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PREPARATION OF RADIOLOGICAL EFFLUENT TECHNICAL SPECIFICATIONS FOR NUCLEAR POWER PLANTS

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Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission

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PREPARATION OF
RADIOLOGICAL EFFLUENT TECHNICAL SPECIFICATIONS
FOR NUCLEAR POWER PLANTS

A Guidance Manual for Users of Standard Technical Specifications

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE

The purpose of this manual is to describe methods found acceptable to the staff of the U.S. Nuclear Regulatory Commission (NRC) for the calculation of certain key values required in the preparation of proposed radiological effluent Technical Specifications using the Standard Technical Specifications for light-water-cooled nuclear power plants. This manual also provides guidance to applicants for operating licenses for nuclear power plants in the preparation of proposed radiological effluent Technical Specifications or in preparing requests for changes to existing radiological effluent Technical Specifications for operating licenses. The manual additionally describes current staff positions on the methodology for estimating radiation exposure due to the release of radioactive materials in effluents and on the administrative control of radioactive waste treatment systems.

1.2 BACKGROUND

Section 50.36, "Technical Specifications," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities" (Ref. 1), requires that each nuclear power reactor operating license issued by the NRC contain Technical Specifications that set forth limits, operating conditions, and other regulatory requirements imposed on the facility operation for the protection of the health and safety of the public. Conditions and limitations corresponding to certain key values which are system-dependent and site-related are to be incorporated in these Technical Specifications for compliance with 10 CFR 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors." Under the provisions of Section 50.36, each applicant for an operating license is required to submit proposed Technical Specifications for his facility, including the supporting bases. These are reviewed by the NRC staff to assure that the proposed Technical Specifications contain such conditions and limitations as deemed appropriate and necessary; approved Technical Specifications are then included as Appendix A of the operating license.

Standard Technical Specifications have been developed by the staff for each appropriate nuclear steam supply system (NSSS) vendor to provide guidance to applicants for the preparation of proposed Technical Specifications. These are as follows:

- NUREG-0212 - "Standard Technical Specifications for Combustion Engineering Pressurized Water Reactors"
- NUREG-0103 - "Standard Technical Specifications for Babcock and Wilcox Pressurized Water Reactors"

NUREG-0452 - "Standard Technical Specifications for Westinghouse Pressurized Water Reactors"

NUREG-0123 - "Standard Technical Specifications for General Electric Boiling Water Reactors"

Current Standard Technical Specifications are available from the National Technical Information Service (NTIS), Springfield, Virginia, 22161. These Standard Technical Specifications will contain the radiological effluent Technical Specifications to be used by the applicant for an operating license. In the interim, model radioactive effluent Technical Specifications have been provided in NUREG-0472 (Ref. 2) for pressurized water reactors, and NUREG-0473 (Ref. 3) for boiling water reactors. Table 1.1 provides a summary of those applicable sections in the Standard Technical Specifications which contain conditions and limitations relative to the radiological effluent Technical Specifications to be discussed in this manual.

The Standard Technical Specifications contain the limiting conditions for operation necessary for complying with the Commission's regulations and are in a format that is acceptable to the NRC staff. The reporting requirements reflect the guidelines provided in Regulatory Guide 1.16, "Reporting of Operating Information - Appendix A Technical Specifications," Revision 4, August 1975 (Ref. 4) and Regulatory Guide 10.1, "Compilation of Reporting Requirements for Persons Subject to NRC Regulations," Revision 3, May 1977 (Ref. 5).

The methodology discussed in this manual and used to implement the requirements of 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Practicable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents" (Ref. 1), is consistent with the Regulatory Guides used in the staff's safety evaluations pursuant to 10 CFR 50.34a(c). These guides are as follows:

Regulatory Guide 1.109 - "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I" (Revision 1), October 1977. (Ref. 6)

Regulatory Guide 1.110 - "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors," March 1976. (Ref. 7)

Regulatory Guide 1.111 - "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors" (Revision 1), July 1977. (Ref. 8)

Regulatory Guide 1.112 - "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors," April 1976. (Ref. 9)

TABLE 1.1
SUMMARY OF APPLICABLE SECTIONS IN THE STANDARD TECHNICAL SPECIFICATIONS
CONSIDERED IN THIS MANUAL

PLANT TYPE	Standard Technical Specification or Model Technical Specification in NUREG-0472 (Ref. 2) or NUREG-0473 (Ref. 3)			TITLE	SECTION REFERENCE IN THIS MANUAL
	SECTION	TABLES	BASES		
PWR BWR	1.0	Yes	No	Definitions	2.0
PWR BWR	3/4.3.3.8	Yes	Yes	Radioactive Liquid Effluent Instrumentation	4.1
PWR BWR	3/4.3.3.9	Yes	Yes	Radioactive Gaseous Effluent Instrumentation	5.1
PWR BWR	3/4.11.1.1	Yes	Yes	Liquid Effluents, Concentration	4.2
PWR BWR	3/4.11.1.2	No	Yes	Liquid Effluents, Dose	4.3
PWR BWR	3/4.11.1.3	No	Yes	Liquid Effluents, Liquid Waste Treatment	4.5
PWR BWR	3/4.11.1.4	No	Yes	Liquid Effluents, Liquid Holdup Tanks	4.4
PWR BWR	3/4.11.2.1	Yes	Yes	Gaseous Effluents, Dose Rate	5.2
PWR BWR	3/4.11.2.2	No	Yes	Dose, Noble Gases	5.3
PWR BWR	3/4.11.2.3	No	Yes	Dose Radioiodines, Radioactive Material in Particulate Form and Radionuclides Other than Noble Gases	5.3
PWR BWR	3/4.11.2.4	No	Yes	Gaseous Effluents, Gaseous Waste Treatment	5.4
PWR BWR	3/4.11.2.5	No	Yes	Gaseous Effluents, Dose	3.8
PWR BWR	3/4.11.2.6A	No	Yes	Explosive Gas Mixtures (Systems designed to withstand a hydrogen explosion)	5.5
PWR BWR	3/4.11.2.6B	No	Yes	Explosive Gas Mixtures (Systems not designed to withstand a hydrogen explosion)	5.5
PWR	3/4.11.2.7	No	Yes	Gaseous Effluents, Gas Storage Tanks	5.6
BWR	3/4.11.2.7	No	Yes	Gaseous Effluents, Main Condenser	5.6
BWR	3/4.11.3.8	No	Yes	Gaseous Effluents, Mark I or II Containment (Optional)	3.0
PWR BWR	3/4.11.3.1	No	Yes	Solid Radioactive Waste	3.0
PWR BWR	3/4.12.1	Yes	Yes	Monitoring Program	4.3, 5.3
PWR BWR	3/4.12.2	No	Yes	Land Use Census	4.3, 5.3
PWR BWR	Fig. 3.11-1	No	No	Unrestricted Area Boundary for Liquid Effluents	2.0
PWR BWR	Fig. 5.1-1	No	No	Unrestricted Area Boundary for Gaseous Effluents	2.0
PWR BWR	6.9	No	No	Reporting Requirements	General

Regulatory Guide 1.113 - "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I" (Revision 1), April 1977. (Ref. 10)

Computer codes used to determine certain values and parameters used with the Regulatory Guides listed above are described in the following documents:

- NUREG-0017 - "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," April 1976 (Ref. 11)
- NUREG-0016 - "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWR-GALE Code)" April 1976 (Ref. 12)
- NUREG-0324 - "XOQDOQ, Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," September 1977 (Ref. 13)

These guides and computer codes provide acceptable methods of complying with the Commission's regulations; however, conformance with the staff's guidelines on Standard Technical Specifications, Regulatory Guides, and dose calculation methodology is not required. If the proposed Technical Specifications include mathematical models and parameters that differ from the methodology used by the staff to calculate set points and release rates or estimate doses due to releases of radioactive materials in effluents, the parameters and calculations used shall be substantiated in the Offsite Dose Calculation Manual.

Based on the findings of the Environmental and Safety Hearings, the Commission may impose certain additional or alternative limiting conditions for operation based on values that are more restrictive than those determined using this manual or provided in the Standard Technical Specifications. In such cases, the limiting conditions will be based on the decisions of the Atomic Safety and Licensing Board rather than the limiting values determined by this manual or included in the Standard Technical Specifications.

CHAPTER 2

DEFINITIONS AND STAFF POSITIONS

2.1 DEFINITIONS

Section 1.0, DEFINITIONS, of the Standard Technical Specifications provides standard definitions of terms and phrases which appear capitalized throughout the specifications. Standard definitions are provided to assure licensing consistency. When a term or phrase is used in a limited subject area of the Standard Technical Specifications, it is defined in the limited subject area and referenced by Specification number, table, figure or footnote.

2.2 STAFF POSITIONS AUGMENTING STANDARD DEFINITIONS

In certain circumstances, terms used in the Standard Technical Specifications are defined or specified in applicable regulations, such as 10 CFR Part 50 (Ref. 1). Staff positions clarifying certain of these definitions are as discussed below.

LIMITING CONDITIONS FOR OPERATION (LCO) is defined in 10 CFR 50.36(c)(2) as "the lowest functional capability or performance levels of equipment required for safe operation of the facility." This definition is applicable to the components of the radioactive waste management systems during normal reactor operations, including anticipated operational occurrences. When an LCO for a nuclear power reactor is not met, the licensee shall either shut down the reactor or follow any remedial action permitted by the Technical Specifications until the LCO can be met. Remedial action by the licensee may include processing by normal or alternate modes of operation for the control of radioactive effluents using such existing equipment as may be installed in the radioactive waste management systems.

MAINTENANCE AND USE of the equipment installed in the radioactive waste management systems is required in 10 CFR 50.34a(c) and in 10 CFR 50.36a(a)(1). The term, MAINTENANCE AND USE, is applicable to the installed components of the liquid, gaseous, and solid radioactive waste management systems and to instrumentation installed for the monitoring and control of potentially radioactive effluents. MAINTENANCE AND USE does not require the installation of fully redundant systems; however, prudent management procedures, such as scheduled standby and maintenance periods should be employed. The Standard Technical Specifications specify levels or values above which equipment installed in the radioactive waste management systems shall be used to enable the licensee to show that he is exerting his best efforts to maintain levels of radioactive effluents "as low as is reasonably achievable," in accordance with 10 CFR 50.36a.

UNRESTRICTED AREA is defined in 10 CFR 20.3(a)(17) (Ref. 14), as "any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters."

For purposes of implementation, the definition of UNRESTRICTED AREA has been expanded as follows: "any area at or beyond the site boundary access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area within the site boundary used for residential quarters or industrial, commercial, institutional and recreational facilities". The UNRESTRICTED AREA boundary may coincide with the exclusion (fenced) area boundary, as defined in 10 CFR 100.3(a) (Ref. 15), may include land areas owned by the licensee, provided that occupancy is controlled by the licensee for the purposes of meeting the requirements of 10 CFR Part 20, but does not include areas over water bodies.

To assure that the UNRESTRICTED AREA boundary is defined in each license, the Standard Technical Specifications require two maps, one for liquid effluents (Figure 3.11-1)* and one for gaseous effluents (Figure 5.1-1)* locating all points surrounding the facility at which the licensee shall comply with the expanded definition, given above. These boundaries shall be consistent with those established in the Safety Analysis Report, or the Final Hazard Summary for the facility. The UNRESTRICTED AREAS, established at or beyond these boundaries, are also considered in the LIMITING CONDITIONS FOR OPERATION to keep levels of radioactive materials in effluents as low as is reasonably achievable, pursuant to 10 CFR 50.36a.

RELEASE RATE used in this manual is defined as, "the discharge of radioactive materials in liquid or gaseous effluents per unit time." The "second" is used as the practical reporting time unit for establishing release rates to show compliance with the requirements of 10 CFR Part 20 and for establishing instantaneous limitations based on potentially radioactive releases. The "hour" is used as the practical reporting time unit in establishing average release rates to show conformance with the requirements of 10 CFR Part 50 for noble gas releases, for gaseous radioactive effluents other than noble gases (radioiodines and particulates) and for radioactive materials released in liquid effluents. Liquid releases are further subdivided into batch and continuous releases. Gaseous releases are subdivided into short- and long-term releases. These gaseous release subdivisions classify cumulative releases as being either less than or greater than 500 hrs/year, respectively, for gaseous effluents. Further discussion is provided in Sections 3.3, 4.2 and 5.2 of this manual.

RADIOACTIVE WASTE MANAGEMENT SYSTEMS are defined as all process and control equipment provided to reduce the amount or concentration of radioactive materials (in any form) released from the facility. The overall systems may be divided into subsystems to handle the radioactive materials contained in liquid and gaseous streams and in solid waste. The Standard Technical Specifications have adopted nomenclature for systems and components which are in common use in the industry. In preparing proposed Technical Specifications, the system and component names may be changed to correspond to the terminology used in the Final Safety Analysis Report (FSAR) or the Final Hazard Summary, if applicable. Engineered Safety Feature (ESF) atmospheric cleanup systems are not considered to be radioactive waste management system components and, therefore, are not within the scope of this manual.

* This Figure is to be included in proposed Technical Specifications.

CHAPTER 3

SPECIAL CONSIDERATIONS

3.1 MULTI-UNIT SITES WITH SHARED RADIOACTIVE WASTE MANAGEMENT SYSTEMS

The Standard Technical Specifications are written on a "per unit" basis, since this is the format in which operating licenses are issued. When shared radioactive waste management systems are used by more than one reactor unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific reactor unit. The licensee should estimate the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases may be allocated equally to each of the radioactive waste producing reactors sharing the treatment system. For determining conformance to LCOs, these allocations from shared treatment systems are to be added to the releases specifically attributed to each unit to obtain the total releases per unit.

It is preferred that discharge lines leading to common release points be separately controlled and monitored, and the licensee should consider instrumentation which will provide volumetric recording and radiological effluent monitoring, sampling and analyses on a unit basis. This has been accomplished for some units by continuous representative sampling and analysis of the streams prior to mixing and continuously monitored and controlled at the common release point. Multi-unit sites with common release points, but without shared radioactive waste management systems, are also required to determine the alarm/trip setpoints in Sections 4.1 and 5.1 of this manual to assure compliance with the requirements of 10 CFR Part 20 (Ref. 14) at each release point.

In preparing Technical Specifications for units at adjacent sites (multi-unit stations with a common boundary), the sites should be considered as a multi-unit site.

3.2 POPULATION EXPOSURE

The Standard Technical Specifications 3.11.1.3 and 3.11.2.4 require the use of equipment installed in the radioactive waste management system to meet the requirements of 10 CFR 50.36a (Ref. 1).

To assure that the Technical Specifications consider the population radiation doses, the use of the installed radioactive waste management system is required when the projected cumulative doses exceed an appropriate fraction of the individual dose limitations. This method of establishing use of the radwaste equipment assures that the staff's Appendix I cost-benefit analysis in the safety evaluation is not invalidated. Sections 4.5 and 5.4 of this manual provide these values for the Standard Technical Specifications. Guidance on reporting population exposures is provided in Regulatory Guide 1.21 (Ref. 17).

3.3 METEOROLOGICAL DATA

The Standard Technical Specifications consider the historical annual average atmospheric dispersion condition rather than real time dispersion conditions in determining the LCO for radioactive materials in gaseous effluents.

Releases are characterized as "long" or "short" term, depending on the frequency and duration of the releases. This characterization permits the matching of the releases to more appropriate atmospheric diffusion, dispersion and decay conditions.

"Long-term" refers to releases that are generally continuous and stable in release rate with some anticipated variation (i.e., <50%, based on a running monthly average) in release rate, such as is experienced in normal ventilation system effluents at nuclear power plants. Determination of doses due to long-term releases should use the historical annual average relative concentration (λ/λ_0) based on meteorological data summarized, as recommended in Regulatory Guide 1.111 (Ref. 8):

"Short-term" refers to releases that are intermittent in radionuclide concentrations or flow, such as releases from PWR gas storage tanks, PWR containment ventings and purges, BWR drywell purges (See Standard Technical Specification 3.11.3.8), BWR mechanical vacuum pump exhausts, and systems or components with infrequent use. Short-term releases may be due to operational variations which result in radioactive releases greater than 50% of the releases normally considered as long-term. Short-term releases from these sources during normal operation, including anticipated operational occurrences, are defined as those which occur for a total of 500 hours or less in a calendar year but not more than 150 hours in any quarter. Determination of doses due to short-term releases can use the annual average relative concentration (long-term) if it can be demonstrated that past short-term releases were sufficiently random in both time of day and duration (e.g., the short-term release periods were not dependent solely on atmospheric conditions or time of day) to be represented by the annual average dispersion conditions. Otherwise, the short-term relative concentration value should be calculated in accordance with the guidelines provided in NUREG-0324 (Ref. 13) for short-term release.

