ABB

April 17, 1997

Docket No. 70-36
License No. SNM-33

Mr. Michael F. Weber, Chief
Licensing Branch
Division of Fuel Cycle Safety and Safeguards
U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Subject: **REVISION OF LICENSE SNM-33, CHAPTER 4, NUCLEAR CRITICALITY SAFETY**

Dear Mr. Weber:

Enclosed is a revised Chapter 4, Nuclear Criticality Safety, to License SNM-33 per our commitment in the Criticality Safety Program Update (CSPU) Plan dated September 20, 1996. This program was undertaken to formalize and strengthen our criticality safety program, taking into account recognized industry standards. Chapter 4 has been revised to include changes and improvements that have been identified to date by the CSPU. This submission constitutes a complete replacement for Chapter 4. Clarifying changes to license conditions have been made, as well as editorial changes and corrections. Descriptive text which did not belong in Part I of the license has been removed.

Also enclosed is a description of significant changes. Six copies of this document are provided for your use.

Please contact me, or Mr. Hal Eskridge of my staff, if there are any questions.

Cordially yours,

COMBUSTION ENGINEERING, INC.

Robert W. Sharkey
Director, Regulatory Affairs

RA565

cc: Sean Soong

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Enclosure 1 to RA565
April 17, 1997

COMBUSTION ENGINEERING, INC.
HEMATITE NUCLEAR FUEL MANUFACTURING FACILITY
LIST OF AFFECTED PAGES

Combustion Engineering is submitting a revised Chapter 4, Nuclear Criticality Safety, to Part I of the SNM-33 license application per our commitment in the Criticality Safety Program Update Plan dated September 20, 1996. This program was undertaken to formalize and strengthen our criticality safety program, and this revision to Chapter 4 is a key element in meeting the CSPU objectives. This submission constitutes a complete replacement for Chapter 4. Since we are submitting the revised Chapter 4 in its entirety, we have designated this edition as "revision 2" with a common date for all pages. The pages of the license application affected are as follows:

List of Affected Pages

Delete Page			Add Page		
Page No.	Rev.	Date	Page No.	Rev.	Date
4-1 and 4-2	0	1/28/94	4-1 through 4-23	2	4/17/97
4-3	0	6/14/94			
4-4 through 4-6	0	1/28/94			
4-7 through 4-10a	0	4/20/94			
4-11 through 4-17	0	1/28/94			
4-18	1	12/15/95			
4-19	0	1/28/95			
4-20 through 4-23a	0	4/20/94			
4-24 through 4-26	0	1/28/94			
4-27	1	12/15/95			
4-28	0	4/20/94			

Enclosure 2 to RA565
April 17, 1997

COMBUSTION ENGINEERING, INC.
LICENSE NO. SNM-33, CHAPTER 4, NUCLEAR CRITICALITY SAFETY
DESCRIPTION OF CHANGES

As stated above, this revision to Chapter 4 is a key element in meeting the CSPU objectives. It is necessary to clearly state the license conditions upon which the Criticality Safety program is based, in order to generate administrative procedures for the program, and to avoid confusion that could result from conditions that are open to interpretation. The intent of this revision is to clarify the license conditions, while removing extraneous descriptive material. Therefore, clarifying changes to license conditions have been made, as well as editorial changes and corrections. Descriptive text which did not belong in Part I of the license has been removed. The chapter has also been reformatted and repaginated. Due to the extensiveness of the changes, it is not practical to denote each change by a vertical line in the right hand margin, so we are separately providing a copy with the new text shown in blue and the deleted text shown with a strikethrough in red to assist in your review. A description of significant changes, with a justification where appropriate, follows:

Introduction:

The introduction was reworded to better define the objective of chapter 4.

Section 4.1

Section 4.1.1 — Standard wording consistent with ANSI/ANI 8.1 is used for the double contingency principle. The existing requirement in the next sentence -that exceptions be specifically approved- leaves this requirement unchanged.

Section 4.1.2 — Minor editorial changes were made.

Section 4.1.3 — The title of Manager, Regulatory Compliance has been updated to Director, Regulatory Affairs. This is a titular change only: no changes have been made in responsibilities. The section referred to for record retention requirements has been corrected.

