

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

November 5, 1993

MEMORANDUM FOR: G. W. Cunningham

COPIES: Board Members

FROM: A. De La Paz

SUBJECT: Savannah River Site - Reviews of Safety Analysis Documentation at the F-Canyon and FB-Line Facilities and Nuclear Criticality Safety at FB-Line

1. Purpose: This memorandum provides DNFSB staff comments resulting from reviews of the safety analysis documentation at the F-Canyon and FB-Line facilities and nuclear criticality safety at the FB-Line facility. The FB-Line nuclear criticality safety review was conducted on July 20, 1993 by Dave Hayes and Sol Pearlstein and the F-Canyon and FB-Line safety analysis documentation review was conducted on July 27 and 28, 1993 by Andy De La Paz and Michael Merritt. Follow-up reviews of documents obtained as a result of these reviews were necessary, along with additional discussions with DOE and contractor personnel, to identify and clarify DNFSB staff observations.
2. Summary: The safety analysis documentation for the F-Canyon and the FB-Line are generally complete with some exceptions. One of these exceptions is the need for DOE-approved Bases for Interim Operations (BIOs). Also, the DNFSB staff is concerned that the safety documentation may not be complete for the storage of curium solutions in Tank 17.1 in F-Canyon and the storage of Mark 42 scrap in FB-Line due to the significant increases in the source term for these materials relative to what is included in the DOE-approved Safety Analysis Reports for F-Canyon and FB-Line (SARs). The DNFSB staff also has concerns regarding the Unreviewed Safety Question review process as implemented by Westinghouse Savannah River Company (WSRC). The root cause of these concerns is the WSRC site 11Q manual and is thus not limited to the F-area. Other DNFSB staff concerns include the lack of not accounting for the radioactive decay of Pu-241 into Am-241 in the source terms for FB-Line, safety system classification inconsistencies in F-Canyon and FB-Line, and older limited-scope process hazards reviews conducted for both F-Canyon and FB-Line.

Pending review of detailed nuclear criticality safety documentation for FB-Line, the nuclear criticality hazards in FB-Line operations appear to have been addressed and analyzed with adequate safety measures adopted.

3. Background: The primary mission of the F-Canyon facility (Building 221-F) is to recover uranium-238 and plutonium-239 from target materials irradiated in the production reactors. The PUREX process is utilized for the recovery of plutonium and uranium.

Scrap plutonium from FB-Line and from offsite is planned to be processed through the New Special Recovery Facility, which has yet to operate.

To process target slugs from the production reactors, the aluminum cladding is dissolved with a solution of sodium hydroxide and sodium nitrate. The uranium metal core is then dissolved in nitric acid. The clarified uranium solution is then prepared for solvent extraction by adjustment to specific concentrations of uranium and nitric acid and the necessary valence state of plutonium. Separation of plutonium and uranium from fission products is accomplished by multistage, counter-current solvent extraction with tributyl phosphate in n-paraffin kerosene as the solvent. The process includes three cycles: a first cycle for separation of the fission products from the plutonium and the uranium, a second cycle for the separation and the purification of plutonium, and a third cycle for the purification of uranium. The uranium solution is concentrated by evaporation and denitrated to trioxide in the FA-Line. The plutonium nitrate solution is transferred to the FB-Line for further processing.

The FB-Line facility is also located in Building 221-F. The mission of the FB-Line is to produce high purity plutonium metal from plutonium-239 solutions received from F-Canyon. Specific operations in FB-Line include the following: 1) Cation Exchange where dilute plutonium nitrate solution is purified and concentrated to limits suitable for precipitation; 2) Precipitation and Filtration where plutonium nitrate from cation exchange and hydrofluoric acid are combined to form plutonium trifluoride in a first stage precipitator with the product vacuum filtered to form a cake; 3) Mechanical Line which dries the cake, converts it to plutonium tetrafluoride and plutonium dioxide, and finally reduces the mixture to metal; and 4) Recovery where scrap plutonium solids are dissolved and purified by anion exchange prior to transfer to F-Canyon.

The specific materials to be processed in F-Canyon, FA-Line, and FB-Line have not been formally identified by DOE. Potential material that has been identified for processing includes the existing facility in-process solution inventory, Mark 31 target slugs from the production reactors, Taiwan Research Reactor fuel, Experimental Breeder Reactor II blanket and fuel assemblies, Rocky Flats scrub alloy, LANL met-al, and FB-Line scrap including oxide and sand, slag and crucible material.