Even though "annual average" atmospheric dispersion conditions are used as basis for the Standard Technical Specifications, "real time" meteorological data should be summarized hour-by-hour and coupled with the corresponding releases, and the summary should be included in the SEMIANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT.

3.4 NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

Operators of nuclear power plants located on fresh water bodies which are used as sources of water for drinking water supply systems, are required to make a special report concerning the impact on the water supply system due to liquid effluent releases into the water bodies which are above the value(s) permitted in Specification 3.11.1.2 of the Standard Technical Specifications. The NRC has no legal responsibility to implement 40 CFR Part 141, "National Interim Primary Drinking Water Regulations" (Ref. 16), or to assure routine conformance to the Act since this is the responsibility of the Environmental Protection Agency and the

water plant operator. This special report is intended for public information and as a tool to assure awareness by the licensee of the impact of radioactive liquid releases on the community's water supply system. The impact within the water supply system is dependent on treatment given to the water taken into the system. The water plant operator is responsible for providing appropriate treatment to assure that 40 CFR Part 141 requirements are met. While the operator of the nuclear power plant is not responsible for meeting the requirements of 40 CFR Part 141 in the water supply system, his success in meeting the requirements of Specification 3.11.1.2 will assure an environmentally acceptable impact on the water supply system. The non-radiological impact is separately considered in the Appendix B Technical Specifications.

3.5 SOLID WASTE MANAGEMENT SYSTEM - PROCESS CONTROL PROGRAM

Standard Technical Specification 3.11.3.1 requires the operator of each nuclear power plant to establish a PROCESS CONTROL PROGRAM for the solid radioactive waste management system. The purpose of the PROCESS CONTROL PROGRAM is to provide reasonable assurance of the complete SOLIDIFICATION of processed wastes and of the absence of free water in the processed waste. At the time the applicant submits proposed Technical Specifications, he should submit the PROCESS CONTROL PROGRAM for NRC review and approval prior to implementation. The PROCESS CONTROL PROGRAM should consist of the processing steps and a set of established process parameters, which include but are not limited to pH, oil content, ratio of solidification agent to influent waste, water content, and ratio of solidification agent to chemical additive for each type of anticipated waste (filter sludges, spent resins, evaporator bottoms, boric acid solutions, sodium sulfate solutions and filter media). The surveillance requirements in the Standard Technical Specifications provide the steps to be taken to assure that operation is within the parameters established by the PROCESS CONTROL PROGRAM. Packaging procedures should demonstrate conformance with Specification 3.11.3.1. The PROCESS CONTROL PROGRAM required by the Standard Technical Specifications is to be documented in the operating procedures for each reactor and available for review by the NRC inspector. A summary of changes to the PROCESS CONTROL PROGRAM shall be provided in the SEMIANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT.

3.6 OFFSITE DOSE CALCULATION MANUAL (ODCM)

Standard Technical Specifications 3.3.3.8 and 3.3.3.9 require the operator of each nuclear power plant to establish alarm and trip action setpoints for each radioactive liquid and gaseous effluent release point in maintained, auditable records, determined in accordance with the OFFSITE DOSE CALCULATION MANUAL (ODCM). The ODCM shall contain the methodology and parameters to be used in the calculation of offsite doses due to radioactive liquid and gaseous effluents pursuant to Specifications 3.11.1.2, 3.11.2.2 and 3.11.2.3, and the established limits of Specifications 3.11.1.1 and 3.11.2.1. The ODCM shall be submitted to the NRC with the proposed Technical Specifications for review and approval by the NRC. Changes to the ODCM shall be provided in the SEMIANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT.

3.7 IDENTIFICATION OF RADIONUCLIDES IN EFFLUENTS

In order to determine the radiological impact associated with the release of radioactive materials in liquid and gaseous effluents, the principal radionuclides contributing to the

dose must be identified. Tables 4.11-1 and 4.11-2** of the Standard Technical Specifications contain the sampling and analysis programs required for identifying principal radionuclides in effluents. These tables were compiled using the guidelines of Regulatory Guide 1.21 (Ref. 17) and reflect current radiochemical analytical methods. Other methods may be necessary to enhance identification and analysis, as provided by the footnotes to Tables 4.11-1 and 4.11-2. In lieu of sample-analysis, if the applicant does not consider that the collection, radiochemical separation, and analytical methods are technically feasible or practical at the specified LLD, then the dose limitations in Specifications 3.11.1.2, 3.11.2.2, and 3.11.2.3 should be proportionally reduced by assuming the continued presence and release concentrations of those radionuclides as determined by the source term (GALE Code, Ref. 11 or 12). For example, the dose LCO may be reduced based on predicted radioactive materials in gaseous effluents from PWR turbine buildings if sampling is not provided. For BWRs and PWRs it may be reduced if carbon-14 analysis is not provided.

3.8 ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR NUCLEAR POWER OPERATIONS

Standard Technical Specification 3.11.2.5 specifies in the Action that when the calculated doses associated with the effluent releases exceed twice* the limits of any one of the Specifications 3.11.1.2, 3.11.2.2 or 3.11.2.3, the licensee shall prepare and submit a Special Report to the Commission and limit subsequent releases such that the dose or dose commitment to a real individual from all uranium fuel cycle sources is limited to ≤ 25 mrem to the total body or any organ (except the thyroid, which is limited to ≤ 75 mrem) over 12 consecutive months. This Special Report shall include an analysis which demonstrates that radiation exposures to all real individuals from all uranium fuel cycle sources (including all liquid and gaseous effluent pathways and direct radiation) are less than the standards in 40 CFR Part 190, Environmental Radiation Protection Standards for Nuclear Power Operations (Ref. 18). If analysis indicates that releases resulting in doses that exceed the 40 CFR 190 Standard could occur, obtain a variance from the Commission to permit such releases. The Standard Technical Specifications 3.11.1.2, 3.11.2.2 and 3.11.2.3 consider doses to a real individual and apply to each reactor but do not include any other portion of the uranium fuel cycle or direct shine from the reactor.

The "Uranium fuel cycle" is defined in 40 CFR Part 190.02(b) as:

"Uranium fuel cycle means the operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy, but excludes mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and by-product materials from the cycle."

The following general guidelines are presented for preparation of the Special Report:

- 1) determine which uranium fuel cycle facilities or operations, in addition to the nuclear power reactor units at the site, contribute to the annual dose to the maximum exposed member of the public. The maximum exposed member of the public for

*This value may be reduced for multi-unit sites depending on staff analysis.

**These Tables are to be included in proposed Technical Specifications.

this evaluation may or may not correspond to the individual considered in the Technical Specification;

- 2) determine the total annual dose to this person from all existing pathways and sources of radioactivity and radiation using the methodologies described in this NUREG document and applicable references. Where additional information on pathways and nuclides is needed, the best available information should be used and documented;
- 3) include direct radiation from the site in the dose determination. An acceptable method for calculating radiation from the N-16 component of direct radiation is: SKYSHINE, A Computer Procedure for Evaluating Effects of Structure Design on N-16 Gamma-Ray Dose Rates, Radiation Research Associates, Inc. Report RRA-T7209, November 1972 (Ref. 19).

In addition to N-16, all direct radiation from the plant and storage facilities should be considered in the dose determination. The direct dose component (including N-16) may be determined by calculation or actual measurement (e.g., high pressure ionization chamber). The calculation or actual measurement must be documented in this Special Report.

The 25 mrem and 75 mrem dose standards are effective December 1, 1979, except for doses arising from operations associated with the milling of uranium ore which is effective December 1, 1980.

Further information on the method of implementation of 40 CFR Part 190 is being developed by the NRC staff.

CHAPTER 4

LIQUID EFFLUENTS

4.1 INSTRUMENTATION

Standard Technical Specification 3.3.3.8 requires that:

"The radioactive liquid effluent monitoring instrumentation channels shown in Table 3.3-11* shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of Specification 3.11.1.1 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."

Table 3.3-11* provides a list of radioactive liquid effluent monitoring instrumentation needed to comply with the requirements of General Design Criteria (GDC) 60, 63, and 64 of Appendix A to 10 CFR Part 50 (Ref. 1). The list includes instrumentation such as radioactivity monitoring and sampling devices, automatic control devices, and essential flow and level devices which are components of the monitoring channels. The list uses common nomenclature for the effluent streams; however, the names may be revised, as necessary, to conform with a particular plant's nomenclature. Deletion of any item listed should be justified. Clarification of proposed Technical Specifications should be provided by a simple drawing or sketch showing stream intersections, instrumentation, and control features. Duplicate instrumentation (i.e., instruments that measure different sensor parameters or ranges) should be listed separately. The channel logic should assure that the alarmed trip action is not negated by switching.

The plant procedures should contain a quality assurance program for instruments as recommended in Regulatory Guide 4.15 (Ref. 20).

4.1.1 Setpoint Determination to be Provided in the ODCM

The alarm and trip setpoint(s) for each instrument channel listed in Table 3.3-11* should be provided and should correspond to a value(s) which represents a safe margin of assurance that the instantaneous liquid release limit of 10 CFR Part 20 is not exceeded. If the alarm and the automatic control trip are separate devices, the alarm/trip setpoint in the ODCM should list the separate trip setpoints. The alarm/trip setpoint in the ODCM should list the alarm setpoint where any trip actions are by manual initiation. The method for calculating fixed and adjustable setpoints shall be provided in the ODCM and auditable records shall be maintained indicating the actual setpoints used at all times. For setpoint calculations, see the Addendum to this manual.

* This Table is to be included in proposed Technical Specifications.

The alarm/trip setpoint for a liquid effluent radiation monitor should be determined based on the instantaneous concentration limits of 10 CFR Part 20, Appendix B, Table II, Column 2, and are to be applied at the point of discharge for that stream, pipe or conduit into the unrestricted area, as defined by Figure 3.1-1.* The alarm/trip setpoint should not consider dilution, dispersion or decay in the unrestricted area beyond the release point. An isolation control valve or system shall be provided on the discharge line prior to the release point to permit termination of radioactive releases prior to exceeding the instantaneous concentration limits of 10 CFR Part 20. The isolation and radiation monitoring points are to be located upstream of the release point far enough to assure that the time lag between the established alarm and isolation of the release will not permit a release exceeding these limits. If the stream is diluted by non-radioactive effluents, and the stream dilution and effluent isolation control system is in the exclusion area, the monitor's alarm/trip setpoint may be determined by considering the known in-plant dilution. In-plant dilution is the ratio of the total release rate at the release point into the unrestricted area to the release rate of the undiluted stream, and should be based on continuous measurement of these liquid flows. In such cases, alarm/trip setpoints should also be provided on the flow or level instrumentation with indication in the main control room. The minimum or actual instantaneous in-plant dilution ratio on which the liquid effluent radiation monitor alarm/trip setpoint has been based, should be continuously measured to aid prompt corrective action to satisfy Specification 3.11.1.1.

Conservative assumptions may be included in establishing setpoints to account for such system variables as the control and measurement system efficiency and detection capabilities during normal and anticipated operating conditions, the effects of multiple release points with common or shared in-plant dilution, variability of dilution flow and principal radionuclide composition, and the time lag between alarm/trip action and final isolation of the radioactive effluent. A record of analyses showing current spectra of radionuclides used to calibrate radiation monitors should be maintained in the plant records.

The instruments listed in Table 3.3-11** should also be included in Table 4.3-11** to provide the instrument surveillance requirements, such as calibration, source checking, functional testing and channel checking.

4.2 REQUIREMENT FOR IMPLEMENTING 10 CFR PART 20

In preparing proposed Technical Specifications, Figure 3.11-1* should consist of a map of the site area, showing the unrestricted area boundary for liquid effluents, as defined in 10 CFR 20.3(a)(17). Guidelines for preparing the figure are contained in Section 2.1.1 of Regulatory Guide 1.70 (Ref. 21).

Standard Technical Specification 3.11.1.1 specifies that:

* This Figure is to be included in proposed Technical Specifications.

** See footnote on page 12.

"The concentration of radioactive material released from the site to unrestricted areas (see Figure 3.11-1)* shall be limited to the concentrations specified in 10 CFR Part 20, Appendix B, Table II, Column 2 for radionuclides other than noble gases and 2×10^{-4} $\mu\text{Ci/ml}$ total activity concentration for all dissolved or entrained noble gases."

The concentration limits provided in 10 CFR Part 20, Appendix B, Table II, Column 2, do not include an MPC for noble gases dissolved or entrained in liquid effluents. An MPC of 2×10^{-4} $\mu\text{Ci/ml}$ has been established, based on the assumption that xenon-135 is the controlling radionuclide; the Xe-135 MPC in air (submersion) was converted to an equivalent concentration in water using the method described in International Commission on Radiological Protection (ICRP) Publication 2 (Ref. 22). The value of 2×10^{-4} $\mu\text{Ci/ml}$ shall be used for a mixture of dissolved or entrained noble gases, not otherwise identified in liquid releases.

To demonstrate that the Specifications are being met, the surveillance requirements specify that a sampling and analysis program be implemented according to Table 4.11-1.** There are two general types of releases: batch and continuous. A batch release is the discharge of liquid waste of a discrete volume. A continuous release is the discharge of liquid wastes of a nondiscrete volume; e.g., from a volume or system that has an input flow during the continuous release. For example, releases from sample monitor tanks are batch, and releases from steam generator blowdown are continuous. The sampling and analysis frequency and the type of analysis required by the Standard Technical Specifications is given in Table 4.11-1 for each type of release. The lower limit of detection is also specified in Table 4.11-1 for typical in-plant radiochemical analysis equipment. This program meets the requirements of 10 CFR Part 50, GDC 64, and conforms to the guidelines given in Regulatory Guides 1.21 (Ref. 17) and 4.15 (Ref. 20).

4.3 REQUIREMENT FOR IMPLEMENTING 10 CFR PART 50

The Standard Technical Specification 3.11.1.2 requires that the cumulative dose contributions be determined in accordance with the ODCM at least once per 31 days. The cumulative dose contributions should consider the dose contributions from the maximum exposed individual's consumption of fish, invertebrates and potable water, as appropriate. Normally, the adult is the maximum exposed individual. All of these pathways should be considered in the calculation unless demonstrated not to be present. For many plant sites, the dose calculations may be performed assuming conservative dilution factors and receptor locations to show compliance with the Technical Specification rather than a more rigorous determination. The relationships presented below are acceptable for inclusion in the ODCM. If other methods are selected to implement this Specification, it is expected that the alternate method will include the same general features considered below.

* See footnote on page 13.

** See footnote on page 12.

The dose contributions for the total time period $\sum_{\ell=1}^m \Delta t_{\ell}$ should be determined by calculation at least once per 31 days and a cumulative summation of these total body and any organ doses should be maintained for each calendar quarter. These dose contributions should be calculated for all radionuclides identified in liquid effluents released to unrestricted areas using the following expression:

$$D_{\tau} = \sum_i [A_{i\tau} \sum_{\ell=1}^m \Delta t_{\ell} C_{i\ell} F_{\ell}]$$

where:

D_{τ} = the cumulative dose commitment to the total body or any organ, τ , from the liquid effluents for the total time period $\sum_{\ell=1}^m \Delta t_{\ell}$, in mrem.

Δt_{ℓ} = the length of the ℓ th time period over which $C_{i\ell}$ and F_{ℓ} are averaged for all liquid releases, in hours.

$C_{i\ell}$ = the average concentration of radionuclide, i , in undiluted liquid effluent during time period Δt_{ℓ} from any liquid release, in $\mu\text{Ci/ml}$.

$A_{i\tau}$ = the site related ingestion dose commitment factor to the total body or any organ τ for each identified principal gamma and beta emitter listed in Table 4.11-1,* in mrem-ml per hr- μCi .