Section 4.1.4 — The description of the types of procedures has been removed. The requirement has been strengthened to require approved, written procedures. Active controls which require inspection, calibration or functional testing have been differentiated from administrative controls and passive barriers which do not.

Section 4.1.5 — The requirement that Production and line Supervisors shall monitor the day-to-day conformance of individual workers to the posted limits and controls has been removed because of the equivalent statement in Section 4.1.3. The requirement to maintain a log of postings has been removed, as this is an administrative detail which does not belong in Part I.

Section 4.1.6 — Shipping containers having a valid Certificate of Compliance were explicitly excluded from the requirements in this section. The requirements of the C of C will have precedence. The prohibition against intermixing empty and loaded containers (of any type) has been removed. The requirement that empty containers be uncovered, i.e. easily verifiable as empty, or properly labeled as empty is sufficient to distinguish them from loaded containers.

Section 4.1.7 — Minor editorial changes were made.

Section 4.1.8 — Minor editorial changes were made.

Section 4.2

Section 4.2.1

Section 4.2.1.1 — This paragraph was restructured and language added to clarify the definition of a safe individual unit (SIU).

Section 4.2.1.2 — Minor editorial changes were made. The section was changed to allow credit for favorable geometry of precipitated material in concentration controlled subcrits.

Section 4.2.1.3 — Minor editorial changes were made. Paragraph 4.2.1.3(e) has had the absolute requirement to periodically verify the presence of the parasitic additive replaced by the requirement to address this question as part of the criticality safety evaluation. A similar change has been made to 4.2.1.3(f) with regard to structural integrity. The requirement for a two-sigma calculational uncertainty in Paragraph 4.2.1.3(d) has been removed. It is implicitly included as part of the "applicable uncertainties and biases". The amount of calculational uncertainty required is best addressed as part of the validation report for the methodology in use and the criticality calculation itself, both of which have specific requirements in this and other sections within Chapter 4. The option to demonstrate an acceptable margin of subcriticality by comparison to existing calculations or critical experiments has been added to Paragraph 4.2.1.3(d). One of the CSPU objectives is to prepare documentation for plant sub-systems so the margin of subcriticality after modifications or process upsets may be established quickly and efficiently by comparison to the existing basis. "Abnormal credible" has been changed to "credible abnormal" for better linguistic flow. Paragraph 4.3.1.3(l) has been reworded and split into paragraphs l and m, addressing geometry and reflection separately to improve clarity.

Section 4.2.2

Minor editorial changes were made.

Section 4.2.2.1 Paragraph 4.2.2.1(i) has had the applicability of the limits for pellet scrap reworded for clarity. Paragraph 4.2.4(s) has been moved to 4.2.2.1(k) and reworded for clarity.

Section 4.2.3

Section 4.2.3.1 Minor editorial changes were made. The combination 35 kg / 5 gallon container limit has been removed because it is not used at this site. It has been replaced by areal density limits which are currently in use.

Section 4.2.3.2 The detailed description of calculational models has been removed. This material properly belongs in the validation report required by this Section. A broad database of critical experiments pertinent to the various systems and operations at this fuel facility has been established and may be extended as additional information becomes available or as the need develops. Since methods evaluation is an evolving process, documentation of results should be kept independently of the license. The requirement to specify the analytical method(s) used for criticality safety analyses and the source of validation of the methods is required by Section 4.2.3.3(b). Minor editorial changes were also made.

Section 4.2.3.3 Minor editorial changes were made.

Section 4.2.4

Paragraph 4.2.4(n) The limit of four pounds of (intermixed) moderator per shelf has been removed. The four pound limit is the result of a calculation of limiting accident conditions and is not used as a operational limit. The operational limit is more restrictive than four pounds of moderator per shelf.

Paragraph 4.2.4(p) The moderator limits in and around each rod box storage matrix location have been removed. These limits are the result of a calculation of limiting accident conditions and are not used as operational limits. The operational limits on moderation are more restrictive than 20 pounds per location and 5 pounds in the fuel rod array. The dimensions used in the analysis of the rod box storage matrix have been removed. These dimensions are in the analysis package. Requirements exist to obtain approval prior to modifying equipment in general and to report any deformation of this unit specifically.

Paragraph 4.2.4(q) The dimensions used in the analysis of the fuel assembly storage area have been removed. These dimensions are in the analysis package. Requirements exist to obtain approval prior to modifying equipment in general and to report deformation of this unit specifically.

