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Idaho National Engineering Laboratory

Evaluation of Arkansas Nuclear One, Units 1 and 2 Nuclear Power Plants Offsite Dose Calculation Manual, Revision 2

Docket No. 50-313, Facility License No. DPR-51
Docket No. 50-368, Facility License No. NPF-6

N. Morcos
D. W. Akers

Lockheed
Idaho Technologies Company

Enclosure

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Technical Evaluation Report for the Arkansas Nuclear One, Units 1 and 2 Nuclear Power Plants ODCM, Revision 2

UNIT 1, NRC Docket No. 50-313 NRC License No. DPR-51
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N. Morcos
D. W. Akers

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Idaho National Engineering Laboratory
Lockheed Martin Idaho Technologies
Idaho Falls, Idaho 83415

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ABSTRACT

Revision 2 of The Offsite Dose Calculation Manual (ODCM) for the Arkansas Nuclear One, Units 1 and 2 (ANO) was transmitted to the Idaho National Engineering Laboratory (INEL) for review by Lockheed Idaho Technologies. The ODCM was reviewed with respect to the criteria outlined in NUREG-0472, Rev. 3, "Standard Radiological Effluent Controls for Pressurized Water Reactors," NUREG-0133, "Preparation of RETS for Nuclear Power Plants," and NRC guidelines promulgated in Regulatory Guides 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I."

The ODCM review indicates general compliance with the requirements of NUREG-0473 and the guidelines contained in NUREG-0133. However, there are inconsistencies related to setpoint calculations and inaccuracies related to dose calculations due to airborne releases. Moreover, the pathways leading to public radiation dose exposure must be clearly delineated. All plant radioactive effluent pathways to the environment must be clearly defined, preferably with a simple diagram identifying their associated alarm/trip monitors. Examples for setpoint and dose calculations should be included, where appropriate, in the ODCM as dictated by TS 3/4.11.2.1. Some degree of conservatism must be included in the derivation of setpoints to ensure that radioactive plant effluents will remain compliant with 10 CFR 20. The ODCM must also include a description of the Inter-Lab Comparisons Program in accordance with the description of Surveillances in the ANO Technical Specifications (4.12.3).

In general, the calculations sections could be better organized, preferably in a parallel fashion for the various pathways evaluated. In particular, for each pathway presented, the concentrations calculations should be followed immediately by their respective dose calculations.

FOREWORD

This report is submitted in partial fulfillment of the "Review of Radiological Issues" project conducted at the Idaho National Engineering Laboratory (INEL) for the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation (NRR). The NRC funded the work under FIN E2084.

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FIGURES

ACRONYMS/SYMBOLS

L	Symbol used for radiation induced doses
D	Symbol used for radiation dose rates
ANO	Arkansas Nuclear One
CFR	Code of Federal Regulations
CSR	Control and Surveillance Requirements
FR	Federal Regulation
INEL	Idaho National Engineering Laboratory
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory document
ODCM	Offsite Dose Calculation Manual
RETS	Radiological Effluent Technical Specifications

Technical Evaluation Report for the Arkansas Nuclear One, Units 1 and 2 Nuclear Power Plants ODCM, Revision 2

1. INTRODUCTION

1.1 Purpose of the Review

This document reports the review and evaluation of the Arkansas Nuclear One (ANO), Units 1 and 2, Offsite Dose Calculation Manual (ODCM), Revision 2 issued in January of 1992. The ODCM was submitted by Energy Operations, Inc., the ANO licensee. It is a supplementary document for implementing the Radiological Effluent Technical Specifications (RETS) in compliance with 10 CFR 50, Appendix I.[1] This review was performed to assess conformity of the ODCM to ANO technical specifications and current applicable NRC guidelines.

1.2 Plant-Specific Background

Revision 2 of the ODCM for ANO Units 1 & 2, dated January 1992, was submitted to the NRC on August 28, 1992[2] together with the Semiannual Radiological Effluent Release Report for the first and second quarters of 1992. The NRC transmitted the new revision to the INEL for review.

The ANO Units 1 and 2 are pressurized water reactors (PWRs). Unit 1 is rated at 850 MWe while Unit 2 is rated at 912 MWe. Both units are located on an 1100-acre site, which is approximately 6 statute miles WNW from the city of Russelleville (Latitude 35°-18′-36″ N, Longitude 93°-13′-53″ W) in an area characterized by remoteness from population centers. The site provides for a 0.65-statute-mile exclusion radius from the reactor building. The exclusion area includes certain portions of the bed and banks of the Dardanelle Reservoir, which is owned by the U. S. Federal Government.

2. REVIEW CRITERIA

Review criteria for the ODCM are provided by the NRC in two documents:

- NUREG-0472, "Standard Radiological Effluent Controls for Pressurized Water Reactors," Revision 3.[3]

- NUREG-0133 "Preparation of RETS for Nuclear Power Plants."[4]

In addition, NRC guidelines promulgated in Regulatory Guide 1.109, Revision 1, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I,"[5] were also used together with the NRC Radiological Assessment Branch Technical Position, Revision 1, February 8, 1979, "General Contents of the Offsite Dose Calculation Manual."[6]

NUREG-0472 specifies that the licensee develop the ODCM to document the methodology used in calculating offsite doses and approaches used in maintaining the operability of the radioactive effluent systems. The reference also indicates that the ODCM should provide, as a minimum, equations and methodology for the following:

- Alarm and trip setpoints on effluent instrumentation.