F_{ℓ} = the near field average dilution factor for $C_{i\ell}$ during any liquid effluent release. Defined as the ratio of the maximum undiluted liquid waste flow during release to the product of the average flow from the site discharge structure to unrestricted receiving waters times _____. (_____ is the site specific applicable factor for the mixing effect of the discharge structure.)

The term $C_{i\ell}$ is the composite undiluted concentration of radioactive material in liquid waste at the common release point determined from the Radioactive Liquid Waste Sampling and Analysis Program, Table 4.11-1* in the Standard Technical Specifications. All dilution factors beyond the sample point(s) are to be included in the F_{ℓ} and $A_{i\tau}$ terms.

The term F_{ℓ} is a near field average dilution factor, considering the combined liquid releases from each unit even if there is more than one release point to the unrestricted area per unit within one-quarter mile of each other. As described in Section 3.1 of this manual, multi-unit sites with shared radioactive waste management systems should calculate the total continuous and batch liquid release concentrations for each reactor. The value of the term F_{ℓ} should be determined as:

* See footnote on page 12.

$$F_{\ell} = \frac{\text{liquid radioactive waste flow per unit}}{\text{discharge structure exit flow per unit} \times \text{applicable factor}}$$

The liquid radioactive waste flow is the maximum flow from all continuous and batch radioactive effluent releases specified in Table 4.11-1, from all liquid radioactive waste management systems, per unit. The discharge structure exit flow is the average flow during disposal from the discharge structure release point into the receiving water body (in an unrestricted area) per unit. The definition of F_{ℓ} also requires a value to be included in Specification 3.11.1.2 for the dilution as a result of mixing effects in the near field of the discharge structure. For plants with once through cooling, the applicable factor is set equal to one, i.e., no additional dilution is considered. For plants with cooling towers, onsite ponds, or lagoons, the factor shall be a number such that the product of the average blowdown flow to the receiving water body, in cfs and the applicable factor, is 1000 cfs or less. The 1000 cfs figure was selected to correspond to a typical flow for a unit with once-through cooling water and agrees with the staff method for determining compliance with Appendix I (Ref. 1) at the OL stage. The value of this applicable factor is to be included in the blank provided for the term F_{ℓ} . The actual dilution factor value is dependent upon the dilution available in the near field of the receiving water body; however, the applicable factor is limited, as stated above.

4.3.1 Dose Factor Related to Liquid Effluents

The above equation for calculating the dose contributions requires the use of a dose factor $A_{i\tau}$ for each nuclide, i , which embodies the dose factors, pathway transfer factors (e.g., bioaccumulation factors), pathway usage factors, and dilution factors for the points of pathway origin. The adult total body dose factor and the maximum adult organ dose factor for each radionuclide will be used from Table E-11 of Regulatory Guide 1.109 (Ref. 6); thus the list should contain critical organ dose factors for various organs. The dose factor may be written:

$$A_{i\tau} = k_0 (U_w/D_w + U_f BF_i + U_I BI_i) DF_i$$

where

$A_{i\tau}$ = composite dose parameter for the total body or critical organ of an adult for nuclide, i , for all appropriate pathways, mrem/hr per $\mu\text{Ci/ml}$.

k_0 = units conversion factor, $1.14 \times 10^5 = 10^6 \text{ pCi}/\mu\text{Ci} \times 10^3 \text{ ml/kg} \div 8760 \text{ hr/yr}$.

U_w = 730 kg/yr, adult water consumption (fresh water site only).

U_f = 21 kg/yr, adult fish consumption (all sites).

U_I = 5 kg/yr, adult invertebrate consumption (salt water site only).

BF_i = Bioaccumulation factor for nuclide, i , in fish (fresh or salt water site, as applicable), pCi/kg per pCi/l , from Table A-1 of Regulatory Guide 1.109 (Ref. 4).

BI_i = Bioaccumulation factor for nuclide, i , in invertebrates (salt water only), pCi/kg per pCi/l , from Table A-1 of Regulatory Guide 1.109 (Ref. 4).

DF_i = Dose conversion factor for nuclide, i , for adults in pre-selected organ, τ , in mrem/pCi, from Table E-11 of Regulatory Guide 1.109 (Ref. 4).

D_W = Dilution factor from the near field area within one-quarter mile of the release point(s) to the potable water intake for the adult water consumption (fresh water site only).

Inserting the usage factors of Regulatory Guide 1.109 (Ref. 6) as appropriate into the equation gives the following expressions:

For Fresh Water sites: $A_{iT} = 1.14 \times 10^5 (730/D_W + 21BF_i) DF_i$

For Salt Water sites: $A_{iT} = 1.14 \times 10^5 (21BF_i + 5BI_i) DF_i$

As noted, all the factors required to calculate the values of A_{iT} should be contained in the ODCM. The staff's method of calculating dilution factors for aquatic dispersion is provided in Regulatory Guide 1.113 (Ref. 10). The ODCM should include a detailed presentation of the calculation model and a tabulation of all values assigned to the parameters in expressions used to implement the Specification 3.11.1.2.

4.3.2 Special Reports

The Standard Technical Specifications 3.11.1.2, 3.11.1.3, 3.11.2.2, 3.11.2.3, 3.11.2.4 and 3.11.3.1 require that action be taken when the Specification cannot be met. The action is in the form of special reports, in lieu of licensee event reports, indicating the corrective action to be taken to reduce the dose impact due to the release of radioactive materials in liquid effluents.

These special reports should be prepared using the methodology provided in this manual to determine the dose impact. Such information in the special reports will be used by the staff in determining if the corrective action proposed by the licensee is adequate to bring the releases within the design objectives of Appendix I to 10 CFR Part 50. These special reports may also require submitting additional information as described in Section 3.4 of this manual.

4.4 SPECIFICATION ON RADIOACTIVITY CONTENTS IN LIQUID-CONTAINING TANKS

Standard Technical Specification 3.11.1.4 and Tables 3.3-11* and 4.3-11* list liquid-containing tanks outside containment that are to be analyzed periodically to verify that the radioactivity content (in curies, excluding tritium and dissolved or entrained noble gases) is below the specified value. Tanks included in this Specification are those that are not surrounded by liners, dikes or walls capable of holding the tank contents and do not have tank overflow and drains connected to the liquid radioactive waste management system. Indoor tanks are not included unless an analysis based on design basis fission product leakage from the fuel results in radionuclide concentrations in excess of the limits of 10 CFR Part 20, Appendix B, Table II, Column 2, where leaked fluid is capable of affecting the nearest existing or known future water supply** in an unrestricted area.

* See footnote on page 12.

** "Supply" means a well or surface water intake that is used as a water source for direct human consumption or indirectly through animals, crops or food processing. "Known future" water supply means potential wells or surface water intakes which are identified, or may be reasonably deduced from available information.

For those tanks that are determined to be included in Specification 3.11.1.4 and Tables 3.3-11 and 4.3-11, a curie limit should be determined based on the methodology presented in Appendices A or B of this manual, using the PWR-RATAFR Computer Code for pressurized water reactor plants, or the BWR-RATAFR Computer Code for boiling water reactor plants, respectively. The methodology is based on the calculated radionuclide inventory in the tank at 80% capacity using a design basis fission product source term of (1) 1% of the operating fission product inventory in the core being released to the primary coolant for a PWR, or (2) a fission product release consistent with a noble gas release rate of 100 $\mu\text{Ci}/\text{Mwt-sec}$ at 30 minutes decay for a BWR. These Computer Codes determine the radionuclide inventory in a tank that would result in concentrations equal to the limits of 10 CFR Part 20, Appendix B, Table II, Column 2, at (1) the nearest potable water supply and (2) the nearest surface water supply in an unrestricted area.

By excluding tritium and dissolved or entrained noble gases from the surveillance analyses, since these can be estimated for any licensee event report, Specification 3.11.1.4 should include the lowest curie quantity of activation and mixed fission products determined for any tank listed in Specification 3.11.1.4 as the curie limit for all tanks included in that Specification.

Most operating reactors have required the use of temporary process and storage tanks during maintenance and service periods, or when temporary solidification equipment is used at the facility; therefore, the Specification 3.11.1.4 should indicate a "temporary tank." The curie limit for a temporary tank may be calculated by the above method, but should be limited to ≤ 10 curies, excluding tritium and dissolved or entrained gases. If the temporary tank is mobile and not used for more than a calendar quarter, it need not be included in Tables 3.3-11* and 4.3-11.*

4.5 SPECIFICATION ON THE USE OF LIQUID RADIOACTIVE WASTE MANAGEMENT SYSTEM

Standard Technical Specification 3.11.1.3 specifies that:

"The liquid radwaste treatment system shall be OPERABLE. The appropriate subsystems shall be used to reduce the radioactive materials in liquid wastes prior to their discharge when the projected doses due to the liquid effluent releases to unrestricted areas (see Figure 3.11-1)* when averaged over 31 days, exceeds 0.06 mrem to the total body or 0.2 mrem to any organ."

The operability of the liquid radioactive waste management system ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the environment. The term "liquid radwaste treatment system" involves all of the installed and available liquid radioactive waste management system equipment, as well as their controls, power instrumentation, and services that make the system functional. Equipment that is considered standby or redundant is also included, since their function is to assure operability. The specification also permits alternate treatment paths using alternate subsystems and equipment to be used in the event that the normal treatment is inoperable.

* See footnote on page 13.

This Specification requires maintenance and use of the liquid radioactive waste management system for conformance to 10 CFR Part 50.36a. Maintenance and use of the radioactive waste management system components are discussed in Section 2.2 of this manual.

To determine if use of the installed equipment is necessary, the licensee must project the cumulative liquid effluent releases over the ensuing 31 days. These releases should include all plant effluents from all liquid radioactive waste management and liquid waste disposal system components that are planned to be operated at the projected capacity and performance of each component used during the specified time. These releases should include a margin, based on operating data, for anticipated and unplanned operational occurrences and should use the methodology discussed in Section 4.3 of this manual. The impact from this projected cumulative release is to be compared to 0.06 mrem for the total body or 0.2 mrem for any organ. If the projection indicates these values will be exceeded, then the installed liquid radioactive waste management system components that will reduce those radioactive materials in liquid effluents and the projected impact, must be used.

The values for the projected impact, given above, correspond to approximately one forty-eighth of the design objective values of Appendix I, Section II.A of 10 CFR Part 50 in a month, and if continued at this rate for a year, they would correspond to less than one-fourth the values limited by Specification 3.11.1.2.b. The calculations of projected cumulative dose impact that could result from the proposed operation should use the methodology provided in Section 4.3 of this manual.

CHAPTER 5

GASEOUS EFFLUENTS

5.1 INSTRUMENTATION

Standard Technical Specification 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 ensure 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."

Table 3.3-12* provides a list of the radioactive gaseous effluent monitoring instrumentation needed to comply with the requirements of General Design Criteria (GDC) 60, 63, and 64 of Appendix A to 10 CFR Part 50. The list includes instrumentation such as radioactivity monitoring and sampling devices, automatic control devices and essential flow and level devices that are components of the monitoring systems. The list uses common nomenclature for the effluent streams; however, the names may be revised as necessary, to conform with a particular plant's nomenclature. The list may include effluent streams which are not applicable to a given plant, or which may be duplicated and, therefore, should be tailored for the proposed Technical Specifications. Clarification of proposed Technical Specifications should be provided by a simple drawing or sketch, showing stream intersections, instrumentation and control features. Duplicate instrumentation (i.e., instruments that measure different sensor parameters or ranges) should be listed separately in Tables 3.3-12* and 4.3-12.* The channel logic should assure that the alarmed trip action is not negated by switching.

The plant procedures should contain a quality assurance program for instruments as recommended in Regulatory Guide 4.15 (Ref. 20).

5.1.1 Setpoint Determination to be Provided in the ODCM

The alarm/trip setpoint or automatic control trip setpoint 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. For channels with separate alarm and automatic control trips, the setpoint for the automatic control trip should be the established value referenced above; 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. For channels with alarm trips only, the setpoint for the alarm/trip should be the established value referenced above, provided that the manual or procedural response to the alarm represents a safe margin of assurance that the instantaneous gaseous release limit of 10 CFR Part 20 will not be exceeded. The alarm/trip setpoint in the ODCM should list the alarm setpoint for those channels where any trip actions are by

* This Table is to be included in the proposed Technical Specifications.

manual initiation. The method for calculating fixed or adjustable setpoints shall be provided in the ODCM and auditable records shall be maintained indicating the actual setpoints used at all times.

The alarm/trip setpoint for any gaseous effluent radiation monitor should be determined based on the instantaneous (see RELEASE RATE fundamental time units in Section 2.2 of this manual) concentration limits of 10 CFR Part 20, Appendix B, Table II, Column 1, and are to be applied at the point at which the discharge leaves the restricted area boundary into an unrestricted area, as defined by Figure 5.1-1.** The bases for each setpoint should consider the type of release at the monitor's location, e.g., long-term releases using the long-term atmospheric dispersion conditions or, if applicable (see Section 3.3 of this manual), short-term releases using the short-term atmospheric dispersion conditions. An isolation control valve or system shall be provided on the discharge line upstream of the release point to permit isolation prior to exceeding the specified release limits.

If the alarm/trip setpoints are based on predetermined factors accounting for atmospheric conditions, the elevation of the release point should be considered. The symbols used in the equations in this manual use a subscript (s) for a free-standing stack for elevated releases (or vents that take the plume out of the building wake) and a subscript (v) for vent for releases that are not completely elevated. Guidance on the staff's method for estimating atmospheric transport and dispersion of gaseous effluents in routine releases is provided in Regulatory Guide 1.111 (Ref. 8). The radiation monitor alarm/trip setpoints for each release point should be based on the radioactive noble gases in gaseous effluents. It is not considered to be practicable to apply instantaneous alarm/trip setpoints to integrating radiation monitors sensitive to radioiodines, radioactive materials in particulate form and radionuclides other than noble gases. Alarm/trip setpoints should also be provided in the main control room for flow measurement devices which are part of continuous monitoring or sampling systems and should alarm on loss-of-flow or departure from an established flow range. In all cases, conservative assumptions may be necessary in establishing these setpoints to account for system variables, such as the control and measurement system efficiency and detection capabilities during normal, anticipated, and unusual operating conditions, the variability in release flow and principal radionuclides, and the time lag between alarm/trip action and the final isolation of the radioactive effluent. The current spectrum of radionuclides used to calibrate radiation monitors should be maintained in the plant records. The instruments listed in Table 3.3-12* should also be included in Table 4.3-12,* to provide the instrument surveillance requirements, such as calibration, source checking, functional testing, and channel checking.

5.2 DOSE LIMIT FOR IMPLEMENTING 10 CFR PART 20

In preparing proposed Technical Specifications, Figure 5.1-1** should consist of a map of the site area showing the exclusion boundary, as defined in 10 CFR 100.3(a) (Ref. 15) and the unrestricted area boundary, as defined in 10 CFR 20.3(a)(17) (Ref. 14). Guidelines for this figure are contained in Section 2.1.1 of Regulatory Guide 1.70 (Ref. 21). Details on the release point locations and significant elevations should be given in Figure 5.1-1.**

* See footnote on page 20.

** This Figure is to be included in proposed Technical Specifications.

5.2.1 Implementation of 10 CFR Part 20 - Airborne Releases

The Standard Technical Specification 3.11.2.1 implements 10 CFR Part 20 as follows:

"The instantaneous dose rate in unrestricted areas (see Figure 5.1-1)** due to radioactive materials released in gaseous effluents from the site shall be limited to the following values:

- a. The dose rate limit for noble gases shall be < 500 mrem/yr to the total body and < 3000 mrem/yr to the skin, and
- b. The dose rate limit for all radioiodines and for all radioactive materials in particulate form and radionuclides other than noble gases with half lives greater than 8 days shall be < 1500 mrem/yr to any organ."

The ODCM should provide the mathematical relationships used to implement the above specification. The relationships presented below are acceptable for inclusion in the ODCM. If other methods are selected to implement the specification, it is expected that the alternative method will include the same general features considered below.