Paragraph 4.2.4(r) The rod arrays that are within the approved envelope have been specified. Note that the number of fuel rods in the fuel assembly may be less than the total number of available rod locations, e.g. the 16 x 16 array may contain less than 256 fuel rods.

Paragraph 4.2.4(s) Paragraph 4.2.4(s) has been moved to 4.2.2.1(k) and reworded for clarity. The lettering of paragraphs (t) through (w) has been adjusted to (s) through (v).

Paragraph 4.2.4(t) Now paragraph 4.2.4(s), this has been strengthened by explicitly requiring 12 feet separation between 927 arrays and other types of loaded fuel shipping containers.

Paragraph 4.2.4(u) Now paragraph 4.2.4(t), the specificity of the type of level detector has been removed.

Section 4.2.5

Minor editorial changes were made.

Table 4-1

Parts A and B placed on separate pages

CHAPTER 4 NUCLEAR CRITICALITY SAFETY

The administrative conditions and technical criteria in this chapter provide protection against an unplanned nuclear chain reaction (criticality). These conditions and criteria are applicable where fissile materials are to be stored, handled, or processed, and where the quantities of such fissile materials may create a potential nuclear criticality hazard.

Administrative conditions define:

(a) the design philosophy used in the definition of processes involving the handling and storage of special nuclear materials (SNM),

(b) the lines of responsibility for ensuring criticality safety aspects of the process are reviewed, documented, and approved by management, and

(c) the written procedures and postings governing the processes for handling and storage of SNM.

Technical criteria provide the bases for:

(a) limits and controls used in the processing, handling, and storage of SNM,

(b) criticality evaluations, and

(c) engineered process controls.

4.1 Administrative Conditions

4.1.1 Process Design Philosophy

The process design philosophy used by Combustion Engineering, Inc. to ensure nuclear criticality safety is based on the following key elements:

(a) Process design, with respect to the handling and storage of SNM, should, in general, incorporate sufficient factors of safety such that at least two unlikely, independent, and concurrent changes in process conditions are required before a criticality accident can occur. Process design which does not meet these double contingency criteria shall be explicitly approved in Chapter 1, Section 1.6, of this application.

(b) Physical controls, e.g., favorable geometry and permanently engineered controls shall be the preferred method of criticality control, to reduce dependence on administrative procedures. In some processes, types of control other than favorable geometry, e.g., moderation, concentration, and/or neutron absorbers may be used to achieve adequate process throughput. In these cases, controlled parameters and their limits shall be clearly specified, approved by management as part of the review and approval of operating procedures, and communicated to affected personnel through postings, operating procedures, or training.

(c) Before a new operation with SNM is begun or an existing operation is changed, it shall be determined that the entire process will be subcritical under normal and operating conditions, consistent with paragraph a) of this section and applicable technical criteria of Section 4.2.1.3.

4.1.2 Positions Responsible for Criticality Safety

Section 2.1 describes the responsibilities and authority for key organizational positions affecting safety. Section 2.2 specifies the professional requirements for these positions.

4.1.3 Documenting Criticality Evaluations and Reviews

Criticality evaluations associated with facility changes affecting the handling and storage of SNM in Nuclear Manufacturing shall be documented by a nuclear criticality specialist and independently reviewed.

The criticality evaluations shall consider potential scenarios which could lead to criticality and barriers erected against criticality in establishing applicable criticality limits and controls.

These limits and controls shall be incorporated into applicable written procedures and/or postings. Postings shall be approved by a qualified Nuclear Criticality Specialist. Procedures shall be approved by the Director, Regulatory Affairs. Day-to-day monitoring of workers for conformance to criticality limits and controls and administrative procedures shall be carried out by line supervision and health physics technicians. Documentation of the criticality evaluations shall be sufficiently detailed such that an independent reviewer can reconstruct the analysis and bases for the conditions presented. Criticality evaluations shall include assumptions affecting criticality safety process limits and controls. If explicit analyses using validated methodologies are used, the margin to criticality and a clear definition of off-nominal conditions shall be provided.

Criticality evaluations shall include a documented review by a qualified reviewer.

Records of the criticality evaluation and review shall be maintained according to the requirements of Section 2.10 of this license.