- Liquid effluent concentrations in unrestricted areas.

- Gaseous effluent dose rates at or beyond the site boundary.

- Liquid and gaseous effluent dose contributions.

- Liquid and gaseous effluent dose projections.

In addition, the ODCM should contain flow diagrams defining the treatment paths and the components of the liquid and gaseous effluent management systems used at the station. The ODCM should also describe and identify the locations of the samples supporting the environmental monitoring program.

3. RADIOACTIVE EFFLUENT RELEASE ROUTES

3.1 Liquid Effluent Release Routes

Each of the ANO units has a single liquid radwaste release point. For UNIT 1, the liquid radwaste release line to the circulating water discharge canal is common to the treated waste monitor tank, the filtered waste monitor tank, and the laundry drain tank. For UNIT 2, the liquid radwaste discharge line to the circulating water discharge canal is common to the boric acid condensate tank, waste condensate tanks, and the non-radioactive regenerative holdup tank.

The turbine floor drains at each unit are normally directly released to the discharge canal. However, a high ^{16}N activity in the main steam lines due to a primary-to-secondary leak will automatically divert the floor drain discharge to a neutralizing tank which must be sampled before discharge. In addition, the condenser air ejector noble gas monitor also triggers the administrative controls for isolation of the tank and grab sampling of the turbine building sump.

The service water at both units is released directly into the discharge canal. The component cooling water systems at each unit are closed systems and are cooled by their respective service water systems. The radioactive components (the reactor building air cooler and decay heat coolers) incorporate process monitors which provide alarms and are used to isolate these legs of the system from the discharge header.

The intermediate cooling water systems in both units are only drained during outages and are sampled prior to release. These systems are cooled by their respective unit's service water systems.

A block diagram of ANO Units 1 and 2 radioactive liquid effluent systems is shown in Figure 1. It was obtained from an informal report prepared by Lockheed Martin Idaho Technologies for the U.S. Nuclear Regulatory Commission under DOE contract No. DE-AC07-76ID01570, dated May 1984, and titled: "Radiological Effluent Technical Specifications (RETS) Implementation - Arkansas Nuclear One Units 1 and 2."[7]