- a. Release rate limit for noble gases:

$$\sum_i [V_i \dot{Q}_{iS} + K_i ((\bar{x}/Q)_V \dot{Q}_{iV})] < 500 \text{ mrem/yr, and}$$

$$\sum_i [(L_i (\bar{x}/Q)_S + 1.1 B_i) \dot{Q}_{iS} + (L_i + 1.1 M_i)((\bar{x}/Q)_V \dot{Q}_{iV})] < 3000 \text{ mrem/yr}$$

where the terms are defined below.

- b. Release rate limit for all radionuclides and radioactive materials in particulate form and radionuclides other than noble gases:

$$\sum_i P_i [W_S \dot{Q}_{iS} + W_V \dot{Q}_{iV}] < 1500 \text{ mrem/yr}$$

where:

K_i = The total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per $\mu\text{Ci}/\text{m}^3$.

L_i = The skin dose factor due to beta emissions for each identified noble gas radionuclide, in mrem/yr per $\mu\text{Ci}/\text{m}^3$.

M_i = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per $\mu\text{Ci}/\text{m}^3$ (unit conversion constant of 1.1 mrem/mrad converts air dose to skin dose).

P_i = The dose parameter for radionuclides other than noble gases for the inhalation pathway, in mrem/yr per $\mu\text{Ci}/\text{m}^3$ and for food and ground plane pathways, in $\text{m}^2(\text{mrem}/\text{yr per } \mu\text{Ci}/\text{sec})$. The dose factors are based on the critical individual organ and most restrictive age group (infant).

V_i = The constant for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume, derived in accordance with the dose methodology in Regulatory Guide 1.109, Appendix B, Section 1, in mrem/yr per $\mu\text{Ci}/\text{sec}$.

B_i = The constant for long-term releases (greater than 500 hrs/yr) for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume, derived in accordance with the dose methodology in Regulatory Guide 1.109, Appendix B, Section 1, in mrad/yr per $\mu\text{Ci}/\text{sec}$.

** See footnote on page 21.

- \dot{Q}_{is} = The release rate of radionuclides, i , in gaseous effluents from free-standing stack, in $\mu\text{Ci}/\text{sec}$ (per unit, unless otherwise specified.)
- \dot{Q}_{iv} = The release rate of radionuclides, i , in gaseous effluent from all vent releases, in $\mu\text{Ci}/\text{sec}$ (per unit, unless otherwise specified).
- $(\overline{x/Q})_s$ = _____ sec/m^3 . For free-standing stack releases. The highest calculated annual average relative concentration for any area at or beyond the unrestricted area boundary.
- $(\overline{x/Q})_v$ = _____ sec/m^3 . For all vent releases. The highest calculated annual average relative concentration for any area at or beyond the unrestricted area boundary.
- W_v = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location due to all vent releases:
- $W_v =$ _____ sec/m^3 , for the inhalation pathway. The location is the unrestricted area boundary in the _____ sector.
- $W_v =$ _____ meters^{-2} , for the food and ground plane pathways. The location is the unrestricted area boundary in the _____ sector.
- W_s = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location due to free-standing stack releases:
- $W_s =$ _____ sec/m^3 , for the inhalation pathway. The location is the unrestricted area boundary in the _____ sector.
- $W_s =$ _____ meters^{-2} , for the food and ground plane pathways. The location is the unrestricted area boundary in the _____ sector."

SPECIAL NOTES: (1) If there are no free-standing stacks, the factors denoted by the subscript, s , need not be considered. (2) In all cases, the tritium releases use the first W parameter, based on relative concentration (sec/m^3). (3) All radioiodines are assumed to be released in elemental form. If analysis includes the capability of determining elemental and nonelemental forms in all releases, the food pathway parameters may be adjusted accordingly.

The Specification is applicable to the location (unrestricted area boundary or beyond), characterized by the values of the parameters V_i , B_i or $(\overline{x/Q})$ which result in the maximum total body or skin dose commitment. In the event that the analyses indicates a different location for the total body and skin dose limitations, the location selected for consideration shall be that which minimizes the allowable release values.

The factors K_i , L_i , and M_i relate the radionuclide airborne concentrations to various dose rates assuming a semi-infinite cloud. These factors may be taken directly from Table B-1 of the Regulatory Guide 1.109 (Ref. 6), if the values therein are multiplied by 10^6 to convert picocuries $^{-1}$ to microcuries $^{-1}$ as used in the above equations. A tabulation of these factors should be included in the ODCM.

The B_i and V_i factors for the radionuclides are based on the finite plume model of Regulatory Guide 1.109 (Ref. 6). From Equation 6 of Section 6.2 of this Regulatory Guide, B_i can be expressed as:

$$B_i = \frac{K}{r_d} \sum_j \sum_k \sum_{\ell} \frac{f_{jk} A_{\ell i} \mu_a E_{\ell} I}{u_j} \left(\frac{\text{mrad/yr}}{\mu\text{Ci/sec}} \right)$$

Where:

- I = the results of numerical integration over the plume spatial distribution of the airborne activity as defined by the meteorological condition of wind speed (u_j) and atmospheric stability class k for a particular wind direction.
- K = a numerical constant representing unit conversions, presented below.
- r_d = the distance from the release point to the receptor location, in meters.
- u_j = the mean wind speed assigned to the j th wind speed class, in meters/sec.
- f_{jk} = the joint frequency of occurrence of the j th wind speed class and k th stability class (dimensionless).
- $A_{\ell i}$ = the number of photons of energy corresponding to the ℓ th energy group emitted per transformation of the i th radionuclide, in number/transformation.
- E_{ℓ} = the energy assigned to the ℓ th energy group, in Mev.
- μ_a = the energy absorption coefficient in air for photon energy E_{ℓ} , in meters⁻¹.

The constant K follows from Equation 6 of Section C.2.a of Regulatory Guide 1.109 (Ref. 6), as:

$$K = \frac{260 \text{ mrad(radians)}(\text{m}^3)(\text{transformation})}{\text{sec(Mev)}(\text{Ci})} \left(\frac{16 \text{ sectors}}{2\pi \text{ radians}} \right) (10^{-6} \frac{\text{Ci}}{\mu\text{Ci}}) (3.15 \times 10^7 \frac{\text{sec}}{\text{yr}})$$

$$= 2.1 \times 10^4 \text{ mrad} (\text{m}^3)(\text{transformation})/\text{yr}(\text{Mev})(\mu\text{Ci}).$$

The V_i factor is computed with conversion from air dose to tissue depth dose, thus:

$$V_i = 1.1 \frac{K}{r_d} \sum_j \sum_k \sum_{\ell} \frac{f_{jk} A_{\ell i} \mu_a E_{\ell} I}{u_j} [e^{-\mu_T T_d}] \left(\frac{\text{mrem/yr}}{\mu\text{Ci/sec}} \right)$$

where:

- μ_T = the tissue energy absorption coefficient for photons of energy E_{ℓ} , in cm²/gm.
- T_d = the tissue density thickness taken to represent the total body dose (5gm/cm²).
- 1.1 = the ratio of the tissue to air absorption coefficients over the energy range of photons of interest. This ratio converts dose (mrad) to dose equivalent (mrem).

The parameter, P_i , contained in the radioiodine and particulates Specification 3.11.2.1.b includes pathway transport parameters of the i th radionuclide, the receptor's usage of the

pathway media and the dosimetry of the exposure. Pathway usage rates and the internal dosimetry are functions of the receptor's age; however, the youngest age group, the infant, will always receive the maximum dose under the exposure conditions for Specification 3.11.2.1. For the infant exposure, separate values of P_i may be calculated using the PARTS computer program given in Appendix D of this manual for the inhalation pathway which uses a W parameter based on $(\overline{\chi/Q})$, and the food (milk) and ground pathway which uses a W parameter normally based on $(\overline{D/Q})$, except for tritium, for application in the ODCM. The following sections provide detail on calculating these P_i values for inclusion in the ODCM.

The values of P_i are independent of vent and stack release elevation. In the case of tritium, $(\overline{\chi/Q})$ is the W parameter for the food (milk) pathway as well as the inhalation pathway. As tritium is a weak beta emitter, the ground plane contribution is zero for tritium. (NOTE: The value for the P_i (food) for tritium is 2.4×10^3 mrem/yr per $\mu\text{Ci}/\text{m}^3$.) If the controlling locations for vent and stack releases are different, the controlling location for vent releases should be used in Specification 3.11.2.1.

Omitting the subscripts for vent and stack releases, the dose rate from the i th radionuclide (except tritium) is:

$$P_i (\text{inhalation})(\overline{\chi/Q}) Q + [P_i(\text{food}) + P_i(\text{ground plane})] (\overline{D/Q}) Q \text{ (mrem/yr)}$$

and for tritium, is:

$$P_i (\text{inhalation})(\overline{\chi/Q}) Q + P_i(\text{food})(\overline{\chi/Q}) Q = 3.0 \times 10^3 (\overline{\chi/Q}) Q \text{ (mrem/yr)}$$

5.2.1.1 Calculation of P_i (Inhalation)

$$P_i = K'(\text{BR}) \text{DFA}_i \text{ (mrem/yr per } \mu\text{Ci}/\text{m}^3)$$

where:

K' = a constant of unit conversion, 10^6 pCi/ μCi .

BR = the breathing rate of the infant age group, in m^3/yr .

DFA_i = the maximum organ inhalation dose factor for the infant age group for the i th radionuclide, in mrem/pCi. The total body is considered as an organ in the selection of DFA_i .

The age group considered is the infant group. The infant's breathing rate is taken as $1400 \text{ m}^3/\text{yr}$ from Table E-5 of Regulatory Guide 1.109 (Ref. 6). The inhalation dose factors for the infant, DFA_i are presented in Table E-10 of Regulatory Guide 1.109, in units of mrem/pCi.

Resolution of the units yields:

$$P_i (\text{inhalation}) = 1.4 \times 10^9 \text{ DFA}_i$$

5.2.1.2 Calculation of P_i (Ground Plane)

$$P_i = K' K'' \text{DFG}_i (1 - e^{-\lambda_i t}) / \lambda_i \quad (\text{m}^2 \cdot \text{mrem}/\text{yr per } \mu\text{Ci}/\text{sec})$$

Where:

K' = a constant of unit conversion, 10^6 pCi/ μ Ci.

K'' = a constant of unit conversion, 8760 hr/year.

λ_i = the decay constant for the i th radionuclide, sec^{-1} .

t = the exposure period, 3.15×10^7 sec (1 year).

DFG_i = the ground plane dose conversion factor for the i th radionuclide (mrem/hr per pCi/ m^2).

The deposition rate onto the ground plane results in a ground plane concentration that is assumed to persist over a year with radiological decay the only operating removal mechanism for each radionuclide. The ground plane dose conversion factors for the i th radionuclide, DFG_i , are presented in Table E-6 of Regulatory Guide 1.109 (Ref. 6), in units of mrem/hr per pCi/ m^2 .

Resolution of the units yields:

$$P_i (\text{Ground}) = 8.76 \times 10^9 \text{DFG}_i (1 - e^{-\lambda_i t}) / \lambda_i.$$

5.2.1.3 Calculation of P_i (Food)

$$P_i = K' r \frac{Q_F (U_{ap})}{Y_p (\lambda_i + \lambda_w)} F_m \text{DFL}_i [e^{-\lambda_i t_f}] \quad (\text{m}^2 \cdot \text{mrem}/\text{yr per } \mu\text{Ci}/\text{sec})$$

where:

K' = a constant of unit conversion, 10^6 pCi/ μ Ci.

Q_F = the cow's consumption rate, in kg/day (wet weight).

U_{ap} = the infant's milk consumption rate, in liters/yr.

Y_p = the agricultural productivity by unit area, in kg/ m^2

F_m = the stable element transfer coefficients, in days/liter.

r = fraction of deposited activity retained on cow's feed grass.

DFL_i = the maximum organ ingestion dose factor for the i th radionuclide, in mrem/pCi.

λ_i = the decay constant for the i th radionuclide, in sec^{-1} .

λ_w = the decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73×10^{-7} sec^{-1} (corresponding to a 14 day half-time).

t_f = the transport time from pasture to cow, to milk, to infant, in sec.

A fraction of the airborne deposition is captured by the ground plant vegetation cover. The captured material is removed from the vegetation (grass) by both radiological decay and weathering processes.

The values of Q_F , U_{ap} , and Y_p are provided in Regulatory Guide 1.109 (Ref. 6), Tables E-3, E-5, and E-15, as 50 kg/day, 330 liters/day and 0.7 kg/m², respectively. The value t_f is provided in Regulatory Guide 1.109 (Ref. 6), Table E-15, as 2 days (1.73x10⁵ seconds). The fraction, r , has a value of 1.0 for radioiodines and 0.2 for particulates, as presented in Regulatory Guide 1.109 (Ref. 6), Table E-15.

Table E-1 of Regulatory Guide 1.109 (Ref. 4) provides the stable element transfer coefficients, F_m , and Table E-14 provides the ingestion dose factors, DFL_i , for the infant's organs. The organ with the maximum value of DFL_i is to be used.

Resolution of the units yields:

$$P_i \text{ (food)} = 2.4 \times 10^{10} \frac{r F_m}{\lambda_i + \lambda_w} DFL_i [e^{-\lambda_i t_f}] \text{ (m}^2 \cdot \text{mrem/yr per } \mu\text{Ci/sec)}$$

for all radionuclides, except tritium.

The concentration of tritium in milk is based on its airborne concentration rather than the deposition rate.

$$P_i = K' K'' F_m Q_F U_{ap} DFL_i [0.75(0.5/H)] \text{ (mrem/yr per } \mu\text{Ci/m}^3)$$

where:

K'' = a constant of unit conversion, 10³ gm/kg.

H = absolute humidity of the atmosphere, in gm/m³.

0.75 = the fraction of total feed that is water.

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

From Table E-1 and E-14 of Regulatory Guide 1.109 (Ref. 6), the values of F_m and DFL_i for tritium are 1.0x10⁻² day/liter and 3.08x10⁻⁷ mrem per pCi, respectively. Assuming an average absolute humidity of 8 grams/meter³, the resolution of units yields:

$$P_i \text{ (food)} = 2.4 \times 10^3 \text{ mrem/yr per } \mu\text{Ci/m}^3$$

for tritium, only.

5.3 DOSE LIMIT FOR IMPLEMENTING 10 CFR PART 50

In preparing proposed Technical Specifications, Figure 5.1-1* should consist of a map of the site area showing the unrestricted area boundary for gaseous effluents as defined in Section 5.2 of this manual. Guidelines for this figure are contained in Regulatory Guide 1.70, Section 2.1.1 (Ref. 21).

*See footnote on page 21.

5.3.1 REQUIREMENTS FOR IMPLEMENTING 10 CFR PART 50

The Standard Technical Specifications 3.11.2.2 and 3.11.2.3 implement 10 CFR Part 50, Appendix I, as follows:

"The air dose in unrestricted areas (see Figure 5.1-1)* due to noble gases released in gaseous effluents shall be limited to the following:

- a. During any calendar quarter, to ≤ 5 mrad for gamma radiation and ≤ 10 mrad for beta radiation;
- b. During any calendar year, to ≤ 10 mrad for gamma radiation and ≤ 20 mrad for beta radiation;

(The dose design objectives may be reduced based on expected public occupancy of areas, e.g., beaches and visitor centers within the unrestricted area boundary. (For PWRs only) the dose design objectives may be reduced based on predicted noble gas releases from the turbine building, if effluent sampling is not provided.)'

"The dose to an individual from radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than 8 days in gaseous effluents released to unrestricted areas (see Figure 5.1-1)* shall be limited to the following:

- a. During any calendar quarter to ≤ 7.5 mrem; and
- b. During any calendar year to ≤ 15 mrem."

The ODCM should provide the mathematical relationships used to implement the Specifications. The relationships presented below are acceptable for inclusion in the ODCM. If other methods are selected to implement these Specifications, it is expected that the alternative method will include the same general features considered below.