4.1.4 Written Procedures

Operations involving the handling and storage of SNM shall be performed according to approved, written procedures.

Operations which include active engineered controls shall have procedures which specify the inspection requirements, the calibration or functional test requirements, or other requirements appropriate for maintaining the active controls. Administrative controls and passive barriers which are relied upon for criticality safety shall be described in appropriate procedures.

4.1.5 Posting of Limits and Controls

Work and storage areas where SNM is handled, processed, or stored shall be posted with the nuclear safety limits and controls applicable to each area. The postings shall be approved by a Nuclear Criticality Specialist.

4.1.6 Labeling of Special Nuclear Material

Mass-limited containers, with the exception of shipping packages having a valid Certificate of Compliance, used in the transport, handling, or storage of special nuclear material shall be labeled with the amount, enrichment, and type of SNM contained. Empty containers shall be labeled accordingly or placed in designated areas. Uncovered empty containers do not require an empty sign.

4.1.7 Preoperational Testing and Inspection

Preoperational testing and inspection shall be performed as described in Chapter 2, Section 2.7.

4.1.8 Criticality Safety Design

New processes or changes in existing processes affecting the handling and storage of special nuclear material shall be evaluated for nuclear criticality safety. Internal procedures shall specify appropriate criticality safety reviews and evaluations for facility changes affecting the handling and storage of SNM.

4.2 Technical Criteria

4.2.1 Individual Units

4.2.1.1 Safe Individual Units (SIU)

When based on experimental data, an SIU is defined as an individual, isolated subcritical unit of fully reflected, optimally moderated SNM whose characteristic mass or geometric parameter is reduced by the applicable safety factor: Mass - 2.3, Volume - 1.3, Slab Thickness - 1.2, Cylinder Diameter - 1.1. For SIUs determined from calculated data, the calculations shall be performed using validated computer analysis methods and the subcritical (safe) limit values calculated consistent with paragraph 4.2.3.3 (a). A conservative process density shall be used.

The resulting units of SNM are Safe Individual Units when isolated from other units by distance or shielding (see Section 4.2.2).

4.2.1.2 Subcritical Units (Subcrits)

Subcritical units other than SIUs may use multiparameter controls such as mass, concentration, volume, moderation, etc., to achieve criticality safety. The configuration and composition of these subcritical units may depend upon the process involved and may include allowed individual SNM unit geometries which are less conservative than favorable geometry or defined configurations of individual SNM units in a given process layout.

Uranium concentration control safe units shall be limited to a maximum of 25 grams of uranium per liter. The effect of evaporation and/or precipitation shall be considered in the nuclear safety analysis, such that, if precipitated, a safe mass or favorable geometry will not be exceeded. Concentration controlled safe units shall not be considered to contribute to interacting arrays, but shall be located outside exclusion areas assigned by the surface density method.

4.2.1.3 Criteria

(a) The possibility of the unintended accumulation of fissile materials in not readily accessible locations shall be minimized through equipment design or administrative controls or included in the nuclear safety evaluation of the process.

(b) Nuclear safety evaluations shall include credible sources of internal moderation.

(c) Criticality safety evaluations shall consider the neutron reflection properties of the environment as well as the heterogeneity of the fissile material within the subcrit on the effective multiplication factor. A conservative process density shall be used.

(d) Nuclear criticality safety evaluations shall include consideration of credible accident conditions consistent with the double contingency principle. Safety factors for SIUs are defined in 4.2.1.1. For subcrits defined in 4.2.1.2, the highest effective multiplication factor, under normal or credible abnormal operating conditions, shall be less than 0.95 including applicable uncertainties and biases. An acceptable margin of subcriticality may be demonstrated using validated calculational methods or by comparison to existing calculations or critical experiments.

(e) Reactivity hold-down by other than fixed neutron absorbers shall not be used in criticality evaluations. Explicit analyses of the effect of structural or fixed neutron absorbers shall use validated methodologies. The criticality safety evaluation shall consider the possibility of depletion of the parasitic isotope(s) in structural or fixed neutron absorbers. Borosilicate-glass raschig rings may be used in solutions of fissile material in a manner consistent with ANSI/ANS 8.5-1986.

(f) Whenever nuclear criticality safety is directly dependent on the integrity of a fixture, container, storage rack or other structure, design shall include consideration of structural integrity.