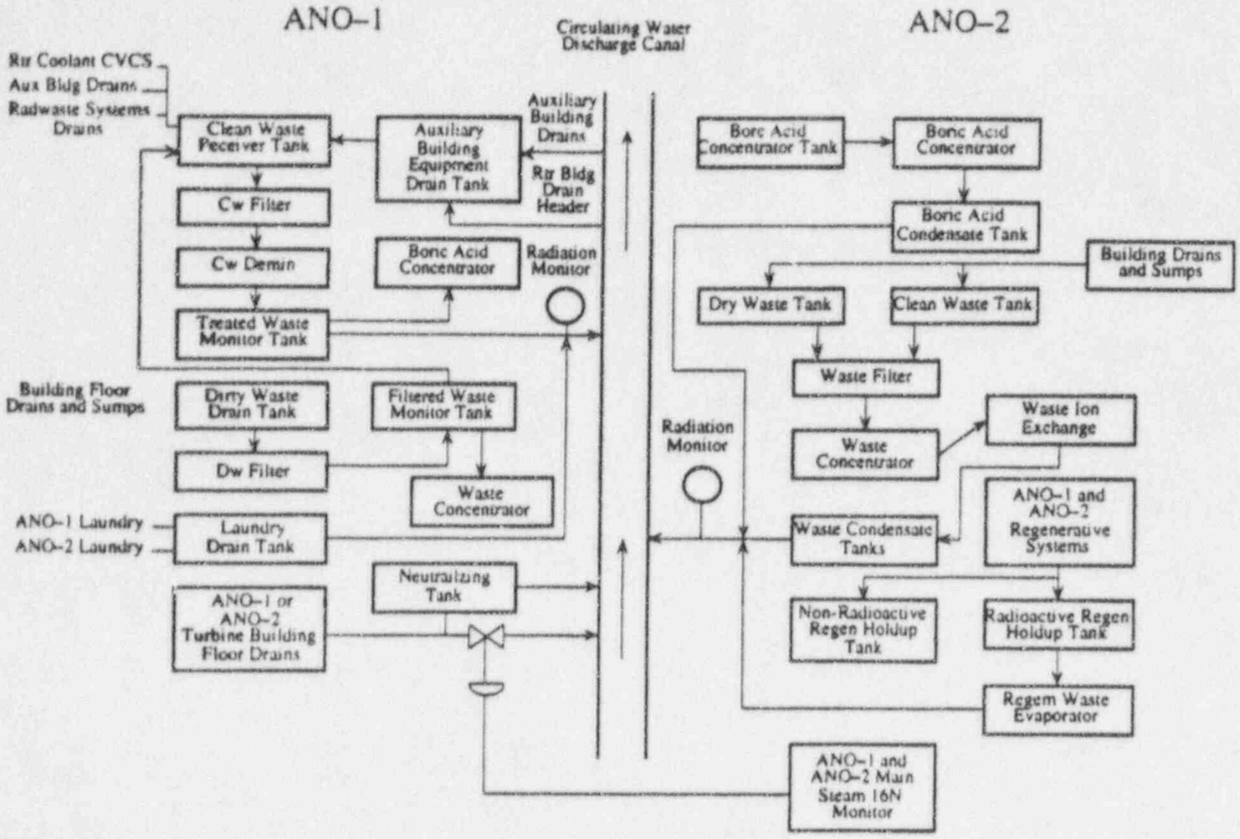

Figure 1. ANO Units 1 and 2 Radioactive Liquid Effluent Release Paths.

3.2 Gaseous Effluents Release Routes

There are four radioactive gaseous effluent release points for Unit 1 and four for Unit 2:

1. Auxiliary Building Ventilation System.
2. Spent Fuel Pool Area Ventilation System.
3. Reactor Building Purge and Ventilation System.
4. Unit 2 Auxiliary Building Extension Ventilation System.

The auxiliary building vent is also the release point for gaseous effluents from the radwaste area, the condenser air ejector, and the waste gas holdup system.

A block diagram describing the gaseous effluent discharge pathways[7] is shown in Figure 2.

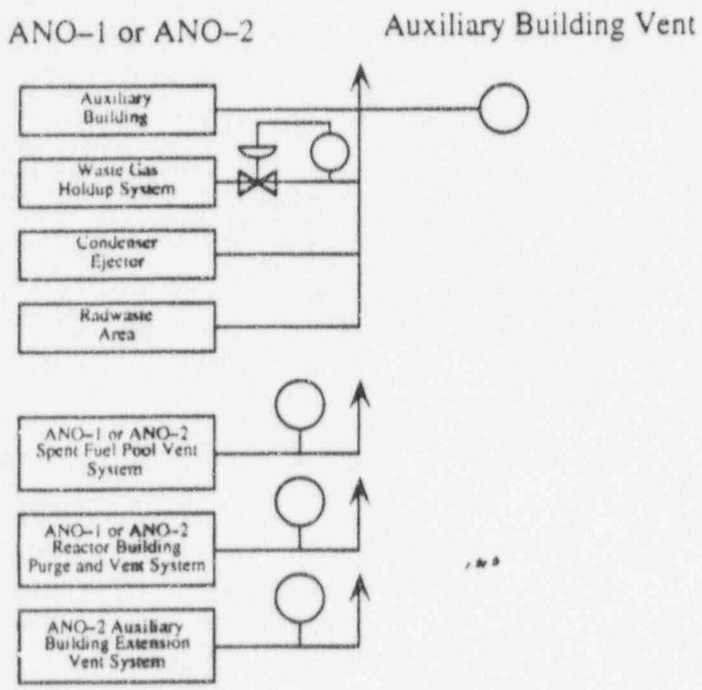

Figure 2. Gaseous Effluent Pathways.

4. EVALUATION

The licensee states that the ODCM provides guidance for making release rate and dose calculations for radioactive liquid and gaseous effluents from Arkansas Nuclear One - Units 1 and 2 in accordance with the methodology described in NUREG-0133 and Regulatory Guide 1.109 except where site-specific information makes changes appropriate.

The ODCM describes, in general, the issues essential for setpoint and radioactive effluent releases calculations. However, some changes are required for clarification and corrections must be made to the setpoint calculations.

4.1 Liquid Effluent Monitor Setpoints

The radioactive Liquid Effluent Instrumentation Specification (3.5.6 for ANO - Unit 1, and 3.3.3.10 for ANO - Unit 2) requires that the radioactive liquid effluents be monitored with the alarm/trip setpoints adjusted to ensure that the limits of the radioactive liquid effluent concentration specifications are not exceeded. NUREG-0133, Section 4.1.1 states that "Alarm/trip setpoints ... should correspond to a value(s) which represents a safe margin of assurance that the instantaneous release limits of 10 CFR 20 are not exceeded."

The definition and calculation of setpoints, as stated in the ODCM, does not include any margin of safety. In fact, alarm setpoints are not considered or defined in this ODCM revision. We suggest that the alarm setpoint for the release monitors be set at 75% of a conservative trip setpoint. The factor *A* or unit allocation fraction should be maintained at less than 0.45 for each unit to preclude exceeding the limit in case both Unit 1 and 2 are discharging simultaneously.