The air dose in unrestricted area (see Figure 5.1-1)* due to noble gases released in gaseous effluents should be determined by the following expressions:

- a. During any calendar quarter, for gamma radiation:

$$3.17 \times 10^{-8} \sum_i \left[M_i \left[(\bar{x}/Q)_v \tilde{Q}_{iv} + (\bar{x}/q)_v \tilde{q}_{iv} \right] + [B_i \tilde{Q}_{is} + b_i \tilde{q}_{is}] \right] \leq 5 \text{ mrad, and}$$

During any calendar quarter, for beta radiation:

$$3.17 \times 10^{-8} \sum_i N_i \left[(\bar{x}/Q)_v \tilde{Q}_{iv} + (\bar{x}/q)_v \tilde{q}_{iv} + (\bar{x}/Q)_s \tilde{Q}_{is} + (\bar{x}/Q)_s \tilde{q}_{is} \right] \leq 10 \text{ mrad, and}$$

- b. During any calendar year, for gamma radiation:

$$3.17 \times 10^{-8} \sum_i \left[M_i \left[(\bar{x}/Q)_v \tilde{Q}_{iv} + (\bar{x}/q)_v \tilde{q}_{iv} \right] + [B_i \tilde{Q}_{is} + b_i \tilde{q}_{is}] \right] \leq 10 \text{ mrad, and}$$

During any calendar year, for beta radiation:

$$3.17 \times 10^{-8} \sum_i N_i \left[(\bar{x}/Q)_v \tilde{Q}_{iv} + (\bar{x}/q)_v \tilde{q}_{iv} + (\bar{x}/Q)_s \tilde{Q}_{is} + (\bar{x}/Q)_s \tilde{q}_{is} \right] \leq 20 \text{ mrad}$$

where:

M_i = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per $\mu\text{Ci}/\text{m}^3$.

*See footnote on page 21.

- N_i = The air dose factor due to beta emissions for each identified noble gas radionuclide, in mrad/yr per $\mu\text{Ci}/\text{m}^3$.
- $(\bar{x}/Q)_v$ = $\frac{\text{sec}/\text{m}^3}{\text{sec}/\text{m}^3}$. For vent releases. The highest calculated annual average relative concentration for area at or beyond the unrestricted area boundary for long term releases (greater than 500 hrs/year).
- $(\bar{x}/q)_v$ = $\frac{\text{sec}/\text{m}^3}{\text{sec}/\text{m}^3}$. For vent releases. The relative concentration for areas at or beyond the unrestricted area boundary for short term releases (equal to or less than 500 hrs/year).
- $(\bar{x}/Q)_s$ = $\frac{\text{sec}/\text{m}^3}{\text{sec}/\text{m}^3}$. For free-standing stack releases. The highest calculated annual average relative concentration for areas at or beyond the unrestricted area boundary for long term releases (greater than 500 hrs/year).
- $(\bar{x}/q)_s$ = $\frac{\text{sec}/\text{m}^3}{\text{sec}/\text{m}^3}$. For free-standing stack releases. The relative concentration for areas at or beyond the unrestricted area boundary for short term releases (equal to or less than 500 hrs/year).
- \tilde{q}_{is} = The average release of noble gas radionuclides in gaseous effluents, i , for short term releases (equal to or less than 500 hrs/year) from the free-standing stack, in μCi . Releases shall be cumulative over the calendar quarter or year as appropriate.
- \tilde{q}_{iv} = The average release of noble gas radionuclides in gaseous effluents, i , for short term releases (equal to or less than 500 hrs/year) from all vents, in μCi . Releases shall be cumulative over the calendar quarter or year as appropriate.
- \tilde{Q}_{is} = The average release of noble gas radionuclides in gaseous releases, i , for long term releases (greater than 500 hrs/year) from the free-standing stack, in μCi . Release shall be cumulative over the calendar quarter or year as appropriate.
- \tilde{Q}_{iv} = The average release of noble gas radionuclides in gaseous effluents, i , for long term releases (greater than 500 hrs/yr) from all vents, in μCi . Releases shall be cumulative over the calendar quarter or year as appropriate.
- B_i = The constant for long term releases (greater than 500 hrs/yr) for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume, derived in accordance with the dose methodology in Regulatory Guide 1.109, Appendix B, Section 1, in mrad/yr per $\mu\text{Ci}/\text{sec}$.
- b_i = The constant for short term releases (equal to or less than 500 hrs/yr) for each identified noble gas radionuclide accounting for the gamma radiation from the elevated finite plume, derived in accordance with the dose methodology in Regulatory Guide 1.109, Appendix B, Section 1, in mrad/yr per $\mu\text{Ci}/\text{sec}$.

3.17×10^{-8} = The inverse of the number of seconds in a year.

The dose to an individual from radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than 8 days in gaseous effluents released to unrestricted areas (see Figure 5.1-1)* should be determined by the following expressions:

a. During any calendar quarter:

$$3.17 \times 10^{-8} \sum_i R_i [W_s \tilde{Q}_{is} + w_s \tilde{q}_{is} + W_v \tilde{Q}_{iv} + w_v \tilde{q}_{iv}] \leq 7.5 \text{ mrem, and}$$

*See footnote on page 21.

b. During any calendar year:

$$3.17 \times 10^{-8} \sum_i R_i [W_s \tilde{Q}_{is} + w_s \tilde{q}_{is} + W_v \tilde{Q}_{iv} + w_v \tilde{q}_{iv}] \leq 15 \text{ mrem}$$

where:

\tilde{Q}_i = The releases of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gases in gaseous effluents, i , for long term releases greater than 500 hrs/yr, in μCi . Releases shall be cumulative over the calendar quarter or year as appropriate.

\tilde{q}_i = The releases of radionuclides, radioactive materials in particulate form and radionuclides other than noble gases in gaseous effluents, i , for short term releases equal to or less than 500 hrs/yr, in μCi . Releases shall be cumulative over the calendar quarter or year as appropriate.

W = The dispersion parameter for estimating the dose to an individual at the controlling location for long term releases (greater than 500 hrs/yr):

$W = (\overline{x/Q})$ for the inhalation pathway, in sec/m^3 .

$W = (\overline{D/Q})$ for the food and ground plane pathways in meters^{-2} .

w = The dispersion parameter for estimating the dose to an individual at the controlling location for short term releases (equal to or less than 500 hrs/yr):

$w = (\overline{x/q})$ for the inhalation pathway in sec/m^3 .

$w = (\overline{D/q})$ for the food and ground plane pathway in meters^{-2} .

3.17×10^{-8} = The inverse of the number of seconds in a year.

R_i = The dose factor for each identified radionuclide, i , in $\text{m}^2(\text{mrem}/\text{yr})$ per $\mu\text{Ci}/\text{sec}$ or mrem/yr per $\mu\text{Ci}/\text{m}^3$.

For the direction sectors with existing pathways within 5 miles from the unit, use the values of R_i for these pathways. If no real pathway exists within 5 miles from the center of the building complex, use the cow-milk R_i assuming that this pathway exists at the 4.5 to 5.0 mile distance in the worst sector. If the R_i for an existing pathway within 5 miles is less than a cow-milk R_i at 4.5 to 5.0 miles, then use the value of the cow-milk R_i at 4.5 to 5.0 miles. The pathway values used for calculating dose contributions shall be consistent with the results of the land use census performed pursuant to Specification 3.12.2. The controlling value of R_i for each radionuclide shall be determined and provided in tabular form in the ODCM. The parameters W and w shall correspond to the applicable pathway location.

SPECIAL NOTES: (1) If there is no free-standing stack, the factors denoted by the subscript, s , need not be considered. (2) In all cases, the tritium releases use the first W or w parameter, based on relative concentration (sec/m^3). (3) All radioiodines are assumed to be released in elemental form. If analysis includes the capability of determining the elemental and non-elemental forms in all releases, the food pathway parameters may be adjusted accordingly.

The following information is provided to further clarify the application of these Specifications and provide more information regarding the individual factors. The ODCM should include a detailed presentation of the calculational model and a complete tabulation of all values assigned to each parameter.

The noble gas Specification 3.11.2.2 is to be evaluated at the location in the unrestricted area where analyses of annual average air doses were found to be maximum. In the event that the analyses indicate different locations for the beta and gamma limitations, the location selected for consideration shall be that which minimizes the allowable release values due to gamma radiation.

The radioiodine and particulate Specification 3.11.2.3 is applicable to the location in the unrestricted area where the combination of existing pathways and receptor age groups indicates the maximum potential exposures. The inhalation and ground plane exposure pathways shall be considered to exist at all locations. The grass-cow-milk, grass-cow-meat, and vegetation pathways are considered based on their existence at the various locations. Of the various age groups, the infant or child receives the largest dose; thus, only these two age groups will be discussed. It is the intent, however, that a licensee undertake annual surveys of the age groups and the land use at the various locations about the site, reports these results according to Specification 3.12.2 and determines the applicable parameters of R_i for tabulation in the ODCM. The new parameters shall be submitted to the NRC for review and approval prior to implementation.

The M_i and N_i factors of the noble gas relationship relate the airborne concentration of the noble gas to the air dose rates assuming a semi-infinite cloud. These factors may be taken directly from Table B-1 of the Regulatory Guide 1.109 (Ref. 6), and the values therein have been multiplied by 10^6 to convert picocuries⁻¹ to microcuries⁻¹.

The factor, B_i , is defined in Section 5.2.1 of this manual. The corresponding short-term factor, b_i is computed following the same procedure replacing the meteorological variables, j , k , and l , for long-term releases with variables for short-term releases using the methodology provided in Regulatory Guide 1.111 (Ref. 8), NUREG-0324 (Ref. 13), and NUREG-75/087 (Ref. 23). Such information should be provided in tabular form in the ODCM.

In developing the R_i values, separate expressions are written for each of the potential pathways. These expressions are similar to those developed in Section 5.2.1 of this manual for P_i , and are denoted by $R_i^G[D/Q]$, $R_i^I[X/Q]$, $R_i^C[D/Q]$, $R_i^M[D/Q]$ and $R_i^V[D/Q]$, where the superscripts G, I, C, M, and V refer to ground plane, inhalation, cow's milk, meat and vegetation, respectively. The 'argument' notation, [], indicates the appropriate dispersion parameter, W , to be applied with the R_i factor. Note that the argument is not included in the following expressions. In the case of tritium, the dispersion parameter, W , is always taken as (\bar{x}/Q) . The R_i parameter is independent of long-term or short-term releases and should be provided in tabular form in the ODCM.

5.3.1.1 Inhalation Pathway Factor, $R_i^I[X/Q]$

$$R_i^I[X/Q] = K'(BR)_a (DFA_i)_a \text{ (mrem/yr per } \mu\text{Ci/m}^3\text{)}$$

where:

$$K' = \text{a constant of unit conversion, } 10^6 \text{ pCi}/\mu\text{Ci}.$$

$(BR)_a$ = the breathing rate of the receptor of age group (a), in m^3/yr .

$(DFA_i)_a$ = the maximum organ inhalation dose factor for the receptor of age group (a) for the i th radionuclide, in $mrem/pCi$. The total body is considered as an organ in the selection of $(DFA_i)_a$.

The breathing rates $(BR)_a$ for the various age groups are tabulated below, as given in Table E-5 of the Regulatory Guide 1.109 (Ref. 6).

Age Group (a)	Breathing Rate (m^3/yr)
Infant	1400
Child	3700
Teen	8000
Adult	8000

Inhalation dose factors $(DFA_i)_a$ for the various age groups are given in Tables E-7 through E-10 of Regulatory Guide 1.109 (Ref. 6).

5.3.1.2 Ground Plane Pathway Factor, R_i^G [D/Q]

$$R_i^G[D/Q] = K'K''(SF)DFG_i[(1-e^{-\lambda_i t})/\lambda_i] \text{ (m}^2 \cdot \text{mrem/yr per } \mu\text{Ci/sec)}$$

where:

K' = a constant of unit conversion, 10^6 pCi/ μ Ci.

K'' = a constant of unit conversion, 8760 hr/year.

λ_i = the decay constant for the i th radionuclide, sec^{-1} .

t = the exposure time, 4.73×10^8 sec (15 years).

DFG_i = the ground plane dose conversion factor for the i th radionuclide ($\text{mrem/hr per pCi/m}^2$).

SF = the shielding factor (dimensionless).

A shielding factor of 0.7 is suggested in Table E-15 of Regulatory Guide 1.109 (Ref. 6). A tabulation of DFG_i values is presented in Table E-6 of Regulatory Guide 1.109 (Ref. 6).

5.3.1.3 Grass-Cow-Milk Pathway Factor, R_i^C [D/Q]

$$R_i^C[D/Q] = K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_i)_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

$(m^2 \cdot \text{mrem/yr per } \mu\text{Ci/sec)}$

where:

- K' = a constant of unit conversion, 10^6 pCi/ μ Ci.
- Q_F = the cow's consumption rate, in kg/day (wet weight).
- U_{ap} = the receptor's milk consumption rate for age (a), in liters/yr.
- Y_p = the agricultural productivity by unit area of pasture feed grass, in kg/m².
- Y_s = the agricultural productivity by unit area of stored feed, in kg/m².
- F_m = the stable element transfer coefficients, in days/liter.
- r = fraction of deposited activity retained on cow's feed grass.
- $(DFL_i)_a$ = the maximum organ ingestion dose factor for the ith radionuclide for the receptor in age group (a), in mrem/pCi.
- λ_i = the decay constant for the ith radionuclide, in sec⁻¹.
- λ_w = the decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73×10^{-7} sec⁻¹ (corresponding to a 14 day half-life).
- t_f = the transport time from pasture to cow, to milk, to receptor, in sec.
- t_h = the transport time from pasture, to harvest, to cow, to milk, to receptor, in sec.
- f_p = fraction of the year that the cow is on pasture (dimensionless).
- f_s = fraction of the cow feed that is pasture grass while the cow is on pasture (dimensionless).

SPECIAL NOTE: The above equation is applicable in the case that the milk animal is a goat.

Milk cattle are considered to be fed from two potential sources, pasture grass and stored feeds. Following the development in Regulatory Guide 1.109 (Ref. 6), the values of f_p and f_s will be considered unity, in lieu of site specific information provided in the annual land census report by the licensee.

Tabulated below are the appropriate parameter values and their reference to Regulatory Guide 1.109 (Ref. 6). In the case that the milk animal is a goat, rather than a cow, refer to Regulatory Guide 1.109 for the appropriate parameter values.

<u>Parameter</u>	<u>Value</u>	<u>Table (Ref. 6)</u>
r (dimensionless)	1.0 for radiiodine 0.2 for particulates	E-15 E-15
F_m (days/liter)	Each stable element	E-1
U_{ap} (liters/yr) - Infant	330	E-5
- Child	330	E-5
- Teen	400	E-5
- Adult	310	E-5
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	E-11 to E-14
Y_p (kg/m ²)	0.7	E-15
Y_s (kg/m ²)	2.0	E-15
t_f (seconds)	1.73×10^5 (2 days)	E-15
t_h (seconds)	7.78×10^6 (90 days)	E-15
Q_F (kg/day)	50	E-3

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore, the R_i^C is based on $[X/Q]$:

$$R_i^C[X/Q] = K'K''F_m Q_{F_{ap}} (DFL_i)_a [0.75(0.5/H)] \text{ (mrem/yr per } \mu\text{Ci/m}^3\text{)}$$

where:

K'' = a constant of unit conversion, 10^3 gm/kg.

H = absolute humidity of the atmosphere, in gm/m^3 .

0.75 = the fraction of total feed that is water.

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

and other parameters and values are given above. The value of H may be considered as 8 grams/meter³, in lieu of site specific information (Ref. 6).

5.3.1.4 Grass-Cow-Meat Pathway Factor, $R_i^M[D/Q]$

The integrated concentration in meat follows in a similar manner to the development for the milk pathway, therefore:

$$R_i^M[D/Q] = K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_f(r)(DFL_i)_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

($\text{m}^2 \cdot \text{mrem/yr per } \mu\text{Ci/sec}$)

where:

F_f = the stable element transfer coefficients, in days/kg.

U_{ap} = the receptor's meat consumption rate for age (a), in kg/yr.

t_f = the transport time from pasture to receptor, in sec.

t_h = the transport time from crop field to receptor, in sec.

Tabulated below are the appropriate parameter values and their reference to Regulatory Guide 1.109 (Ref. 6).