(g) Computer analysis methods shall be validated in accordance with the criteria of Section 4.2.3.2 and Regulatory Guide 3.4, Revision 2, dated March 1986, "Nuclear Criticality Safety in Operations with Fissionable Materials at Fuels and Materials Facilities". The highest effective multiplication factor derived by the validated analytical methods for credible operating conditions shall be less than or equal to 0.95 including applicable biases and calculational uncertainties.

(h) The analytical method(s) used for the safety evaluation of SIUs and the source of validation of the methods shall be specified.

(i) Mass control shall be administered using a calibrated mass measurement instrument.

(j) Volume control shall be administered by the following methods: 1) geometric devices to restrict the volume; or 2) engineered devices or instrumentation to limit the accumulation of SNM.

(k) Moderation control shall be administered by the following methods to restrict or measure moderation: 1) instrumentation; 2) physical structure; or 3) a sampling program.

(l) When geometry is used as a criticality safety control, the evaluation shall consider the effect of credible bulging or other deformation on criticality safety.

(m) When less than full neutron reflection is used as a criticality safety control, the evaluation shall consider the effect of credible upset conditions leading to an increase in reflection on criticality safety.

4.2.2 Multiple Units and Arrays

Criticality safety may be based on the use of limiting parameters which are applied to simple geometries. This approach uses safe units which assume optimum moderation and full reflection using published criticality data. Safe units may be arrayed using the surface density method. An alternate empirical method is the Solid Angle Method.

A more rigorous method is based on two dimensional transport and/or three dimensional Monte Carlo methods. These methods permit the evaluation of more complex geometric configurations of SNM and the evaluation of multiparameter control methods.

4.2.2.1 Spacing of Safe Units

The following criteria shall be used:

(a) Application of the surface density method of spacing safe mass, volume, or cylinder diameter limited units requires meeting the following criteria:

  (1) Safe mass, volume, or cylinder diameter limited units shall meet the maximum values defined in Table 4-1, Part A.

  (2) The spacing areas for the safe mass, volume, or cylinder diameter limited units of Table 4-1, Part A shall use spacing areas no less than those defined in Table 4-3. Safe units shall use a minimum spacing between units of twelve inches. Coplanar slabs specified in Table 4-1 require no additional spacing; non-coplanar slabs require a minimum spacing of twelve inches.

  (3) Each safe unit shall be approximately centered in its respective spacing area.

(b) When the above criteria for the surface density model cannot be met, the spacing may be established by the solid angle method of TID-7016 (Rev. 2) providing that the applicable criteria on subcriticality of the primary unit and subtended solid angle of interacting units are met.

(c) Nuclear safety shall be independent of the degree of moderation between units up to the maximum credible mist density. The maximum mist density will be determined by studying sources of water in the vicinity of the single units or arrays. The maximum mist density may be limited by design and/or by administrative controls.

(d) Safety margins for individual units and arrays shall be based on accident conditions such as flooding, multiple batching, and fire.

(e) Optimum conditions (limiting case) of water moderation and heterogeneity credible for the system shall be determined in applicable calculations.

(f) The water content will be verified to be less than 1.0 w/o in powder storage cans which are arranged in two layers on rollers conveyors.

(g) Vessels and other items of equipment requiring exclusion areas shall have the limits of these areas clearly marked on the floor. Safe units in transit shall not be permitted to enter an exclusion area unless a criticality safety evaluation has been performed for such transit.

(h) The analytical method(s) used for the safety evaluation of the spacing of safe units and the source of validation of the methods shall be specified.

(i) Part B of Table 4-1 summarizes safe limits for pellets, pellet scrap, and Zircaloy clad pellet columns. For the purposes of this license, sintered pellet diameters may range from 0.32 to 0.40 inches. The limits for pellet scrap may be applied to any pellet diameters less than or equal to 0.40 inches. The safe mass limit for pellet scrap is based on the most reactive pellet diameter (0.10"). Randomly stacked pellets are defined as having a volume averaged density of 5.804 ± 0.147 g/cc. The average void to UO2 volume ratio for randomly stacked pellets is 0.79965 ± 0.04495. Loosely packed rods are defined as rods of a given diameter stacked on square or triangular pitches having an average gap between rods of up to 6 percent or up to 14 percent, respectively, of the clad outer diameter. This definition is applicable to clad pellet columns containing UO_2 pellets having diameters in the range of 0.3224 to 0.40 inches.