In Section 2.1 of the ODCM, the calculation of the dilution factor *DF* is excessively conservative. Consider the concentrations of three different radioisotopes (*A*, *B*, and *C*) in the effluent where *A* is 4 times MCP_A, *B* is 2 times MCP_B, and *C* is equal to MCP_C. Diluting the effluent to a fourth of its concentration would certainly dilute the concentration of radioisotope *A* to MCP_A, and would also dilute the concentrations of *B* to 1/2 (MCP_B), and *C* to 1/4 (MCP_C). However, as presented, the ODCM directs to dilute such a mixture by a factor of (4 + 2 + 1) or 7. This dilution factor is greater than the required value of "4." The ODCM further suggests adding the dilution factor for the noble gases to the already high dilution factor. This is an acceptable conservatism.

In Section 2.1, part 5 of the ODCM - Definition of Setpoint:

1. The term F_M is used in the ratio F_M/F_A and does not appear to be defined. The reader may guess that it is the F_M defined earlier. Moreover, the difference between F_M and F_A is not clear. The reader can infer that F_M is essentially F_A/DF. Consequently, $F_M/F_A = 1/DF$.

2. The calculation of the term *K* is mathematically incorrect if it is based on a log-log interpolation as the definition of Slope suggests. The ODCM defines *K* as: $\text{Slope} \times 10^{SA} + \text{Offset}$. *K* should be defined as:

   $$K = 10^{(\text{Slope} \times \log(SA))} + \text{Offset}$$

3. Flow setpoints must also be considered since they impact the release radioconcentration values at the discharge point.

4.2 Gaseous Effluents Monitor Setpoints

Standard Technical Specifications 3.3.3.9 requires that "The radioactive gaseous process and effluent monitoring instrumentation channels shown in Table 3.3-12 shall be OPERABLE with their alarm/trip setpoints set to insure that the limits of Specification 3.11.2.1 are not exceeded. The setpoints shall be determined in accordance with procedures as described in the ODCM, and shall be recorded in the station log." Furthermore, Section 5.1.1 of NUREG-0133 states that "The alarm/trip setpoints or automatic control trip setpoints for each instrument channel listed in Table 3.3-12 should be provided and should correspond to a value(s) which represents a safe margin of assurance that the instantaneous gaseous release limit of Specification 3.11.2.1(a) will not be exceeded. The corresponding setpoint for alarm/trip should be established such that an alarm trip will occur either in advance of the automatic control trip or simultaneously with the automatic control trip..." The current revision of the ODCM does not provide for alarm setpoint calculations.

In Section 3.1.1.b of the ODCM, the MPC fractions assigned to the various release points must be identified in the ODCM to show compliance with 10 CFR 20:

1. The calculation of S as shown defines its value to exceed the limits since a value twice background $2.0 \times B$ is added to $C_M \times K$. This added factor, in essence, allows for higher radionuclide concentration to pass by the monitor.

2. This section must show the derivation of the ^{133}Xe equivalent concentration at the monitor term C_M (μCi/ml). In particular, the derivation should show that the constant value used can be attributed to a potentially varying mixture of radioisotopes with different decay characteristics.

3. This section must show the derivation of the K "conversion factor determined from response curve of monitor (counts/sec per μCi/ml)." In particular, the derivation must show how this term considers the different radioisotopes processed by the monitor and their different decay characteristics.

In Section 3.1.2 of the ODCM - Eberline SPING (Final Effluent) Monitor Setpoint Calculations, The ODCM must clarify to the reader if all the monitors listed for ANO-1 and ANO-2 are part of the SPING Monitor.

In Section 3.1.2.b of the ODCM, SPING Monitor Setpoint Calculations:

1. The assumption of using a ^{133}Xe equivalent concentration implies that the gaseous effluents always have the same composition. These data should be included in the ODCM if they are available. If not, a valid argument must be made to support using a constant value.

2. The "annual average gaseous dispersion factor (corrected for radioactive decay) as defined in Section 2.3 of the ANO-2 SAR" should be explained here in detail. In particular, the calculations showing the decay corrections for the various radioisotopes leading to one constant value of 2.8×10^{-6} should be included in the ODCM.

3. Annual Total Body Dose Rate calculation does not show contributions from gamma or beta exposure. The ODCM should show contributions from both radiation dose terms since each will have a different DFB_i value.

4.3 Concentrations in Liquid Effluents

Comments for this section are covered in Section 4.1 of this review due to the ODCM methodology. The current version of the ODCM does not contain an adequate elaboration of liquid effluent concentrations.

4.4 Dose Rates Due to Gaseous Effluents

4.4.1 General

The dose at any time beyond the site boundary from gaseous effluents from all units on the site shall be within the annual dose limits set in 10 CFR Part 20, Appendix B, Table II, Column 1. The specified limits always restrict the corresponding gamma and beta dose rates above background to a member of the public at or beyond the site boundary.

The title of Section 3.2 of the ODCM includes the word "Effects" although no effects of airborne release dose rates are discussed or evaluated in this section.

4.4.2 Dose Rates Due to Noble Gases

No comments for this section (Section 3.2.1 of ODCM).

4.4.3 Dose Rates Due to Other Than Noble Gases

No comments for this section (Section 3.2.2 of ODCM).