Parameter	Value	Table (Ref. 6)
r (dimensionless)	1.0 for radioiodine 0.2 for particulates	E-15 E-15
F_f (days/kg)	Each stable element	E-1
U_{ap} (kg/yr) - Infant	0	E-5
- Child	41	E-5
- Teen	65	E-5
- Adult	110	E-5
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	E-11 to E-14
Y_p (kg/m ²)	0.7	E-15

Parameter	Value	Table (Ref. 6)
Y_s (kg/m ²)	2.0	E-15
t_f (seconds)	1.73×10^6 (20 days)	E-15
t_h (seconds)	7.78×10^6 (90 days)	E-15
Q_F (kg/day)	50	E-3

The concentration of tritium in meat is based on its airborne concentration rather than the deposition. Therefore, the R_i^M is based on $[X/Q]$:

$$R_i^M [X/Q] = K' K' F_f Q_F U_{ap} (DFL_i)_a [0.75(0.5/H)] \text{ (mrem/yr per } \mu\text{Ci/m}^3\text{)}$$

where all terms are defined above and Section 5.3.1.3 of this manual.

5.3.1.5 Vegetation Pathway Factor, $R_i^V [D/Q]$

The integrated concentration in vegetation consumed by man follows the expression developed in the derivation of the milk factor. Man is considered to consume two types of vegetation (fresh and stored) that differ only in the time period between harvest and consumption, therefore:

$$R_i^V [D/Q] = K' \left[\frac{(r)}{Y_v (\lambda_i + \lambda_w)} \right] (DFL_i)_a \left[U_a^L f_L e^{-\lambda_i t_L} + U_a^S f_g e^{-\lambda_i t_h} \right]$$

(m²·mrem/yr per $\mu\text{Ci/sec}$)

where:

K' = a constant of unit conversion, 10^6 pCi/ μCi .

U_a^L = the consumption rate of fresh leafy vegetation by the receptor in age group (a), in kg/yr.

U_a^S = the consumption rate of stored vegetation by the receptor in age group (a), in kg/yr.

f_L = the fraction of the annual intake of fresh leafy vegetation grown locally.

f_g = the fraction of the annual intake of stored vegetation grown locally.

t_L = the average time between harvest of leafy vegetation and its consumption, in seconds.

t_h = the average time between harvest of stored vegetation and its consumption, in seconds.

Y_v = the vegetation areal density, in kg/m².

and all other factors are defined in Section 5.3.1.3 of this manual.

Tabulated below are the appropriate parameter values and their reference to Regulatory Guide 1.109 (Ref. 6).

<u>Parameter</u>	<u>Value</u>	<u>Table (Ref. 6)</u>
r (dimensionless)	1.0 for radioiodines 0.2 for particulates	E-1 E-1
(DFL _i) _a (mrem/pCi)	Each radionuclide	E-11 to E-14
U _a ^L (kg/yr) - Infant	0	E-5
- Child	26	E-5
- Teen	42	E-5
- Adult	64	E-5
U _a ^S (kg/yr) - Infant	0	E-5
- Child	520	E-5
- Teen	630	E-5
- Adult	520	E-5
f _L (dimensionless)	site specific (default = 1.0)	
f _g (dimensionless)	site specific (default = 0.76) (see Ref. 6, page 28)	
t _L (seconds)	8.6 X 10 ⁴ (1 day)	E-15
t _h (seconds)	5.18 X 10 ⁶ (60 days)	E-15
Y _v (kg/m ²)	2.0	E-15

The concentration of tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, the R_i^V is based on [X/Q]:

$$R_i^V [X/Q] = K'K'' U_a^L f_L + U_a^S f_g (DFL_i)_a [0.75(0.5/H)] \text{ (mrem/yr per } \mu\text{Ci/m}^3\text{)}.$$

where all terms have been defined above and in Section 5.3.1.3 of this manual.

The staff has developed a computer code PARTS for calculating the R_i parameters, which is described in Appendix D of this manual.

5.4 SPECIFICATION ON THE USE OF GASEOUS RADIOACTIVE WASTE MANAGEMENT SYSTEM

Standard Technical Specification 3.11.2.4 specifies that:

"The gaseous radwaste treatment system shall be OPERABLE. The appropriate subsystems shall be used to reduce radioactive materials in gaseous waste prior to their discharge when the projected gaseous effluent releases from all release points to unrestricted areas (see Figure 5.1-1)* would result in a dose in any period of 31 days that exceeds 0.2 mrad for gamma radiation, 0.4 mrad for beta radiation, or 0.3 mrem to any organ for that same 31 day period."

The operability of the gaseous radioactive waste management system ensures that this system will be available for use whenever gaseous effluents require treatment prior to release to the environment. The term "gaseous radwaste treatment system" includes all of the installed and available gaseous radioactive waste management system equipment, as well as their controls, power, instrumentation and services that make the system functional. Equipment that is considered standby or redundant is also included, since the function is to assure operability. The action also permits alternate treatment paths using alternate subsystems and equipment to be used in the event that the normal treatment is inoperable.

*See footnote on page 21.

This Specification provides impetus to maintain and use the gaseous radioactive waste management system as required in 10 CFR 50.36a. Maintenance and use of the gaseous radioactive waste management system components are discussed in Section 2.2 of this manual. Since features; such as, free-standing stacks or elevated vents are not considered to be treatment systems, the NRC staff considers that BWR offgas systems must be used without bypassing normal treatment during reactor operation.

To determine if use of the installed equipment, other than in BWR offgas systems, is necessary, the licensee should calculate the expected dose to an individual in the unrestricted area by projecting the plant's cumulative gaseous effluent release over a 31-day period. These releases should include all potentially radioactive plant gaseous effluents from all gaseous radioactive waste management systems and ventilation exhaust treatment systems. Calculations should include a margin, based on operating data, for anticipated operational occurrences and should use the dose calculation models discussed in Section 5.3 of this manual. The dose impact from the projected 31-day release should be compared to 0.2 mrad for gamma radiation, 0.4 mrad for beta radiation, or 0.3 mrem to any organ. If the projection indicates these values will be exceeded, then installed radwaste treatment system components, which are capable of reducing the quantities or concentrations of radioactive materials in gaseous effluents and which are capable of reducing the projected impact to less than the values specified above, must be used. The values for the projected impact, given above, corresponds to approximately one forty-eighth of the annual design dose objective values of Appendix I, Section II.B and II.C of 10 CFR Part 50 in a month, and if continued for a year, these values would correspond to less than one-fourth the values limited by Specifications 3.11.2.2.b and 3.11.2.3.b. The calculation of projected cumulative dose impact that could result from the proposed operation may use the methodology provided in Section 5.3 of this manual.

5.5 SPECIFICATION ON EXPLOSIVE GAS MIXTURE LIMITATION

The Standard Technical Specifications for BWRs and PWRs contain Specification 3.11.2.6A and alternate Specification 3.11.2.6B for the limiting conditions for operation for systems designed to treat and store radioactive gases which also contain quantities of uncombined hydrogen and oxygen. Specification 3.11.2.6A applies to a system designed to withstand a hydrogen explosion. If all components of the system, from containment to the release point, are designed and tested to 20 times the normal operating pressure, the system is considered to be designed to withstand a hydrogen explosion. Alternate Specification 3.11.2.6B applies to a system not considered to be designed to withstand a hydrogen explosion.

The functional name, "waste gas holdup system," has been used in this manual to include the various system designs found in BWRs and PWRs which serve the same basic purpose, i.e., to remove radioactive waste gases from the reactor coolant, to treat and hold gases for radioactive decay, and to monitor and control the radioactive materials in the gaseous waste prior to final release.

The potentially explosive components of the waste gas holdup system may be effectively inerted by nitrogen or steam, treated and re-used in the plant or stored and released after delay. The treatment may involve hydrogen-oxygen recombiners, filters, holdup tanks, decay

pipes, charcoal adsorbers, and cryogenic stills. The Specification is provided to ensure that the concentrations of potentially explosive gases contained in the system are maintained outside the explosive envelope for hydrogen and oxygen (i.e., less than 4% H₂ by volume or less than 4% O₂ by volume). The alternate Specification 3.11.2.6B provides an additional setpoint limitation to ensure that the automatic dilution, inerting or recombiner control is functioning to maintain the relative concentration of components of potentially explosive gas mixtures outside one-half the above flammability limits (i.e., 2% H₂ and/or O₂). Based on the design, the licensee should specify the gas to be measured: hydrogen, oxygen or both hydrogen and oxygen.

5.6 SPECIFICATIONS UNIQUE TO LWR DESIGN FEATURES

The Standard Technical Specifications contain several Specifications unique to certain design features of PWRs and BWRs; in general, these Specifications contain limiting conditions for operation. The following Sections describe these limitations and the method for determining the limiting values.

5.6.1 PWR Gas Storage Tank Specification 3.11.2.7

Specification 3.11.2.7 requires that the quantity of radioactive gas in each gas storage tank at a PWR be limited to a predetermined curie content. It is not applicable to PWRs that use adsorption units for gas holdup, but is applicable for compressed gas storage and for cryogenic storage systems. The purpose of this Specification is to assure that, in the event of an uncontrolled release of the tank contents, the resulting total body exposure to an individual at the nearest exclusion area boundary will not exceed 0.5 rem.

Determination of the curie limit should consider the following expression;

$$\sum Q_{iT} \leq \frac{500 \text{ mrem } (3.15 \times 10^7 \text{ sec/year})}{10^6 \mu\text{Ci/Ci} \sum_i K_i (\bar{x}/Q)_{\text{DBA}} (\text{mrem}\cdot\text{sec}/\mu\text{Ci}\cdot\text{yr})}$$

where:

$\sum Q_{iT}$ = The sum quantity of all noble gas nuclides (i) in a gas storage tank based on a gas mixture resulting from gaseous wastes, in curies.

K_i = The total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per $\mu\text{Ci}/\text{m}^3$. (See Section 5.2.1 of this manual.)

$(\bar{x}/Q)_{\text{DBA}}$ = The relative concentration at the exclusion area boundary used for evaluation of design basis accidents for ground release conditions, in sec/m^3 . Guidelines are provided in Standard Review Plan 2.3.4 (Ref. 23).

Normally the major radioactive nuclide constituent in PWR waste gas storage tanks is Xe-133. Radiation monitoring and sampling of these tanks should consider the Xe-133 (equivalent) concentration. Plant procedures shall not permit operation with communication between tanks.

Alternate Specification 3.11.2.7, "PWR Waste Gas Processing System," should be used for plants that use adsorption units for gas holdup prior to release. This Specification requires that the gross radioactivity in noble gases removed from the waste gas system by means of steam jet air ejectors (or other devices) and as measured prior to entering the adsorption systems at PWR plants shall be limited by a release rate alarm setpoint with indication in the main control room. The purpose of this pretreatment continuous radiation monitor setpoint is to provide reasonable assurance that the potential accident total body dose to an individual at the exclusion area boundary will not exceed a small fraction of the limits specified in 10 CFR Part 100 in the event this effluent is inadvertently discharged directly to the environment without treatment. Guidelines for determining the release rate limit are provided in Standard Review Plan 15.7.1 (Ref. 24), and guidance on the radiation monitoring instrumentation is given in Regulatory Guide 1.97 (Ref. 25).

5.6.2 BWR Main Condenser Evacuation System Specification 3.11.2.7

This Specification requires that the gross radioactivity in noble gases removed from the main condenser by means of steam jet air ejectors (or other devices) and as measured prior to entering the treatment, adsorption and delay systems at BWR plants shall be limited by a release rate alarm setpoint with indication in the main control room. The purpose of this pretreatment continuous radiation monitor setpoint is to provide reasonable assurance that the potential total body accident dose to an individual at the exclusion area boundary will not exceed a small fraction of the limits specified in 10 CFR Part 100 in the event this effluent including the radioactivity accumulated in the treatment system is inadvertently discharged directly to the environment without treatment.

The method for determining the specified rate limit, in $\mu\text{Ci}/\text{sec}$, should use the following assumptions:

1. The release of radioactive material from the fuel is postulated to have an isotopic composition of noble gases determined from noble gas source term distribution for a 3500 MWT reactor. These values should be scaled linearly for reactors of higher and lower powers.
2. The assumptions related to the release of radioactive material from the system following the accident are:
 - a. For systems which are not fully detonation-resistant or for those systems which are equipped with rupture discs that have not been isolated or loop seals which do not vent back to the main condenser, release occurs from a break just downstream of the main condenser evacuation system. Release from the main condenser evacuation system is assumed to be at ground level and a delay of five minutes is assumed to account for radioactive decay during transit from the release point to the exclusion area boundary.

NOBLE GAS SOURCE TERM

Isotope	Approx. Half-Life	Source Term, $\mu\text{Ci}/\text{sec}$, at the main condenser evacuation system (SJAЕ) λ Decay
Xe-140	13.7 s	1.1×10^6
Kr-90	33 s	9.8×10^5
Xe-139	41.0 s	9.8×10^5
Kr-89	3.2 m	4.6×10^5
Xe-137	3.8 m	5.3×10^5
Xe-138	14.0 m	3.1×10^5
Xe-135m	15.6 m	9.1×10^4
Kr-87	76 m	7.0×10^4
Kr-83m	1.86 hr	1.2×10^4
Kr-88	2.8 hr	7.0×10^4
Kr-85m	4.4 hr	1.1×10^4
Xe-135	9.2 hr	7.7×10^4
Xe-133m	2.3 d	1.0×10^3
Xe-133	5.27 d	2.9×10^4
Xe-131m	11.9 d	5.2×10^1
Kr-85	10.76 y	7.0×10^1
	Total	$\sim 4.7 \times 10^6$

- b. For systems which are detonation-resistant (i.e., rupture discs have been isolated and loop seals are vented back to the main condenser), release from the main condenser evacuation system exits via the normal release point.
- c. Activity release into the system continues for one hour following the accident at the Technical Specification limit unless positive means (such as automatic isolation) are provided to limit the releases from this source.
- d. Radioiodines and activation gases may be ignored.
- e. No deposition during downwind transport occurs.
- f. The total radioactive inventory (neglecting radioiodines and activation gases) in any delay lines and from the process equipment is released within a two-hour period with no decay.
- g. The total noble gas content of all charcoal delay beds is released over a period of two hours. A fractional release of the particulate inventory on the charcoal beds should be assumed. The rate of release is equal to the rate of absorption using the information contained in NUREG-0016 (Ref. 12).
- h. The main condenser air inleakage is 6 scfm for three shell main condensers.

3. The relative concentration, $(\bar{x}/\bar{Q})_{DBA}$, to be used is described in Section 5.6.1 of this manual.

Based on these assumptions, the applicant should backcalculate from a whole body dose of 2.5 rem to an individual at the exclusion area boundary to obtain the main condenser evacuation system rate limit, in $\mu\text{Ci}/\text{sec}$, having a noble gas isotopic distribution proportional to the noble gas source term, given above. For licensed BWR facilities that have a Technical Specification limit, in $\mu\text{Ci}/\text{sec}$, based on a 5 rem consequence criteria, a reevaluation of the specified limit is not required. Guidance on the radiation monitoring instrumentation is given in Regulatory Guide 1.97 (Ref. 25).

5.6.3 PWR Monitoring of Steam Generator Blowdown Flash Tank Vent

Standard Technical Specification 3.3.3.9, including Tables 3.3-12* and 4.3-12,* requires that PWRs continuously monitor the steam generator blowdown tank vent for gross noble gas radioactivity and continuously sample for radioactive iodines and particulates. Many PWRs with U-tube steam generators direct their blowdown to a blowdown treatment system without venting, so that item f in Tables 3.3-12 and 4.3-12 is not applicable. Others vent their flash tank to the main condenser, where the airborne radionuclides are either removed by condensing steam or drawn into the main condenser evacuation system, where they are then monitored prior to release to the atmosphere; therefore, this design provision makes item f not applicable. However, there are several operating PWR's that direct their blowdown to a flash tank which is vented directly to the atmosphere. Monitoring these releases presents serious difficulties, due to the presence of steam in the exhaust. In lieu of a flash tank vent radiation monitor, a determination of the release of radioiodine-131 via the flash tank vent can be made by calculating from a measured concentration in the secondary water by the following equation:

$$\dot{Q}_y = \bar{C}_y [R_{SGB}] f_{FT} (1 - SQ_{FTV})$$

where:

\dot{Q}_y = The release rate of radioiodine-131, y, from the steam generator flash tank vent, in $\mu\text{Ci}/\text{sec}$.