(j) The safe mass limits of Table 4-1, Part B, include the double batching allowance. This allowance may be eliminated for operations where double batching is not credible.

(k) Loaded shipping containers may be stored in an array size not exceeding a total transportation index (TI) of one hundred. Container types may be mixed and the array may contain 927s.

4.2.3 Technical Data and Validation of Calculational Methods

4.2.3.1 Technical Data

Safe unit limits which meet the subcriticality criteria for spacing by the surface density method are listed in Table 4-1, Part A. Minimum spacing criteria are as listed in Table 4-3.

Mass limited units may be stacked on a vertical centerline with at least a 10 inch separation.

Table 4-2 provides safe limits for aqueous solutions with enrichments up to 5 w/o ^{235}U. The uranyl fluoride data may be used for UO_4.

Well distributed SNM may be stored based on areal density. Homogeneous material may be stored with a maximum areal density of 5.2 g UO_2 (five weight percent) per square foot or 229 g $^{235}U/ft^2$. Heterogeneous material may be stored with a maximum areal density of 4.9 g UO_2 (five weight percent) per square foot or 216 g $^{235}U/ft^2$. No spacing is required.

4.2.3.2 Validation of Calculational Methods

Criticality safety evaluations for SNM process/storage systems using computerized methodologies such as transport and Monte Carlo codes shall use validated models. These models shall be validated by analysis of pertinent critical or subcritical experiments to define the range of applicability of the model and associated bias in calculated eigenvalues. The validation analyses for each model shall be documented consistent with ANSI/ANS-8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," independently reviewed, and retained according to the requirements of Section 2.10 of this license.

Computer codes used in validated calculational models shall be subjected to formal configuration control procedures. These procedures shall provide a defense against unauthorized changes to the algorithms in the codes. If authorized changes to the codes are made, the procedures shall require appropriate testing to verify the mathematical operations are performed as intended.

4.2.3.3 Other Criteria

(a) For validated computer analysis methods, the highest effective multiplication factor for normal or credible abnormal operating conditions shall be less than or equal to 0.95 including applicable biases and calculational uncertainties.

(b) The analytical method(s) used for criticality safety analyses and the source of validation of the methods shall be specified.

4.2.4 Special Controls

The following technical criteria shall be used.

(a) Process areas containing fissile materials will not have fire sprinkler systems. Water hoses shall not be used to fight fires in the Oxide Building, and in Building Nos. 253, 254, 255, 256-1, and 230 (with the exception of the warehouse area).

(b) The hygrometers on the plant air to the Receivers in the Oxide Building and to the micronizers and blenders in Buildings 254 and 255 will be set to alarm at a dew point no higher than 0 °C and checked on a 6 month interval. The hygrometers on the cooler hopper at the exit of the screw cooler in the oxide building will be set to alarm at a dew point no higher than 15 °C and checked on a 6 month period. Upon alarm, automatic or manual action stops the process. The source of alarm must be investigated and the problem corrected before the process can be continued.

(c) The R-2 and R-3 steam lines will have two (redundant) fail-safe shut-off valves, each activated by two independent high and low temperature alarm setpoints on the R-2 and R-3 reactors. The operability of this system will be ascertained at least once every 6 months.

(d) The moisture content of the UO_2 powder transferred into the bulk storage hoppers and the recycle storage hoppers will be verified as being less than or equal to one weight percent. The instruments used for measuring moisture in UO_2 shall be calibrated on a 6 month interval. Loading and unloading of hoppers shall be done with hoods that prevent water ingress.

(e) The R-1, R-2 and R-3 inlet pressure switches will be tested at least once every 6 months.

(f) Dual, independent verifications of moisture content in UO_2 shall be made prior to transfer of material into the bulk storage hoppers or into the blenders in Buildings 254 or 255.

(g) Moderation controlled containers shall be covered such that no moderator can enter the container when external to protective hoods.

