannah River. They are operated, however, according to the waste management procedures applied at Hanford. Spare tanks are provided so that wastes may be transferred to another tank should leakage develop.

1.414 A general purpose evaporator is provided in the tank farm area for reducing the volume of low level wastes. It is backed up by an ion exchange unit for the condensate. The overhead product is expected to be water, sufficiently pure to be discarded to Buttermilk Creek.

1.415 High level, solid wastes, such as hulls, will be stored in the tank farm area in concrete-lined bins buried in the ground and monitored to assure that no water collects in them. Any seepage will be pumped out and processed in the general purpose evaporator. Low level solid waste will be buried in the silty till of very low permeability.

V Equipment Description

1.51 In this section, all major equipment is described in detail. In general, the equipment is classified either by the area in which it is located or by function.

Fuel Receiving and Storage Area

1.52 The equipment in this area is designed to permit underwater handling by remote control of the fuel elements and to confine radioactive contamination in the event of ruptured elements. The major equipment pieces are:

a. 100-Ton crane with two auxiliary 5-ton cranes running on a monorail attached to the underside of the main bridge beam. The controls are of a fail-safe type requiring manual operation.

b. Fuel storage pool complex with water demineralized before use and continuously filtered to maintain its purity and with cleanup equipment, including a filter, demineralizer, and resin add tank. The pool has three smaller pools which can be separated by means of removable gates.

c. Storage baskets perforated for cooling and drainage, made of stainless steel with spacers to prevent movement of fuel in the basket during storage or movement.

d. Ruptured fuel canister, water and gas-pressure tight, to confine radioactive contamination. These are adapted to remote control attachment by the crane and have spacers to prevent movement of the fuel.

e. Movable bridge and 2-ton overhead crane which service the storage pool. The crane has a limited verical lift to assure minimum water shielding.

f. Storage rack for storage of fuel assemblies in the storage pool. It is designed to prevent a critical array of any configuration of any fuel.

g. Underwater conveyor for transfer of storage baskets to the mechanical cell. The conveyor is so designed that only one basket can be handled at a time. It has an endless chain and can be controlled either at the fuel receiving area or at the mechanical cell area.

Process Mechanical Area

1.53 Equipment is provided for the transport, disassembly and chopping of the various fuel elements. Flexible facilities are provided for variations in fuel element construction or other special conditions in the fuel bundles. The major equipment pieces are:

a. Remote handling equipment, including two fuel handling bridge cranes, a power manipulator and four pairs of master-slave manipulators, one pair of which has extended reach. All operations in this area are carried out remotely by the use of this equipment.

b. Pushout table, including a pushout ram and a drier for removal of fuel from basket and drying of fuel. There is a gas loop in the drier which is sampled to assure that the fuel is dried. The pushing pressure is controlled by a preset regulator.

c. Radial saw table on which the ends of the element are sawed off after the element is positioned in a fuel carrier and on which special cutting can be done if the fuel cannot be pushed out of its casing.

d. Fuel bundle carriers designed to hold a single fuel bundle by means of manipulator-operated clamps.

e. Inspection table with a remotely operated vise, vee blocks, gauges and other devices to hold and measure fuel elements.

f. Fuel bundle shear for chopping the fuel into pre-selected lengths from to 2 inches. The shear blade is driven by a hydraulic ram which can develop a 250-ton force. The hydraulic power units for this cutting operation are located in the aisle adjacent to the processing cell.

g. Casing shear for chopping casings in pre-selected lengths of 1 to 6 inches.

h. Fuel pin shear, a portable machine shearing single fuel pins if necessary.

i. Maintenance table for the service and adjustment of in-cell equipment. It is designed for flexibility in handling the equipment and includes pneumatic portable harness, nibblers, and other power tools for the manipulator equipment.

j. Deactivation autoclave cart for transport of the baskets containing the chopped fuel.

k. Transfer cart used in the airlock between the mechanical and chemical cells designed to prevent accidental dropping of the fuel basket and remotely removable for maintenance.

l. Remotely operated shielding door for foyer into which the manipulator and cranes can be removed for decontamination and maintenance.

Dissolvers

1.54 There are four batch dissolvers: three are made of 309 SCb stainless steel with a nominal capacity of 2,000 gallons designed to dissolve 1,000 kg/day uranium as UO_2; the fourth is made of titanium for the dissolution of stainless steel by the Darex process. It has a nominal capacity of 1,500 gallons designed to dissolve 100 lb/day of stainless steel. They are designed for remote maintenance and replacement and are isolated from one another. The tanks are cylindrical with a heating coil near the bottom and a condenser coil located in a bustle around the top. Each dissolver has a series of appurtenant equipment for handling the off-gas from it, including an off-gas scrubber, a condenser, and a silver reactor. During dissolution, the liquid level and density of the solution is continuously recorded and the system pressure is recorded and controlled by a PRC in the off-gas line, backed up by a manually controlled valve. Alarms are provided for high and low liquid level, temperature of solution and off-gas, and off-gas pressure.

