Maximum Credible Uranium-235 Release from 211-H to the ETF

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INTER-OFFICE MEMORANDUM

SAVANNAH RIVER PLANT

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TO: E. W. MANCI, 703-H

FROM: T. G. CAMPBELL, 221-H

MAXIMUM CREDIBLE URANIUM-235 RELEASE FROM 211-H TO THE ETF

Introduction and Summary

The Effluent Treatment Facility (ETF) criticality review identifies two potential scenarios for criticality:

- o An instantaneous release of a significant quantity of fissile material from a process upset.
- o A gradual accumulation of fissile material in process vessels.¹

The potential for an instantaneous release from 211-H will be eliminated by the installation of a nuclear safety blank as recommended in the criticality review.

With the nuclear safety blank installed, the only mechanism for introducing a gradual accumulation of uranium to the ETF from 211-H will be via Acid Recovery Unit (ARU) and General Purpose (GP) evaporator overheads. This study has determined that the maximum credible annual release of uranium-235 to the ETF from these sources is 106 grams.

Discussion

Basis

To perform this study the following assumptions were made:

- o Annual H-Canyon production of 10,000 kg uranium.
- o Nuclear Safety blank installed as recommended by ETF criticality review. (Only ARU and GP overheads transferred to the ETF from 211-H.)

- o Evaporator decontamination factor (DF) for uranium of 10^4 . (U DF reported in DP-500 for batch evaporators is 10^6 . GP evaporator DF for nonvolatiles reported as 10^5 .)²
- o ARU uranium DF of 10^4 .

ARU

The ARU (Figure 1) is a ten tray distillation column that recovers 50% nitric acid from H-Canyon evaporator overheads. The ARU overheads, at a pH of 2-3, are sampled for alpha and beta-gamma activity and then transferred to the seepage basin (ETF), if within limits. Supplying overheads to the ARU are the 1CU evaporator, head end and high activity waste (HAW) evaporators, low activity waste (LAW) evaporators, the 2BP evaporator, and the rerun evaporator. Any uranium entering the ARU system must be contained in these overhead streams. The 1CU evaporator concentrates the uranium product stream from first cycle and has the highest potential to produce overheads containing uranium. The rerun evaporator concentrates sump solutions which often contain uranium. The LAW evaporators concentrate large volumes of solvent extraction waste solution, which contain low levels of uranium. HAW evaporation is a two stage process in which the overheads from the first stage are evaporated again to improve decontamination. The 2BP evaporator concentrates second neptunium cycle product which contains essentially no uranium.

1CU Evaporator

The 1CU evaporator concentrates the uranium product stream from first cycle to about 6 gU/l; a typical batch contains about 15 kg of total uranium. For 10,000 kg U annual production, 667 1CU evaporator batches are required. Assuming a U DF of 10^4 in the evaporator, the U concentration in the overheads would be 0.0006 gU/l. Since a typical 1CU evaporator batch produces 1211 liters of overheads³, the total amount of uranium sent to the ARU per year from the 1CU evaporator is 485 grams.

LAW Evaporators

The LAW evaporators process waste streams from second Np cycle and second U cycle, as well as other miscellaneous low level wastes such as decontamination waste and HB-Line waste. These wastes normally contain only trace quantities of uranium; however, for the purposes of this study, the evaporators were assumed to always contain the maximum amount of uranium that can be discarded to waste (50 grams). According to the HM process flowsheet³, the LAW evaporators produce about 2050 liters of overheads per kg of uranium processed, or 2.05E7 liters annually for 10,000 kg U production. Assuming an average evaporator volume of 3600 liters and a U DF of 10^4 , the overheads U concentration would be 1.4E-6 gU/l. The total amount of uranium annually in the overheads would be 30 grams.

Rerun Evaporator

The rerun evaporator concentrates H-Canyon sump solutions containing recoverable amounts of uranium. Typical sump solution batches contain about 1750 liters and the maximum number of sump batches expected per month is 20. If all of these batches are assumed to contain recoverable amounts of uranium, the total volume evaporated per year is 420,000 liters. Making the conservative assumption that the evaporator always contains 5 gU/l, the overheads would contain 0.0005 gU/l. Assuming 400,000 liters of overheads are produced, the total amount of uranium contained annually in the rerun overheads is 200 grams.

Head End and HAW Evaporators

The head end evaporator concentrates dissolver solution to prepare feed for first cycle. The uranium concentration in the head end evaporator is about 6 gU/l and the amount of uranium in the overheads should be similar to that found in the 1CU overheads. However, the head end evaporator overheads are reevaporated in the HAW second stage evaporator for further DF. The HAW evaporators process the waste from the first cycle of solvent extraction. Because of the two stages of evaporation, no uranium is assumed to be in the overheads sent to the ARU from the HAW system, which includes the head end evaporator overheads.

ARU Summary

As discussed above, the calculated annual uranium input to the ARU is as follows:

<u>Source</u>	<u>Uranium, g</u>
1CU Evaporator	485
LAW Evaporators	30
Rerun Evaporator	<u>200</u>
Total	715

Assuming a U DF in the ARU of 10^4 , the amount of total uranium expected to be contained annually in the ARU overheads is 0.07 grams.