(h) The number of 5 gallon or less containers allowed on the second and third floors of Building 254 shall be limited as follows: lubricant and/or poreformer, 12 on each floor; UO_2 powder, 24 spaced on 2 foot centers on each floor. Additionally, the second and third floors of Building 254 shall be limited on each floor to a maximum of 10 gallons total of water, cleaning solutions, paints and powder moderators (exclusive of lubricant and poreformer) when the poreformer or lubricant mixing operations have material in process.

(i) UO_2 powder charges added to each poreformer mixer in Building 254 shall not exceed 4.4 kg ^{235}U.

(j) Fissile aqueous solution transfers from favorable to unfavorable geometry vessels in the wet recovery system shall have at least two independent methods for control of the fissile content of the solution prior to release of the solution to the unfavorable geometry vessel; solution transfers shall be limited such that the unsafe vessels never contain more than a fraction of the calculated critical mass. Physical barriers in piping systems shall exist to prevent the inadvertent transfer of fissile aqueous solutions to unfavorable geometry vessels.

(k) Process systems shall be designed to minimize the likelihood for the unanalyzed accumulation of fissile material within the system. In addition, process procedures shall have provisions for verifying that fissile material has not inadvertently accumulated within the system, especially in those systems using unfavorable geometry containers.

(l) Measurement controls shall be used whenever geometry controls are not used to ensure criticality safety. Instrumentation used for measurement controls shall be maintained as part of the calibration program or instrumentation qualification program.

(m) Pellets and pellet scrap transferred in quantities greater than a safe mass between Building 230 and non-contiguous buildings shall be transported within a container that maintains a safe slab geometry.

(n) Storage of sintered pellets in the Kardex storage device shall be limited to Kardex storage pans with a maximum of 70 kg of UO_2 in each pan. There shall be a minimum of two physical water barriers over Kardex pans to prevent the ingress of water.

(o) Criticality safety evaluations for ventilated hoods may be based on either the limits of Table 4-1, Part A, or have specific safety evaluations. For hoods employing more than one limit, but based on Table 4-1, Part A, mechanical devices shall be used to ensure that the required minimum separation distance will be maintained between SNM containers in accordance with Section 4.2.2.1.

(p) The rod box storage matrix shall be limited to 112 rod storage boxes and prestack boxes. There shall be a minimum of two physical water barriers over the rod storage boxes and prestack boxes to prevent the ingress of water.

(q) Fuel assemblies, when wrapped and stored in the Fuel Assembly Storage Area shall have the bottom end open to ensure drainage of water.

(r) Isolated fuel assemblies shall be limited to arrays of 16 x 16, 14 x 14, and 10 x 10 rods and a maximum array size of 8.048" x 8.048", independent of the number of rods. Pellet diameters shall be less than or equal to 0.40" and greater than or equal to 0.3224". Fuel assembly designs outside this envelope shall require a criticality safety evaluation to ensure the assembly and storage processes have adequate subcriticality margin.

(s) Shipping package arrays containing SNM UO_2 product shall be stored within the security fence, in Building 230 or in the parking lot south of Building 230. Loaded 927 (927A1 and 927C1) shipping packages shall be stored no more than three high. There are no restrictions on the number of loaded 927 packages or their orientation in the horizontal plane. Loaded fuel shipping packages of types other than 927s shall be separated from arrays of loaded, unrestricted 927 packages by at least twelve feet.

(t) The volume of UO_2F_2 solution in the vaporizer chest following a UF_6 leak and continuing steam flow into the chest shall be controlled by multiple, independent level detection devices which shut off steam flow into the vaporizer.

(u) Receivers No. 1 and No. 2 shall each have a barrier to ensure that no significant moderating material can be brought within 1 foot of the vessel surface.

(v) The reactor gas filtration system shall have a barrier to ensure that no significant moderating material can be brought within 1 foot of the vessel surface.

4.2.5 Criticality Control Variables for Plant Processes

Table 4-4 lists the criticality control variables for various major plant processes. Table 4-5 lists major plant processes which are controlled as Safe Individual Units.