4.4.4 Dose Rates Due to Iodine-131, Iodine-133, Tritium, and Radioactive Material in Particulate Form

In Section 3.4 of the ODCM - Dose Due to ^{131}I, Tritium, and Particulates in Gaseous Effluents:

1. Reference is made to a dispersion parameter of 2.8×10^{-6} sec/m^3 in accordance with the ANO-2 FSAR, Section 2.3.4.4 and used for "w". The derivation of this term should be included in the ODCM since it is used here (see comment # 2 about Section 3.1.2.b in Section 4.2 above). Furthermore, the term "w" is probably used in an equation which is not shown.
2. The general definition of D^{TOT} is provided in this section. However, the equations for calculating the terms used to define D^{TOT} must also be shown and explained.

4.5 Dose Due to Liquid Effluents

Technical Specification 3.11.1.2 provides the limits for dose to a member of the public from radioactive materials in liquid effluents released to unrestricted areas. These limits are:

During any calendar quarter	During any calendar year
$D \leq 1.5$ mrem to the total body	$D \leq 3$ mrem to the total body
$D \leq 5$ mrem to any organ	$D \leq 10$ mrem to any organ

The ODCM should clearly identify all radioactive liquid effluent pathways contributing to radiation dose exposure to the public and the environment. This should also be shown with a simple diagram.

In Section 2.2.1 of the ODCM, Dose Calculations for Aquatic Foods, the licensee states that "two different pathways are calculated for aquatic foods: sport and commercial freshwater fish." However, the primary variable differentiating doses from these two pathways is the bioaccumulation factor B_i. The note in this section states that the same B_i is used for both calculations. We suggest that the statement: "two different pathways are calculated for aquatic foods: sport and commercial freshwater fish" be modified to reflect that doses from these two pathways are considered identical.

4.6 Doses Due To Gaseous Effluents

Standard Technical Specifications 3.11.2.1 implements the requirements of 10 CFR Part 20 and Technical Specifications 3.11.2.2 and 3.11.2.3 implement the requirements of 10 CFR Part 50. Furthermore, NUREG-0133 requires that the ODCM includes methodology to implement the requirements set in 10 CFR Parts 20 and 50. In particular, 10 CFR Part 20 establishes yearly total body, skin, and organ dose rates due to noble gases, radioiodines, and all radioactive materials in particulate form and radionuclides other than noble gases with half-lives greater than 8 days.

10 CFR Part 50 provides quarterly and annual limits to air dose in unrestricted areas due to gamma and beta radiation from noble gases released in gaseous effluents.

No comments for this section (Section 3.3 of ODCM).

4.6.1 Doses Due to Noble Gases

No comments for this section (Section 3.3.1 of ODCM).

4.6.2 Doses Due to Other Than Noble Gases

In Section 3.4.1.b of the ODCM,

1. It is not clear on the method by which the value of Q_i or "release of nuclide '*i*' in curies" is determined. If it is a direct measurement of each radionuclide '*i*', the ODCM should state so. If it is determined by using a "scaling factor," the ODCM should state so, and show that the scaling factor used is valid for a varying radioisotopic mixture of effluents. Furthermore, the units for Q_i should also be stated in Ci/hr for compatibility with the rest of the equation as stated.

2. The term $D2DPX/Q(r,\theta)$, as defined, is unique for each radioisotope, and hence must have a subscript "*i*", and must be calculated accordingly in particular for deposition and decay. The ODCM must show this calculation.

In Section 3.4.1.c.1 of the ODCM, the definition of CF^{V_i}, Y_v should be replaced with Y_v to be consistent with the definition of terms that ensue.

In Section 3.4.1.c.4 of the ODCM,

1. $DOQ(r,\theta)$ is unique for each radioisotope considered and should be subscripted accordingly.

2. $D2DPX/Q(r,\theta)$ should be different for ^{14}C and ^{3}H. As written, the equations imply a constant value.

In Section 3.4.1 of the ODCM, the dose calculations for contributions from cow's milk and meat consumptions are not shown. Sections 3.4.1.d and 3.4.1.e, respectively, show only the nuclide concentration calculations for these two pathways.

4.7 Dose Projections

No comments for this section (ODCM Section 2.3 for liquid dose projections, and ODCM Section 3.5 for gaseous dose projections).

4.8 Diagrams of Effluent Release Routes

No diagrams for the effluent release routes are included in the ODCM. Simplified diagrams of the effluent release routes should be included in the ODCM.

4.9 Total Dose

Standard Technical Specifications 3/4.11.4 provides for controls of total dose in 3.11.4. The annual dose or dose commitment to any member of the public due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to less than or equal to 25 mrems to the whole body or any organ, except the thyroid which shall be limited to ≤ 75 mrems. Moreover, Standard Technical Specification surveillances 4.11.4.1 states that the cumulative dose contribution from liquid and gaseous effluents shall be determined in accordance with controls 4.11.1.2, 4.11.2.2, and 4.11.2.3, and in accordance with the methodology and parameters in the ODCM.