\bar{C}_y = The concentration of radioiodine-131, y, in the secondary coolant water averaged over not more than one week, in $\mu\text{Ci}/\text{ml}$.

R_{SGB} = The steam generator blowdown rate to the flash tank, in ml/sec.

f_{FT} = The fraction of blowdown flashed in the flash tank determined from a heat balance taken around the flash tank at the applicable reactor power level.

SQ_{FTV} = The measured steam quality in the flash tank vent; or an assumed value of 0.85, based on NUREG-0017 (Ref. 11).

If this option is chosen, the applicant shall perform this calculation every time measurements of secondary water radioiodine concentrations are required by Technical Specifications, and the calculated release shall be assumed at this calculated level until the next secondary water analysis is completed. These calculations shall be provided by the applicant in his semiannual effluent release report.

*See footnote on page 20.

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13. U.S. Nuclear Regulatory Commission, "XOQDOQ, Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," USNRC Report NUREG-0324, Washington, D.C. 20555, September 1977.
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16. Title 40, "Protection of Environment," Chapter I, Code of Federal Regulations, Part 141, pages 169 to 182, U.S. Government Printing Office, Washington, D.C. 20402, January 1, 1977.
17. Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," Revision 1, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, June 1974.

18. Title 40, "Protection of Environment," Chapter I, Code of Federal Regulations, Part 190, Federal Register, Vol. 42, No. 9, pages 2858 to 2861, Washington, D.C. 20402, January 13, 1977.
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APPENDIX A

RATAFR CODE FOR PRESSURIZED WATER REACTORS
Input Cards and Sample Calculation

1. Parameters Required for the PWR-RATAFR Code

Complete the cards from information given in the Applicant's Safety Analysis and Environmental Reports and in Section 2 of this Appendix.

a. CARD 1: Name of Reactor

Enter in spaces (33-60) the name of the reactor.

b. CARD 2: Thermal Power Level

Enter in spaces (73-80) the maximum thermal power level (MWt) evaluated for safety considerations in the Safety Analysis Report.

c. CARD 3: Mass of Coolant in Primary System

Enter in spaces (73-80) the mass of coolant (10^3 lbs) in the primary system at operating temperature and pressure.

d. CARD 4: Primary System Letdown Rate

Enter in spaces (73-80) the average letdown rate (gpm) from the primary system to the purification demineralizers.

e. CARD 5: Letdown Cation Demineralizer Flow Rate

Enter in spaces (73-80) the annual average flow rate (gpm) through the cation demineralizers for the control of cesium in the primary coolant. The average flow rate is determined by multiplying the average letdown rate (value entered on Card 4) by the fraction of time cation demineralizers are in service to obtain the average cation demineralizer flow rate.

f. CARD 6: Hydrological Travel Time

Enter in spaces (73-80) the travel time (days) it takes for the liquid waste of a failed tank to reach the nearest potable water supply or nearest surface water in an unrestricted area.

g. CARD 7: Hydrological Dilution Factor

Enter in spaces (73-80) the dimensionless value of:
The annual volume of water flowing past the potable water supply divided by the total volume of liquid waste in the failed tank (80% of design capacity).

h. CARDS 8-16: Liquid Tank Parameters

Tanks in two separate processing systems are considered in the PWR-RATAFR Code:

- (1) Shim Bleed Processing System, Cards 8-12;
- (2) Waste Drain Processing System, Cards 13-16.

In each of the processing systems considered, the Code can calculate the tank concentrations in either the collector tank or the evaporator bottoms tank. However, separate computer runs must be made for these two tank classifications. If it is desired, the Code can calculate concentrations in one tank of each of the processing systems in one computer run by making the appropriate entries in CARDS 8-16. If a tank in only one of the processing systems is to be considered, then the appropriate entries need only be made in CARDS 8-12 or 13-16, depending on which system contains the tank of interest.

Five input data cards define the major parameters for the failed tank in the shim bleed processing system. The first two cards (CARDS 8 and 9) describe the inputs to the tank. The shim bleed wastes are entered on CARD 8. For reactor designs which combine the shim bleed with other reactor grade wastes prior to processing, the other wastes are entered as equipment drain wastes on CARD 9.

Four input data cards define the major parameters for the failed tank in the waste drain processing system. The first card (CARD 13) describes the inputs to the tank. Essentially the same information is required on CARDS 8, 9 and 13, on CARDS 10 and 14, on CARDS 11 and 15, and on CARDS 12 and 16.

The following information explains the use of the parameters in this Appendix and information given in the SAR/ER to complete the input data cards.

For CARD 8, enter in spaces (42-49) the flow rate (gpd) of the inlet stream. The value of the shim bleed rate must always be entered, even if the tank being evaluated is not in this system, since it is used in determining the primary coolant concentrations. Do not enter inlet waste activity for the shim bleed since the activity for this waste stream is calculated by the Code.

The following information is required on CARDS 9 and 13 for both of the processing systems considered in the Code.

- (1) Enter in spaces (17-40) the name of the waste stream (e.g., clean wastes).
- (2) Enter in spaces (42-49) the flow rate (gpd) of the inlet stream.
- (3) Enter in spaces (57-61) the activity of the inlet stream expressed as a fraction of primary coolant activity (PCA).

For CARDS 10 and 14, the following information is required:

- (1) Enter in spaces (27-50) the name of the tank to be failed (e.g., shim bleed collector).
- (2) Enter in spaces (65-73) the volume (gallons) of the tank to be failed. If a tank in either of the two processing streams is not being considered, leave spaces (65-73) blank for that tank.

For CARDS 11 and 15, enter a 1 in space (80) if the tank to be failed is an evaporator bottoms tank. Otherwise leave space (80) blank.

CARDS 12 and 16 for both waste streams contain the overall system "tank" factors. The "tank" factors indicate the type of processing the waste has undergone prior to its entry into the tank. The tank factors should be entered as follows:

- (1) For a collector tank in either waste stream, without demineralizers upstream of the tank, values of TF=1.0 should be entered in the appropriate spaces.
- (2) For a collector tank in either waste stream with demineralizers upstream of the tank, or for an evaporator bottoms tank in either waste stream, TF's based on the description given in Section 2.a(3) should be entered in the appropriate spaces.

The appropriate spaces for the TFs are:

- (1) Enter in spaces (21-28) the TF for iodine.
- (2) Enter in spaces (34-41) the TF for cesium and rubidium.
- (3) Enter in spaces (47-54) the TF for other nuclides.

The following section explains the use of the parameters in this note and information given in the SAR/ER to complete data input CARDS 8-16.

2. Explanation of Parameters used in Filling out CARDS 8-16

a. Liquid Waste Flow Rates and Activities

(1) Shim Bleed Wastes and Equipment Drain Wastes

The flow rates of the shim bleed waste stream and equipment drain wastes processed with the shim bleed and the activity of the equipment drain wastes are based on information given in the SAR/ER. The activity of the shim bleed wastes is based on the primary coolant letdown system effluent activity and is calculated in the Code.

The activity of the combined inlet stream is calculated by the Code based on the weighted average of the composite stream entering the tanks.

(2) Waste Drain Tank Wastes

Flow rates and activities are calculated using the waste volumes and activities given in NUREG-0017, Table 1-2, "PWR Liquid Wastes" (Ref. 11).

These input flow rates are supplemented by the use of expected flows and activities more specific to the plant design as given in the SAR/ER. The individual streams are combined based on the radwaste treatment system described in the SAR/ER. Input activities are based on the weighted average activity of the composite stream entering the waste collection tanks. The input flow rates and activities are entered in units of gpd and fractions of PCA.

(3) Tank Factors

The tank factors indicate the type of processing the waste has undergone prior to its entry into the tank. The tank factors provide the capability to consider radionuclide removal by demineralizers or other treatment equipment prior to the tank. For evaporator bottoms tanks, the tank factors provide the capability to consider the effects of radionuclide concentration in the evaporator. Therefore, in determining the radionuclide concentration in the tank, the type of processing upstream of the tank must be considered and entered as tank factors on CARDS 12 and 16.

The following factors are considered in calculating overall tank factors for the systems.

- (a) TFs are categorized by radionuclides.

Halogens

Cs, Rb

Other Nuclides

Note: TF of 1 is assumed for tritium.

- (b) The system TF is the product of the individual equipment TF in each of the systems, e.g., the effect of the demineralizer removal, if any, is multiplied by the effect of the evaporator concentration, if any.

- (c) Tank Factors for Demineralizers

The tank factors for demineralizers are entered in the same manner as decontamination factors (DFs) are entered in the PWR-GALE Code. Therefore, the values used for TFs for demineralizers are the same as those given in NUREG-0017, Table 1-3, "Decontamination Factors for PWR Liquid Waste Treatment Systems" (Ref. 11).

- (d) Tank Failures for Evaporators

The tank factors for evaporators express the increase in concentration of radionuclides in the evaporator bottoms resulting from evaporator operation. The values entered on the CARDS are the ratio of the evaporator bottom stream flow to the evaporator inlet stream flow. Therefore, the TFs for evaporators are as follows:

<u>Evaporator</u>	<u>All Nuclides</u>
Waste Drain Stream	0.02
Shim Bleed Stream	0.02

1.	CARD 1	NAME	NAME OF REACTOR	SAMPLE CASE PWR 4/78	TYPE = PWR
2.	CARD 2	POWTH	THERMAL POWER LEVEL (MEGAWATTS)		3391.
3.	CARD 3	PCVOL	MASS OF PRIMARY COOLANT (THOUSANDS LBS)		561.
4.	CARD 4	LETDWN	PRIMARY SYSTEM LETDOWN RATE (GPM)		75.
5.	CARD 5	CBFLR	LETDOWN CATION DEMINERALIZER FLOW (GPM)		7.5
6.	CARD 6	HYTRTM	HYDROLOGICAL TRAVEL TIME (DAYS)		1.
7.	CARD 7	HYDF	HYDROLOGICAL DILUTION FACTOR		1000.
8.	CARD 8		SHIMBLEED RATE	16200. GPD	
9.	CARD 9		EQUIPMENT DRAINS INPUT	810. GPD AT 1.0	
10.	CARD 10		TANK NAME CONDENSATE HOLDUP	TANK VOLUME 250000.	
11.	CARD 11		IS TANK IN SYSTEM A BOTTOMS TANK 0 IF NO 1 IF YES		
12.	CARD 12		DFI= 1.0E03DFCS= 1.0E05DFO= 1.0E05		
13.	CARD 13		DIRTY WASTES INPUT	1375. GPD AT .075 PCA	
14.	CARD 14		TANK NAME WASTE HOLDUP	TANK VOLUME 250000.	
15.	CARD 15		IS TANK IN SYSTEM A BOTTOMS TANK 0 IF NO 1 IF YES		
16.	CARD 16		DFI= 1.0E03DFCS= 1.0E04DFO= 1.0E04		

SAMPLE CASE PWR 4/78

THERMAL POWER LEVEL (MEGAWATTS)	
PLANT CAPACITY FACTOR	
MASS OF PRIMARY COOLANT (THOUSANDS LBS)	
PERCENT FUEL WITH CLADDING DEFECTS	
PRIMARY SYSTEM LETDOWN RATE (GPM)	
LETDOWN CATION DEMINERALIZER FLOW (GPM)	
HYDROLOGICAL TRAVEL TIME (DAYS)	
HYDROLOGICAL DILUTION FACTOR	
SHIMBLEED RATE	GPD
EQUIPMLNT DRAINS INPUT	GPD
DIRTY WASTES	INPUT GPD

PWR	3391.0000
	0.80
	561.0000
	1.0000
	75.0000
	7.5000
	1.00
	1000.
	1.62E+04
	8.10E+02
	1.38E+03

FAILED TANK PARAMETERS

FAILED TANK	VOLUME	TANK FACTORS		
		I	CS	OTHERS
CONDENSATE HOLDUP	250000.	1.00E+03	1.00E+05	1.00E+05
WASTE HOLDUP	250000.	1.00E+03	1.00E+04	1.00E+04

SAMPLE CASE PWR 4/78 LIQUID TANK FAILURE
 NAME OF TANK FAILED: CONDENSATE HOLDUP
 VOLUME OF TANK FAILED: 200000. GAL. (80% OF TANK CAPACITY)
 HYDROLOGICAL TRAVEL TIME (DAYS): 1.00
 HYDROLOGICAL DILUTION FACTOR: 1000.

NUCLIDE	HALF-LIFE (DAYS)	PRIMARY COOLANT CONC. (UCI/ML)	10CFR20 LIMITS (UCI/ML)	FAILED TANK CONC. (UCI/ML)	CRITICAL RECEPTOR CONC. (UCI/ML)	FRACTION 10CFR20
CORROSION AND ACTIVATION PRODUCTS						
H 3	4.49E+03	1.00E+00	3.00E-03	1.00E+00	1.00E-03	0.3300
FISSION PRODUCTS						
1131	8.05E+00	2.18E+00	3.00E-07	2.00E-04	1.80E-07	0.6000
1133	8.75E-01	3.08E+00	1.00E-06	4.70E-05	2.10E-08	0.0210
ALL OTHERS		6.38E+00		2.40E-05	3.10E-09	0.0003
TOTAL EXCEPT TRITIUM		1.16E+01		2.70E-04	2.00E-07	0.6200

THE MAXIMUM QUANTITY OF TRITIUM IN THE TANK IS 2.3E+03 CURIES.

THE MAXIMUM QUANTITY OF CORROSION AND FISSION PRODUCTS (EXCLUDING TRITIUM) IN THE TANK IS 3.3E-01 CURIES.

SAMPLE CASE PWR 4/78 LIQUID TANK FAILURE
 NAME OF TANK FAILED: WASTE HOLDUP
 VOLUME OF TANK FAILED: 200000. GAL. (80% OF TANK CAPACITY)
 HYDROLOGICAL TRAVEL TIME (DAYS): 1.00
 HYDROLOGICAL DILUTION FACTOR: 1000.

NUCLIDE	HALF-LIFE (DAYS)	PRIMARY COOLANT CONC. (UCI/ML)	10CFR20 LIMITS (UCI/ML)	FAILED TANK CONC. (UCI/ML)	CRITICAL RECEPTOR CONC. (UCI/ML)	FRACTION 10CFR20
CORROSION AND ACTIVATION H 3	4.49E+03	1.00E+00	3.00E-03	7.40E-02	7.40E-05	0.0250
FISSION PRODUCTS						
1131	8.05E+00	2.18E+00	3.00E-07	1.30E-05	1.20E-08	0.0400
ALL OTHERS		9.46E+00		6.70E-06	3.60E-09	0.0011
TOTAL EXCEPT TRITIUM		1.16E+01		2.00E-05	1.60E-08	0.0410

THE MAXIMUM QUANTITY OF TRITIUM IN THE TANK IS 2.3E+03 CURIES.

THE MAXIMUM QUANTITY OF CORROSION AND FISSION PRODUCTS (EXCLUDING TRITIUM) IN THE TANK IS 3.6E-01 CURIES.

APPENDIX B

RATAFR CODE FOR BOILING WATER REACTORS
Input Cards and Sample Calculation

1. Parameters Required for the BWR-RATAFR Code

Complete the cards from information given in the Applicant's Safety Analysis and Environmental Reports and in Section 2 of this Appendix.

a. CARD 1: Name of Reactor (SAR/ER)

Enter in spaces (33-60) the name of the reactor.

b. CARD 2: Thermal Power Level (SAR/ER)

Enter in spaces (73-80) the maximum thermal power level (MWt) evaluated for safety considerations in the Safety Analysis Report.

c. CARD 3: Total Steam Flow Rate (SAR/ER)

Enter in spaces (73-80) the total steam flow rate from the reactor (10^6 lbs/hr).

d. CARD 4: Mass of Coolant in Reactor Vessel (SAR/ER)

Enter in spaces (73-80) the mass of water in the reactor vessel (10^6 lbs).

e. CARD 5: Cleanup Demineralizer Flow (SAR/ER)

Enter in spaces (73-80) the primary coolant flow rate (10^6 lbs/hr) through the reactor coolant cleanup system demineralizers.

f. CARD 6: Condensate Demineralizer Regeneration Time

For deep bed condensate demineralizers, use 3.5 day regeneration frequency per demineralizer. If ultrasonic resin cleaning is used, assume 7-day regeneration frequency per demineralizer. Multiply the frequency by the number of demineralizers, and enter the calculated number of days in spaces (73-80). For filter/demineralizers (Powdex), enter zero in spaces (73-80).

g. CARD 7: Fraction of Feed Water Through Condensate Demineralizer (SAR/ER)

Enter in spaces (73-80) the fraction of feedwater processed through the condensate demineralizers.

h. CARD 8: Hydrological Travel Time

Enter in spaces (73-80) the travel time (days) it takes for the liquid waste of a failed tank to reach the nearest potable water supply or nearest surface water in an unrestricted area.

i. CARD 9: Hydrological Dilution Factor

Enter in spaces (73-80) the dimensionless value of:

The annual volume of water flowing past the potable water supply divided by the total volume of liquid waste in the failed tank (80% of design capacity).

j. CARD 10-17: Liquid Tank Parameters

Tanks in two separate processing systems are considered in the BWR-RATAFR Code:

- (1) Waste Drain Processing System, CARDS 10-13.
- (2) Regenerant Solutions Processing System, CARDS 14-17.