Table 4-1

PART A. Safe Unit Limits Meeting Fractional Critical Criteria for Surface Density Modeling

	MASS (Kg UO_2)	
w/o ^{235}U	Homogeneous	Heterogeneous
>1.0 - 2.5	54	50
>2.5 - 3.0	41	38
>3.0 - 3.2	36	36
>3.2 - 3.4	35	33
>3.4 - 3.6	32	30
>3.6 - 3.8	28	27
>3.8 - 4.1	24	24
>4.1 - 4.3	22	22
>4.3 - 4.5	20	20
>4.5 - 4.7	18	18
>4.7 - 5.0	16	16

	VOLUME(ℓ)	
>1.0 - 3.5	31	22
>3.5 - 4.1	25	18
>4.1 - 5.0	22	17

	CYLINDER DIAMETER (In.)	
>1.0 - 3.5	10.7	9.5
>3.5 - 4.1	9.8	8.9
>4.1 - 5.0	9.2	8.4

	SLAB THICKNESS (In.)	
>1.0 - 5.0	4.0	(see Part B)

Table 4-1

PART B. Other Operational Limits: 5 w/o ^{235}U or less UO_2

Pellets (1)	Slab Th. (In.)	Cyl. Dia. (In)	Vol. (ℓ)	Kg UO_2 (2)
Randomly Stacked	4.65	10.2	31.4	90.85
Optimally Moderated	3.75	8.3	17.0	17.45
Pellet Scrap	3.75	8.3	17.0	14.55

Zircaloy Clad Rods	Slab Th.	Cyl. Dia. (in.)
Loose Packed (3)	7.15	14.7
Optimally Moderated	4.17	9.0

Notes:

(1) Pellet OD 0.32" to 0.4"

(2) Including Double Batching Allowance.

(3) See definition in third paragraph, Section 4.2.2.1.

Table 4-2

Aqueous Solution Limits for ^{235}U Enrichments
Less Than or Equal to 5 w/o ^{235}U

	UO_2F_2	$UO_2(NO_3)_2$
Mass (Kg ^{235}U)(1)	0.82	1.77
Cylinder Diameter (in.)(1)	10.0	16.4
Slab Thickness (in.)(1)	4.42	8.33
Volume (liters)(1)	26.9	105.5
Concentration (g ^{235}U/L)		
Critical Limit	273	298
Subcritical Limit(2)	261.0	283.0

(1) With safety margins

(2) ANSI/ANS-8.1-1983

Table 4-3

Minimum Spacing Areas[1] for Homogeneous and Heterogeneous Mass and Geometric Limits

	Spacing Area (ft^2)
Mass	3.5
Volume	9.0
Cylinder [2]	5.0

(1) Subject to a minimum edge-to-edge unit separation of 12 inches.

(2) Per foot of cylinder height.

Table 4-4

Criticality Control Variables for Plant Processes

Plant Process	Control Variable
UF_6 Vaporizer	Volume - Note 1
Reactors R1 and R3	Geometry and Partial Reflection - Note 2
Reactor R2	Note 1
Reactor Offgas Filtration	Geometry and Partial Reflection - Note 2
Receivers No. 1 and No. 2	Geometry and Partial Reflection - Note 2
Bulk Storage and Recycle Hoppers	Moderation
Micronizer and Blender	Moderation
Buildings 254 and 255 Oxidation/Reduction Furnaces	Geometry
Slugging, Granulation and Pressing	Batch and Moderation
SNM Shipment Offsite and Receipt Onsite	Per Shipping Container Certificate of Compliance
Kardex Storage	Moderation - Note 1
Rod Box Storage Matrix	Moderation - Note 1
Fuel Assembly Rack Storage	Geometry - Note 1
UO_4 Dryer Assembly	Geometry

Notes

1. See also Special Controls, Section 4.2.4.
2. See also the Design Criteria associated with Partial Reflection, Sections 4.2.1.3(c) and 4.2.1.3(m).

Table 4-5

SIU Controlled Plant Processes

UF_6 Scrubber
UO_2 Cooler - Oxide Building
UO_2 Cooler Discharge Hopper - Oxide Building
Pellet Press Oil Sump
Pellet Handling in Buildings 254 and 255
Grinder Sludge Centrifuge
Pellet Grinding Sump
UF_6 Heel Removal
Incinerator
Oxide Building Trench and Sump
Vacuum Cleaners
Mop Buckets
Building 240 Oxidation/Reduction Furnaces
Filter Presses
Dissolution Vessels
UO_4 Precipitation Tank
UO_4 Centrifuge
Hold and Evaporation Tank Complex
ADU Precipitation Tank
Steam Cooker
Analytical Laboratory