In Section 3.4.1 of the ODCM - Total Dose from Atmospherically Released Radionuclides. Consistency is expected for upper or lower case superscripts used in the equations. A change in letter case is confusing as it may indicate a different variable. Moreover, the radioactive concentrations ($C_i^V, C_i^L, C_i^M, C_i^F$), as used in the equations, do not match their definitions which intermittently use the letter D instead of C.

4.10 Environmental Monitoring Program

The Environmental Monitoring Program as presented in the ANO ODCM consists of an Environmental Sampling Stations list. The ODCM should include a description of the program. As such, it does not meet the NRC guidelines.

4.11 Interlaboratory Comparison Program

The ANO ODCM does not include a description of the Interlaboratory Comparison Program. As such, it does not meet the NRC guidelines.

5. TECHNICAL FINDINGS

Deficiencies and suggestions are summarized below in four categories in order of decreasing importance. Items in Category A identify the most serious deficiencies, including omissions that cause uncertainty in establishing proper methodology for calculations used in the ODCM. Category B contains less serious deficiencies, and Category C contains minor deficiencies and editorial recommendations. Category D contains suggestions for changes that the licensee may wish to implement to simplify calculations, update data, or remove excess conservatism from the methodology. The number in parentheses at the end of each item, for example (4.1) refers to the section of this review that contains a discussion of the item.

Category A

The items in this category should be addressed promptly. Some items identify errors or omissions that result in erroneous calculated doses and dose rates. Others identify omissions or inappropriate values that may result in release rate limits being exceeded or reported doses that are insufficiently documented.

1. In Section 2.1, part 5 of the ODCM - Definition of Setpoint:

   a. The calculation of the term K is mathematically incorrect if it is based on a log-log interpolation as the definition of Slope suggests K should be defined as:

      $K = 10^{(\text{Slope} \times \log(SA))} + \text{Offset}$.

   b. The waste tank composition varies from discharge to discharge and therefore is not the same for all releases, and a simplistic scaling factor is unfounded. The derivation of the value of S_A used in Section 3.1.1.b must justify using ^{137}Cs equivalent value for different mixtures of radioisotopes encountered in different releases.

   c. Flow setpoints impact the release radioconcentration values at the discharge point and must be considered.

   d. The term F_M is used in the ratio F_M/F_A and does not appear to be defined. The reader may guess that it is the F_M defined earlier. Moreover, the difference between F_M and F_A is not clear. The reader can infer that F_M is essentially F_A/DF. Consequently, $F_M/F_A = 1/DF$.

2. In Section 3.1.1.b of the ODCM, the MPC fractions assigned to the various release points must be identified in the ODCM to show compliance with 10 CFR 20.

   a. The calculation of S must be corrected to include conservatism instead of artificially increasing the setpoint by twice the background count. As shown, the calculation defines its value to exceed the limits since a value twice background $2.0 \times B$ is added to $C_M \times K$. This added factor, in essence, allows for a higher radioactivity to proceed by the monitor.

   b. This section must show the derivation of the "^{133}Xe equivalent concentration at the monitor" term C_M (μCi/ml). In particular, the derivation should show that the constant value used can be attributed to a potentially varying mixture of radioisotopes with different decay characteristics.

   c. This section must also show the derivation of the K "conversion factor determined from response curve of monitor (counts/sec per μCi/ml)." In particular, the derivation must show how this term considers the different radioisotopes processed by the monitor and their different decay characteristics.

d. The MPC fractions assigned to the various release points must be identified in the ODCM to show compliance with 10 CFR 20.

3. In Section 3.1.2.b of the ODCM, SPING Monitor Setpoint Calculations:

   a. The assumption for using a ^{133}Xe equivalent concentration implies that the gaseous effluents always have the same composition. These data should be included in the ODCM if they are available. If not, a valid argument must be made to support using a constant value.

   b. The "annual average gaseous dispersion factor (corrected for radioactive decay) as defined in Section 2.3 of the ANO-2 SAR" should be explained here in detail. In particular, the calculations showing the decay corrections for the various radioisotopes leading to one constant value of 2.8×10^{-6}.

   c. Annual Total Body Dose Rate calculation must show contributions from gamma or beta exposure. The ODCM should show contributions from both radiation dose terms since each will have a different DFB_i value.

   d. The corresponding setpoint for alarm/trip should be established such that an alarm trip will occur either in advance of the automatic control trip or simultaneously with the automatic control trip..." The current revision of the ODCM does not provide for alarm setpoint calculations.

   e. In Section 3.1.2 of the ODCM - Eberline SPING (Final Effluent) Monitor Setpoint Calculations, the ODCM must clarify to the reader if all the monitors listed for ANO-1 and ANO-2 are part of the SPING Monitor.

4. In Section 3.4 of the ODCM - Dose Due to ^{131}I, Tritium, and Particulates in Gaseous Effluents:

   a. Reference is made to dispersion parameter of 2.8×10^{-6} sec/m^3 in accordance with the ANO-2 FSAR, Section 2.3.4.4 and used for "w". The derivation of this term should be included in the ODCM since it is used here. Furthermore, the term "w" is probably used in an equation which is not shown. Either delete reference to "w", or show its relationship to dose calculations.

   b. The general definition of D^{TOT} is provided in this section. However, the equations for calculating the terms used to define D^{TOT} must also be shown and explained.