The first phase operations in F-Canyon will include the second plutonium cycle and dissolvers (including decladding and metal dissolution). The second phase operations include the first cycle solvent extraction, the second uranium cycle, the head end cycle, and the FA-Line. FB-Line operation includes recovery, cation exchange, precipitation, and operation of the mechanical line.

A nuclear criticality accident is considered a credible event in the FB-Line facility with an estimated recurrence frequency of $1.4E-4$ per year. Criticality scenarios that have been considered include process solution and solid accidents, as well as storage vault and miscellaneous accumulation accidents. The dominant accident threats are due to leaks in the solution transfer system and errors in transfers between process vessels.

Extensive Monte Carlo calculations have been performed using the KENO code. Normally, WSRC adds 0.02 to the calculated multiplication factors for safety. However, as a result of benchmarking efforts for solution experiments, WSRC has often found it necessary to add 0.05 or even 0.1 to ensure an adequate safety margin.

4. Discussion: This section details specific DNFSB staff comments related to criticality safety at the FB-line facility and safety analysis documentation at F-Canyon and the FB-Line facility.

- a. Criticality Safety at FB-Line:

1. Administrative and equipment (active and passive) controls are used as nuclear criticality safety controls. One such administrative control is necessary to prevent the inadvertent transfer of highly concentrated plutonium solutions from geometrically favorable tanks to large unfavorable geometry tanks. The solution being transferred must pass through an eductor which dilutes the highly concentrated solutions to below subcritical limits. Prior to transfer of the solutions to the larger tanks, samples are taken and analyzed. Failure to correctly detect the concentration of the solution and thus, use an incorrect eductor ratio, could lead to an unfavorable condition in the large tanks. The DNFSB staff will follow up with a review of the procedure for sampling and relaying the analysis results to the cognizant personnel prior to transferring solutions from geometrically favorable vessels to geometrically unfavorable vessels.

- b. Safety Analysis Documentation: The existing F-Canyon safety analysis report (SAR) was completed in February 1986 and follows guidance which was provided in July 1982 for the now cancelled DOE Order 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations. The FB-Line SAR was completed in April 1988 to the same guidance as the F-Canyon SAR.

The DOE Savannah River Operations Office (DOE-SR) and WSRC currently plan on completing a BIO for F-Canyon prior to restart. A BIO is required by Section 9.b.(2) of DOE Order 5480.23 to specify "restrictions on interim operations, and administrative controls during the upgrade process." For FB-Line, a Justification for Continued Operation (JCO) has been recently revised. DOE-SR is considering revising the JCO and submitting it as a BIO.

With one exception, the DOE Office of Defense Programs (DOE-DP) has approval authority for FB-Line and F-Canyon SARs and Technical Safety Requirements. This exception is for the F-Canyon SAR Addendum 2, for which DOE-SR has approval authority.

There are currently no plans to complete a SAR to the requirements of DOE Order

5480.23, Nuclear Safety Analysis Reports, for either F-Canyon or the FB-Line facility. Per section 7.b.(4).(b) of DOE Order 5480.23, permanent exemptions can be requested by the PSO for hazard Category 2 facilities subsequent to obtaining concurrence of DOE-EH and the Secretary of Energy. Also, temporary exemptions can be granted for any facility for up to one year. The DNFSB staff was informed that DOE-SR plans to request permanent exemption from DOE Order 5480.23 and temporary exemption from DOE Order 5480.22, Technical Safety Requirements. DOE-SR stated that they plan to have TSRs for F-Canyon and FB-Line in a standby condition (subsequent to cleanout) completed in 1994.