General Purpose Evaporator

The GP evaporator (Figure 2) receives wastes from 211-H basins and aprons, canyon floor drains, cold feed and third level tank drains, hot and warm gang valve corridor catch tanks, and target cleaning solution and deionizer regeneration solution from RBOF. These wastes are neutralized to a pH of 8 or greater and then fed continuously to the GP evaporator until the evaporator bottoms reach a density endpoint. The concentrated bottoms are then transferred to a concentrate hold tank, sampled, pH adjusted if necessary, and then transferred to the waste tank farm. The GP overheads, usually pH 9 or greater, are sampled for alpha and beta-gamma and then sent to seepage (ETF), if within specifications.

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Before the GP evaporator feed is neutralized, it is sampled for acid and uranium. There is a nuclear safety control that requires the acidity to be greater than 0.01N to assure representative uranium analyses. If the acidity is low, acid is added until the minimum acid limit is met. Another nuclear safety control requires the GP evaporator system to be flushed with acid after a total of 700 grams of U-235 have been fed to the system. There is also a nuclear safety control which limits the amount of U-235 that can be fed to any individual batch to 250 grams.

Accountability records show that from 1981 to 1987 the average amount of uranium processed through the GP evaporator system each year was 1067 grams. The highest yearly total was 1983 when 2116 grams were processed. Using this historical data and assuming a uranium DF of 10^4 , less than one gram of uranium per year would be expected in GP evaporator overheads. However, for this study, the following conservative assumptions are made:

- o Evaporator contains NSC max 250 grams U-235 at all times.
- o Feed 16 hours per day, allow 8 hours for sample analyses.
- o Operate 292 days per year (80% of the time).
- o Feed rate of 5000 lbs/hour.
- o Operating volume of 2500 liters.

Using these assumptions, the GP evaporator will produce about $1.06E7$ liters of overheads per year with a uranium concentration of 0.00001 g/l. This gives a total of 106 grams of U-235 released to the ETF each year.

Evaporator Upsets

Operating upsets, which reduce the evaporator DF by causing excessive entrainment of nonvolatiles, are uncommon but do occasionally occur during evaporator operations. Canyon batch evaporators are equipped with column differential pressure (DP) instruments which easily detect these upsets. In addition, the evaporator steam supply is interlocked off if a high column DP is detected. Batch evaporators are also equipped with three bubble cap deentrainment trays which minimize the effects of minor upsets. All evaporator overheads are sampled and are recycled if analyses indicate an upset resulting in poor DF.

Severe upsets (burps) can result in some portion of the evaporator contents being expelled into the condensed overheads. Burps have the greatest tendency to occur in the head end evaporator and the low activity waste evaporators. The material processed in these evaporators has a tendency to foam, which is often the cause of burps. Operating experience indicates that a frequency of one evaporator burp per year per evaporator is conservative. The observed frequency of burps in some evaporators (1CU and second stage HAW) is much less. No more than 5 to 6% of an evaporator's contents has been observed to be

expelled during a severe burp. For the 1CU evaporator, which typically contains about 15 kg uranium, 1500 grams of uranium would result in the overheads, assuming a conservative 10% of the evaporator contents were expelled during a burp. In the unlikely event that the burp is undetected by either instrumentation or sample analysis, and is transferred to the ARU, only 0.15 grams of uranium would result in the ARU overheads, assuming an ARU DF of 10^4 . Based on this evaluation, the effect of canyon batch evaporator upsets on releases of uranium to the ETF is considered to be insignificant.

The ARU and GP evaporators have no history of upsets or burps that could reduce the DF of nonvolatiles such as uranium. The ARU is a ten bubble cap tray distillation column and it is very unlikely that an upset could occur that would result in an excessive amount of uranium in the overheads. The GP evaporator is very different from the canyon batch evaporators. Canyon batch evaporators are heated by steam coils in the evaporator pot. The GP evaporator has no coils; the feed is continuously pumped through a preheater and into the evaporator where it flashes into vapor and bottoms. The bottoms are continuously recycled through the preheater and back to the evaporator until the endpoint density is reached. The evaporator is operated under vacuum (200 mmHg) and has four bubble cap trays for deentrainment. Since the evaporator feed is heated externally, there is really no mechanism to produce the types of upsets or burps sometimes seen in canyon batch evaporators.

Conclusions

This study indicates a maximum credible release to the ETF from the 211-H facility of 106 grams of U-235, essentially all from the GP evaporator. The assumption that the GP evaporator contains 250 grams U-235 at all times is highly conservative and does not in any way represent current (normal) operation. This "worst case" assumption results in a calculated maximum credible release that is more than 100 times that expected from normal operation.

As stated in the ETF criticality review, historically 34 grams of U-235 has been released to the seepage basin annually. Eliminating the conservatism used in assumptions for the GP evaporator, this study predicts annual releases of less than 1 gram of U-235 from ARU and GP evaporator overheads. This apparent discrepancy is due to the changes, which are the basis for this study, that will be made in 211-H before ETF startup. A nuclear safety blank will be installed in 211-H that eliminates the transfer of basins and tank aprons directly to the ETF. All of this material, which could contain some uranium, will be evaporated in the GP evaporator, and only the overheads released to the ETF. The majority of the uranium released to the seepage basin in the past probably came from these basins and tank aprons that were sent directly to seepage without evaporation.

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/tgc
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CAPACITIES ARE WORKING VOLUMES
IN LBS H₂O (SP GR = 1.0)

FIGURE 1. ACID RECOVERY UNIT

[NOTE: CAPACITIES ARE WORKING VOLUMES IN LBS H₂O (sp gr 1.0)]

FIGURE 2. GP EVAPORATOR