5. In Section 3.4.1.b of the ODCM:

   a. The method by which the value of Q_i or "release of nuclide 'i' in curies" must be clearly stated. If it is a direct measurement of each radionuclide 'i', the ODCM should state so. If it is determined by using a "scaling factor," the ODCM should state so, and show that the scaling factor used is valid for a varying radioisotopic mixture of effluents. Furthermore, the units for Q_i should also be stated in Ci/hr for compatibility with the rest of the equation as stated.

b. The term $D2DPX/Q(r,\theta)$ as defined, is unique for each radioisotope, and hence must have a subscript 'i', and must be calculated accordingly. In particular, this must be done for radioisotopic deposition and decay. The ODCM must show this calculation.

6. In Section 3.4.1.c.4 of the ODCM:

a. $DOQ(r,\theta)$ is unique for each radioisotope considered and should be subscripted accordingly.

b. $D2DPX/Q(r,\theta)$ should be different for ^{14}C and ^{3}H. As written, the equations imply a constant value and would lead to erroneous calculated results.

7. In Section 3.4.1 of the ODCM, the dose calculations for contributions from cow's milk and meat consumptions must be shown. Sections 3.4.1.d and 3.4.1.e, respectively show, only the nuclide concentration calculations for these two pathways.

8. The Environmental Monitoring Program as presented in the ANO ODCM consists of an Environmental Sampling Stations list. The ODCM should include a description of the program. As such, it does not meet the NRC guidelines.

9. The ANO ODCM does not include a description of the Interlaboratory Comparison Program. As such, it does not meet the NRC guidelines.

10. In Section 2.1 of the ODCM, the calculation of the dilution factor DF is excessively conservative. Consider the concentrations of three different radioisotopes (A, B, and C) in the effluent where A is 4 times MCP_A, B is 2 times MCP_B, and C is equal to MCP_C. Diluting the effluent to a fourth of its concentration would certainly dilute the concentration of radioisotope A to MCP_A, and would also dilute the concentrations of B to 1/2 (MCP_B), and C to 1/4 (MCP_C).

11. The ODCM should clearly identify all radioactive liquid effluent pathways contributing to radiation dose exposure to the public and the environment. This should also be shown with a simple diagram.

Category B

The items below concern information that should be added to make the ODCM more complete, prevent erroneous interpretation of the methodology, or correct erroneous methodology.

1. The ODCM must include descriptive diagrams of gaseous and liquid effluents which incorporate the locations of the isolating discharge monitors.

2. In Section 2.2.1 of the ODCM, Dose Calculations for Aquatic Foods, the licensee states that "two different pathways are calculated for aquatic foods: sport and commercial freshwater fish". However, the primary variable differentiating doses from these two pathways is the bioaccumulation factor B_i. The note in this section states that the same B_i is used for both calculations. We suggest that the statement : "two different pathways are calculated for aquatic foods: sport and commercial freshwater fish" be modified to reflect that doses from these two pathways are considered identical.

3. No diagrams for the effluent release routes are included in the ODCM. Simplified diagrams of the effluent release routes should be included in the ODCM.

Category C

The items in this category indicate omissions and editorial deficiencies that are not likely to cause significant problems.

1. Section 3.2 of the ODCM, the title includes the word "Effects" although no effects of airborne release dose rates are discussed or evaluated in this section.

2. In Section 3.4.1 of the ODCM - Total Dose from Atmospherically Released Radionuclides, use consistent notation for upper and lower case superscripts in the equations. A change in letter case is confusing as it may indicate a different variable. For example, the radioactive concentrations ($C_i^V, C_i^L, C_i^M, C_i^F$) as used in the equations do not match their definitions which intermittently use the letter *D* instead of *C*.

3. In Section 3.4.1.c.1 of the ODCM, the definition of CF^{V_i}, Y_v should be replaced with Y_v to be consistent with the definition of terms that ensue.

Category D

There are no category D comments.

6. CONCLUSIONS

The licensee's ODCM, Revision 2, transmitted to the U. S. NRC on August 28, 1992, uses documented and approved methods that are, in general, consistent with the methodology and guidance of NUREG-0133 and Regulatory Guide 1.109. The ODCM contains essentially all of the required methodology. However, because of several omissions and errors, it is recommended that the NRC request another revision of the ODCM to address and correct the most significant deficiencies identified in this review.

The most important corrections and additions needed are summarized below:

1. In Section 2.1, part 5 of the ODCM - Definition of Setpoint:

   a. The calculation of the term K is mathematically incorrect if it is based on a log-log interpolation as the definition of Slope suggests K should be defined as:

      $K = 10^{(\text{Slope} \times \log(SA))} + \text{Offset}$.

   b. The derivation of the value of S_A used in Section 3.1.1.b must justify using ^{137}Cs equivalent value for different mixtures of radioisotopes encountered in different releases.

   c. Flow setpoints impact the release radioconcentration values at the discharge point and must be considered.