1. Both F-Canyon and FB-Line are classified as hazard category 2 facilities per direction from DOE-DP and by use of the facility inventory tables presented in DOE-STD-102792, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports. Thus, the facilities are not categorized based upon an assessment of the consequences of an unmitigated release of the radioactive material inventory in each of the facilities. The DNFSB staff will follow up on this issue via discussions with the DOE Headquarters Office of Environment, Safety and Health (DOE-EH).
2. F-Canyon USQ determination USQ-FCAN-93-182 (Revision 1) evaluates the potential accident consequences related to the long-term storage of americium and curium solutions in Tank 17.1. Review of the F-Canyon SAR shows that this significant source term is unanalyzed in the SAR, including Addendum 2. As part of USQ-FCAN-93-182, the postulated tank spill subsequent to a design basis earthquake results in dose to the maximum off-site individual (MOI) of 98 mrem, which exceeds the bounding F-Canyon SAR MOI dose of 17 mrem (85 mrem for the Recycle Unit Operation divided by 5). The DNFSB believes that a unreviewed safety question exists for this reason per the guidance provided in DOE Order 5480.21, Unreviewed Safety Questions, since the Am-Cm source term results in consequences much greater than those previously evaluated in the SAR.

In the USQ evaluation, WSRC compares the consequences of several postulated accidents to "USQ Acceptance Curves." Since the consequences for these postulated accidents fall below the acceptance curve, WSRC has concluded that a USQ does not exist. The DNFSB staff is concerned since these acceptance curves were not identified as part of the authorization basis documentation for the F-Canyon. The DNFSB staff will follow up with a review of the DOE-SR approval of this WSRC USQ evaluation procedure, which usurps a great deal of the DOE authorization function by providing WSRC with a "wild card" authorization process.

3. The FB-Line source term does not include the Pu-241 daughter Am-241.

DOE and WSRC state that not accounting for Am-241 in-growth is bounded by the "conservative" assumption that the material at risk in FB-Line is at the maximum allowed by Nuclear

Criticality Safety Supplements for weapons-grade plutonium. The DNFSB staff believes that a conservative estimate of the Am-241 inventory should be included in the material at risk for FB-Line or data justifying the current assumption, and DOE approval of it, should be presented. Thus, the DNFSB staff will continue to follow up on this point, as well as for the basis for the revised F-Canyon source term.

4. Safety system classification in FB-Line and F-Canyon is inconsistent. For example, nuclear safety blanks are classified as critical protection equipment in F-Canyon but classified as nuclear safety equipment in FB-Line. The DNFSB staff will review the system classification methodology and requirements for the different classes of systems further, as well as the resulting lists of safety-related systems.
5. One purpose of a JCO is to describe changes to facility equipment which are not reflected in the DOE-approved SAR. However, the FB-Line JCO only broadly discusses configuration management. Changes to the facility (including operations and procedures) which impact the accident analyses or the functionality of safety-related equipment should be documented and assessed. The DNFSB staff believes that the BIO is an opportunity for such an assessment, for both FB-Line and F-Canyon, and will review the BIOs for these attributes when the BIOs are completed.
6. The F-Canyon and FB-Line use a similar approach as the HB-Line SAR where accidents are classified into one of four categories: high, medium, or low energetic events and residual release events. This leads to the ready application of release fractions as specified in DuPont Letter DPST-82-789, Guides for Estimating Consequences in the 200 Area Systems and Safety Analysis. The DNFSB staff believes that additional justification should be provided for use of these release fractions.
7. For both F-Canyon and FB-Line, WSRC is creating and training operations personnel on a control procedure which contains the following information for each safety-related system: selection criteria, intended design function, operability definitions, required actions, and functional testing requirements. A linking document was also created for F-Canyon which confirmed that all applicable Operation! Safety Requirements and Technical Standard limits are implemented in procedures. However, there is no program to periodically update this linking document. The DNFSB staff will follow up on both the content and training of operations personnel on the control procedures.

8. The draft DP standard provides toxicological accident acceptance criteria. The DNFSB staff were not aware of evaluations of toxicological hazards to the MOI. The DNFSB staff will review the BIOs for toxicological evaluations.
 9. The DNFSB staff reviewed several Process Hazards Reviews (PHRs) conducted for the FB-Line and F-Canyon. It was obvious that several of the PHRs which were performed in the early 1980s were of very limited scope relative to the quality of PHRs performed today. The DNFSB staff is concerned that many of the PHRs for FB-Line and F-Canyon are of this vintage and in addition to depth, they may not necessarily reflect today's system configuration. In addition, the PHRs noted that they must be performed at least every five years. This was not the case. The DNFSB staff will follow up further on additional reviews of PHRs and DOE plans for upgrading them.
5. Future Staff Actions: The DNFSB staff plans to continue efforts in at least the areas noted above related to the safety analyses documentation for F-Canyon and the FB-Line facilities and for criticality safety at the FB-Line.