Pulse Columns

1.55 Continuous solvent extraction is effected by 12 pulse columns with varying functions. The columns are fabricated from 304-L stainless steel and located in three extraction cells. They perform the functions of extraction, partition, stripping and scrubbing. With the exception of two columns, all will have cartridges of boron-304-L stainless plates installed in the enlarged disengaging sections to protect against criticality. Control of the columns is maintained primarily through control of the effluent from the bottoms of the columns and by control of aqueous effluent removal and interface level through sensing pots located near the tops of the columns. Further, the column bottom pressure, temperature at the top and bottom of the column and specific gravity of the organic effluent are recorded.

Evaporators

1.56 Products and wastes are concentrated in seven evaporators: 2 waste evaporators and 1 rework evaporator designed for remote maintenance; 2 uranium and 1 plutonium product evaporators and 1 general purpose evaporator, designed for contact maintenance. Each is designed as an integral package with external reboilers and condensors supported from the shell of the evaporator. All are made of 304-L stainless, except the plutonium product evaporator which is to be titanium for corrosion resistance.

Acid Fractionator

1.57 This is a vacuum unit made of 304-L stainless and designed for contact maintenance.

Process Tanks

1.58 These are of eight basic designs, and have variances depending on size, location within the plant, and type of maintenance.

Radioactive Waste Storage Tanks

1.59 These are of four types: 500,000-gallon tanks for high and low level liquid wastes, 100,000-gallon for Darex waste, 30,000-gallon for depleted uranium, and 60,000-gallon for thorium product. Each is built in a 4-foot high steel pan and the pan and the tank are enclosed in a concrete vault with sufficient earth cover to reduce radiation levels at grade to 1 mr/hr. All plate welds will be fully radiographed and all tanks have internal columns to support the tank roof and act as ties for the internal pressure design. The Darex tanks are of 304-L stainless and are cooled by circulation of cooling water through two vertical cooling coils. The sludge in the high level waste tank is prevented from settling by agitation with four air agitators. Limited access to all tanks is possible through a shielded plug from grade through the top of the tank.

Pumps

1.510 A variety of pumps are used including positive displacement with and without flow adjustment, canned, centrifugal, and remote head diaphragm pumps.

Miscellaneous Equipment

1.511

a. Silica gel columns

b. Small column for the final solvent extraction product stream.

c. Ion exchange units

d. Equipment for solvent washing system.

VI Engineering Analysis of the Plant

1.61 In this section, the salient features of a number of the engineering aspects of this plant are discussed, including:

a. Ventilation
b. Sampling
c. Maintenance
d. Shielding
e. Monitoring
f. Utilities

There are also sections which discuss the control of criticality and the possible effects of process maloperation.

Ventilation

1.62 The plant has four ventilation systems which are separate from one another. These are: (1) the general building ventilation, (2) the process ventilation, (3) the process vessel system, and (4) the dissolver off-gas system. The systems are designed so that: (1) the total volume of air is kept to a minimum, (2) all air entering is mechanically or chemically cleaned to remove particulate matter and fumes, (3) air pressure to limited access areas is less than atmospheric and to process areas at an even lower pressure, (4) normal access openings are ventilated from the less active to the more active area, (5) gases from process and laboratory equipment are segregated to permit special treatment and close monitoring, (6) back-up systems are employed where desirable for reliability and continuity, (7) distribution equipment contains volumetric control, isolation, diversion, and concentration, (8) toxic and radioactive aerosols are kept to a minimum, and (9) final exhaust to the atmosphere is accomplished at sufficient volume to insure dilution of irremovable gases and at sufficient height (202 feet above grade) to assure secondary dilution and adequate distribution to the atmosphere. The total volume of air discharged is 46,000 cfm. Fume hood and radiolaboratory exhaust, the process ventilation system, the various vessels and equipment pieces in the process area are separately vented to duplicated systems of preheaters, prefilters, absolute filters, and exhauster installations prior to release to the stack. The waste tank farm vent gas system consists of two glass fiber-packed columns and parallel exhaust discharging to its own stack. Each system is separately adjusted automatically and has a spare absorber train with automatic start-up and phase-in. The duplicate systems are isolated by butterfly valves. All of the exhaust fans are connected to the emergency electrical system and will come back into operation within ten seconds and automatically start up if static pressure in an area drops below a preset point or if activity increases beyond a preset point. The entire system may be operated manually if desired.