2. In Section 3.1.1.b of the ODCM, the MPC fractions assigned to the various release points must be identified in the ODCM to show compliance with 10 CFR 20.

   a. The calculation of S must be corrected to include conservatism instead of artificially increasing the setpoint by twice the background count.

   b. This section must show the derivation of the "^{133}Xe equivalent concentration at the monitor" term C_M (μCi/ml). In particular, the derivation should show that the constant value used can be attributed to a potentially varying mixture of radioisotopes with different decay characteristics.

   c. This section must also show the derivation of the $\mathcal{K}$ "conversion factor determined from response curve of monitor (counts/sec per μCi/ml)." In particular, the derivation must show how this term considers the different radioisotopes processed by the monitor and their different decay characteristics.

3. In Section 3.1.2.b of the ODCM, SPING Monitor Setpoint Calculations:

   a. The assumption for using a ^{133}Xe equivalent concentration implies that the gaseous effluents always have the same composition. These data should be included in the ODCM if they are available. If not, a valid argument must be made to support using a constant value.

   b. The "annual average gaseous dispersion factor (corrected for radioactive decay) as defined in Section 2.3 of the ANO-2 SAR" should be explained here in detail. In particular, the calculations showing the decay corrections for the various radioisotopes leading to one constant value of 2.8×10^{-6}.

c. Annual Total Body Dose Rate calculation must show contributions from gamma or beta exposure. The ODCM should show contributions from both radiation dose terms since each will have a different DFB_i value.

4. In Section 3.4 of the ODCM - Dose Due to ^{131}I, Tritium, and Particulates in Gaseous Effluents:

   a. Reference is made to dispersion parameter of 2.8×10^{-6} sec/m^3 in accordance with the ANO-2 FSAR, Section 2.3.4.4 and used for "w". The derivation of this term should be included in the ODCM since it is used here. Furthermore, the term "w" is probably used in an equation which is not shown. Either delete reference to "w", or show its relationship to dose calculations.

   b. The general definition of D^{TOT} is provided in this section. However, the equations for calculating the terms used to define D^{TOT} must also be shown and explained.

5. In Section 3.4.1.b of the ODCM:

   a. The method by which the value of Q_i or "release of nuclide 'i' in curies" must be clearly stated. If it is a direct measurement of each radionuclide 'i', the ODCM should state so. If it is determined by using a "scaling factor," the ODCM should state so, and show that the scaling factor used is valid for a varying radioisotopic mixture of effluents. Furthermore, the units for Q_i should also be stated in Ci/hr for compatibility with the rest of the equation as stated.

   b. The term $D2DPX/Q(r,\theta)$, as defined, is unique for each radioisotope, and hence must have a subscript "i", and must be calculated accordingly. In particular, this must be done for radioisotopic deposition and decay. The ODCM must show this calculation.

6. In Section 3.4.1.c.4 of the ODCM:

   a. $DOQ(r,\theta)$ is unique for each radioisotope considered and should be subscripted accordingly.

   b. $D2DPX/Q(r,\theta)$ should be different for ^{14}C and ^{3}H. As written, the equations imply a constant value and would lead to erroneous calculated results.

7. In Section 3.4.1 of the ODCM, the dose calculations for contributions from cow's milk and meat consumptions must be shown. Sections 3.4.1.d and 3.4.1.e, respectively show, only the nuclide concentration calculations for these two pathways.

8. The Environmental Monitoring Program as presented in the ANO ODCM consists of an Environmental Sampling Stations list. The ODCM should include a description of the program. As such, it does not meet the NRC guidelines.

9. The ANO ODCM does not include a description of the Interlaboratory Comparison Program. As such, it does not meet the NRC guidelines.

7. REFERENCES

1. Title 10, Code of Federal Regulations, Part 50, "Domestic Licensing of Production and Utilization Facilities".

2. Letter of submittal from James J. Fisicaro, Director of Licensing, Energy Operations, to U.S. NRC, Document Desk Control. Subject: Arkansas Nuclear One - Units 1 and 2, Docket Nos. 50-313 & 50-368, License Nos. DPR-51 & NPF-6, Semiannual Radiological Effluent Release Report, First and Second Quarter of 1992.

3. NUREG-0472, "Standard Radiological Effluent Controls for Pressurized Water Reactors", Revision 3

4. NUREG-0133, "Preparation of RETS for Nuclear Power Plants"

5. Regulatory Guide 1.109, Revision 1, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I"

6. NRC Radiological Assessment Branch Technical Position, Revision 1, February 8, 1979 "General Contents of the Offsite Dose Calculation Manual".

7. Informal report prepared by EG&G for the U. S. Nuclear Regulatory Commission under DOE contract No. DE-AC07-76ID01570, dated May, 1984, and titled: "Radiological Effluent Technical Specifications (RETS) Implementation - Arkansas Nuclear One Units 1 and 2".