In each of the processing systems considered, the Code can calculate the tank concentrations in either the collector tank or the evaporator bottoms tank. However, separate computer runs must be made for these two tank classifications. If it is desired, the Code can calculate concentrations in one tank of each of the processing systems in one computer run by making the appropriate entries in CARDS 10-17. If a tank in only one of the processing systems is to be considered, then the appropriate entries need only be made in CARDS 10-13 or 14-17 depending on which system the tank of interest is in.

Four input data cards are used to define the major parameters for the failed tank in each of the processing systems. Essentially, the same information is required on the four input data cards used for each of the processing systems. The instructions given in this section are applicable to both processing streams, with the following exception. The inlet waste activity is not entered on CARD 14 for the regenerant solutions wastes for systems using regenerable condensate demineralizers, since the activity is calculated by the Code.

The following information explains the use of the parameters in this Appendix and information given in the SAR/ER to complete the input data cards.

The following information is required on CARDS 10 and 14 for both of the streams considered in the Code.

- (1) Enter in spaces (18-40) the name of the waste stream (e.g., high-purity wastes).
- (2) Enter in spaces (42-49) the flow rate (gpd) of the inlet stream.
- (3) Enter in spaces (57-61) the activity of the inlet stream, expressed as a fraction of the primary coolant activity (PCA).

On CARD 14, do not enter the activity of the regenerant solutions waste inlet stream in spaces (57-61).

For CARDS 11 and 15, the following information is required:

- (1) Enter in spaces (27-50) the name of the tank to be failed (e.g., High Purity Collector).
- (2) Enter in spaces (65-73) the volume (gallons) of the tank to be failed. If a tank in either of the two processing streams is not being considered, leave spaces (65-73) blank for that tank.

For CARDS 12 and 16, enter a 1 in space (80) if the tank to be failed is an evaporator bottoms tank. Otherwise leave space (80) blank.

CARDS 13 and 17 for both waste streams contain the overall system "tank" factors. The "tank" factors indicate the type of processing the waste has undergone prior to its entry into the tank. The tank factors should be entered as follows:

- (1) For a collector tank in either waste stream, without demineralizers upstream of the tank, values of TF = 1.0 should be entered in the appropriate spaces.
- (2) For a collector tank in either waste stream with demineralizers upstream of the tank, or for an evaporator bottoms tank in either waste stream, TFs based on the description given in Section 2.b should be entered in the appropriate spaces.

The appropriate spaces for the TFs are:

- (1) Enter in spaces (21-28) the TF for iodine.
- (2) Enter in spaces (34-41) the TF for cesium and rubidium.
- (3) Enter in spaces (47-54) the TF for other nuclides.

The following section explains the use of the parameters in this note and information given in the SAR/ER to complete data input CARDS 10-17.

2. Explanation of Parameters used in Filling out Cards 10-17

a. Liquid Waste Flow Rates and Activities

Flow rates and activities are calculated using the waste volumes and activities given in NUREG-0016, Table 1-2, "BWR Liquid Wastes" (Ref. 12).

These input flows are supplemented by the use of expected flows and activities more specific to the plant design as given in the SAR/ER. The inlet streams are combined to form the principal waste streams (drain wastes and regenerant wastes) considered in this guide, based on the radwaste treatment system described in the SAR/ER.

Input activities are based on the weighted average activity of the composite stream entering the waste collection tanks.

b. Tank Factors

The tank factors indicate the type of processing the waste stream has undergone prior to its entry into the tank. The tank factors provide the capability to consider radionuclide removal by demineralizers prior to the waste stream input into the tank. For evaporator bottoms tanks, the tank factors provide the capability to consider the effects of radionuclide concentration in the evaporator. Therefore, in determining

the radionuclide concentration in a tank, the type of processing upstream of the tank must be considered and entered as tank factors on CARDS 13 and 17.

The following factors are considered in calculating overall tank factors for the systems:

- (1) TFs are categorized by radionuclides.

Halogens

Cs, Rb

Other Nuclides

Note: TF of 1 is assumed for tritium.

- (2) The system TF is the product of the individual equipment TF in each of the systems, e.g., the effect of the demineralizer removal, if any, is multiplied by the effect of the evaporator concentration, if any.

- (3) Tank Factors for Demineralizers

The tank factors for demineralizers are entered in the same manner as decontamination factors (DFs) are entered in the BWR-GALE Code. Therefore, the values used for TFs for demineralizers are the same as those given in NUREG-0016, Table 1-3, "Decontamination Factors for BWR Liquid Waste Treatment Systems" (Ref. 11).

- (4) Tank Factors for Evaporators

The tank factors for evaporators express the increase in concentration of radionuclides in the evaporator bottoms resulting from evaporator operation. The values entered on the cards are the ratio of the evaporator bottoms stream flow to the evaporator inlet stream flow. Therefore, the TFs for evaporators are entered as follows:

<u>Evaporator</u>	<u>All Nuclides</u>
Waste Drain Stream	0.01
Regenerant Waste Stream	0.05

1.	CARD 1	NAME	NAME OF REACTOR	SAMPLE CASE BWR	4/78	TYPE =	BWR
2.	CARD 2	POWTH	THERMAL POWER LEVEL (MEGAWATTS)				3440.
3.	CARD 3	GTO	TOTAL STEAM FLOW (MILLION LBS/HR)				14.166
4.	CARD 4	WLIQ	MASS OF WATER IN REACTOR VESSEL (MILLION LBS)				0.588
5.	CARD 5	GDE	CLFAN-UP DEMINERALIZER FLOW (MILLION LBS/HR)				0.135
6.	CARD 6	REGENT	CONDENSATE DEMINERALIZER REGENERATION TIME (DAYS)				36.75
7.	CARD 7	FFCDM	FRACTION FEED WATER THROUGH CONDENSATE DEMIN				1.
8.	CARD 8	HYTRTM	HYDROLOGICAL TRAVEL TIME (DAYS)				2.0
9.	CARD 9	HYDF	HYDROLOGICAL DILUTION FACTOR				200000.
10.	CARD 10		HIGH PURITY WASTE INPUT 27800. GPD AT .164 PCA				
11.	CARD 11		TANK NAME WASTE COLLECTION	TANK VOLUME 30000.		GAL	
12.	CARD 12		IS TANK IN SYSTEM A BOTTOMS TANK 0 IF NO 1 IF YES				0
13.	CARD 13		DFI= 1.0E-00DFCS= 1.0E-00DFO = 1.0E-00				
14.	CARD 14		REGENERATION SOLTNS INPUT 2550. GPD				
15.	CARD 15		TANK NAME CONCENTRATOR WASTE	TANK VOLUME 5000.		GAL	
16.	CARD 16		IS TANK IN SYSTEM A BOTTOMS TANK 0 IF NO 1 IF YES				1
17.	CARD 17		DFI= 5.0E-02DFCS= 5.0E-02DFO = 5.0E-02				

	BWR
SAMPLE CASE BWR 4/78	
THERMAL POWER LEVEL (MEGAWATTS)	3440.0000
PLANT CAPACITY FACTOR	0.80
TOTAL STEAM FLOW (MILLION LBS/HR)	14.1660
MASS OF WATER IN REACTOR VESSEL (MILLION LBS)	0.5880
OFF-GAS RELEASE RATE(UC/SEC)	350000.
FISSION PRODUCT CARRY-OVER FRACTION	0.0010
HALOGEN CARRY-OVER FRACTION	0.0200
CLEAN-UP DEMINERALIZER FLOW (MILLION LBS/HR)	0.1350
CONDENSATE DEMINERALIZER REGENERATION TIME (DAYS)	36.7500
FRACTION FEED WATER THROUGH CONDENSATE DEMIN	1.0000
HYDROLOGICAL TRAVEL TIME (DAYS)	2.00
HYDROLOGICAL DILUTION FACTOR	200000.
HIGH PURITY WASTE INPUT GPD	2.78E+04
REGENERATION SOLTNS INPU GPD	2.55E+03

FAILED TANK PARAMETERS

FAILED TANK	VOLUME	TANK FACTORS		
		I	CS	OTHERS
WASTE COLLECTION	30000.	1.00E+00	1.00E+00	1.00E+00
CONCENTRATOR WASTE	5000.	5.00E-02	5.00E-02	5.00E-02

SAMPLE CASE BWR 4/78 LIQUID TANK FAILURE
 NAME OF TANK FAILED: WASTE COLLECTION
 VOLUME OF TANK FAILED: 24000. GAL. (80% OF TANK CAPACITY)
 HYDROLOGICAL TRAVEL TIME (DAYS): 2.00
 HYDROLOGICAL DILUTION FACTOR: 200000.

NUCLIDE	HALF-LIFE (DAYS)	PRIMARY COOLANT CONC. (UCI/ML)	10CFR20 LIMITS (UCI/ML)	FAILED TANK CONC. (UCI/ML)	CRITICAL RECEPTOR CONC. (UCI/ML)	FRACTION 10CFR20
CORROSION AND ACTIVATION PRODUCTS						
FISSION PRODUCTS						
I131	8.05E+00	2.84E-02	3.00E-07	4.50E-03	1.90E-08	0.0630
I133	8.75E-01	1.07E-01	1.00E-06	1.30E-02	1.30E-08	0.0130
ALL OTHERS		1.81E+00		4.90E-02	3.30E-08	0.0008
TOTAL						
EXCEPT TRITIUM		1.95E+00		6.60E-02	6.50E-08	0.0770

THE MAXIMUM QUANTITY OF TRITIUM IN THE TANK IS 5.0E+03 CURIES.

THE MAXIMUM QUANTITY OF CORROSION AND FISSION PRODUCTS (EXCLUDING TRITIUM) IN THE TANK IS 1.5E+01 CURIES.

SAMPLE CASE BWR 4/78 LIQUID TANK FAILURE
 NAME OF TANK FAILED: CONCENTRATOR WASTE
 VOLUME OF TANK FAILED: 4000. GAL. (80% OF TANK CAPACITY)
 HYDROLOGICAL TRAVEL TIME (DAYS): 2.00
 HYDROLOGICAL DILUTION FACTOR: 200000.

NUCLIDE	HALF-LIFE (DAYS)	PRIMARY COOLANT CONC. (UCI/ML)	10CFR20 LIMITS (UCI/ML)	FAILED TANK CONC. (UCI/ML)	CRITICAL RECEPTOR CONC. (UCI/ML)	FRACTION 10CFR20
CORROSION AND ACTIVATION PRODUCTS						
P 32	1.43E+01	1.96E-04	2.00E-05	2.00E-02	8.90E-08	0.0045
CR 51	2.78E+01	4.91E-03	2.00E-03	9.50E-01	4.50E-06	0.0023
MN 54	3.03E+02	5.90E-05	1.00E-04	2.30E+02	1.10E-07	0.0011
FE 55	9.50E+02	9.83E-04	8.00E-04	3.90E-01	2.00E-06	0.0025
CO 58	7.13E+01	1.97E-04	9.00E-05	6.00E-02	2.90E-07	0.0032
CO 60	1.92E+03	3.93E-04	3.00E-05	1.60E-01	8.00E-07	0.0270
ZN 65	2.45E+02	1.97E-04	1.00E-04	7.40E-02	3.70E-07	0.0037
FISSION PRODUCTS						
SR 89	5.20E+01	5.73E-04	3.00E-06	1.60E-01	7.60E-07	0.2500
SR 90	1.03E+04	3.44E-05	3.00E-07	1.40E-02	7.10E-08	0.2400
Y 90	2.67E+00	0.0	2.00E-05	1.40E-02	4.20E-08	0.0021
Y 91	5.88E+01	2.29E-04	3.00E-05	1.10E-01	5.20E-07	0.0170
MO 99	2.79E+00	1.13E-02	4.00E-05	1.80E-02	5.60E-08	0.0014
RU103	3.76E+01	1.15E-04	8.00E-05	2.70E-02	1.30E-07	0.0017
RU106	3.67E+02	1.72E-05	1.00E-05	6.70E-03	3.30E-08	0.0033
TE129M	3.40E+01	2.29E-04	2.00E-05	5.00E-02	2.40E-07	0.0120
I131	8.05E+00	7.84E-02	3.00E-07	2.20E+01	9.40E-05	310.0000
CS134	7.49E+02	1.72E-04	9.00E-06	3.80E-02	1.90E-07	0.0210
CS137	1.10E+04	4.02E-04	2.00E-05	9.10E-02	4.60E-07	0.0230
BA140	1.28E+01	2.29E-03	2.00E-05	2.00E-01	8.90E-07	0.0440
LA140	1.67E+00	0.0	2.00E-05	2.30E-01	5.00E-07	0.0250
CE141	3.24E+01	1.72E-04	9.00E-05	4.00E-02	1.90E-07	0.0021
PR143	1.37E+01	2.29E-04	5.00E-05	2.40E-02	1.10E-07	0.0021
CE144	2.84E+02	1.72E-05	1.00E-05	6.50E-03	3.30E-08	0.0033
ALL OTHERS		1.90E+00		2.50E-01	2.90E-07	0.0046
TOTAL						
EXCEPT TRITIUM		1.95E+00		2.50E+01	1.10E-04	310.0000

THE MAXIMUM QUANTITY OF TRITIUM IN THE TANK IS 5.0E+03 CURIES.

THE MAXIMUM QUANTITY OF CORROSION AND FISSION PRODUCTS (EXCLUDING TRITIUM) IN THE TANK IS 1.2E+00 CURIES.

APPENDIX C

RATAFR LISTING

This appendix contains the program listing in FORTRAN for the RATAFR Code, applicable to PWR's and BWR's using the input data cards from Appendix A or B of this manual. The nuclear data library and subroutines are available in card deck form from the Effluent Treatment Systems Branch, USNRC, (301)492-7775. The remainder of this appendix contains the RATAFR program listing.

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1. C RATAF CODE FOR CALCULATING CONSEQUENCES OF RADIOACTIVE LIQUID
2. C TANK FAILURES. MODIFIED MARCH 1976 TO CALCULATE TANK ISOTOPIC
3. C CONCENTRATIONS TO PROVIDE AS INPUT FOR DETERMINING CONCENTRATIONS
4. C AT POTABLE WATER SUPPLIES. BASES FOR CODE IS THE LIQUID GALE
5. C CODE OF JULY 1975.
6. C
7. C INTEGER*2 NAME(3),ELE(99),STA(2),LOC,NONC,KD 00000080
8. C REAL*4 LETDWA,LETDWN,MCH3,MQH3,MCCFP,MQCFP
9. C COMMON/LABEL/ ELE,STA
10. C COMMON/MATRIX/A(2500),LOC(2500),NONO(800),KD(800) 00000190
11. C COMMON/FLEX/FLUX(10),MMN,MOUT,INDEX,QXN,AXN,ERR,NOBLND,MZERO 00000200
12. C COMMON/PROCESS/ NPROS,PRATE(8),NPROS(8),NZPROS(8,20),PR(800) 00000210
13. C COMMON/EG/XZERO(800), XZH(800),XTEMP(800),XNEW(10,800), 00000220
14. C 1 B(800),D(800) 00000230
15. C COMMON/FLUXN/T(20),POWER(10),TOCAP(800),FISS(100),DIS(800),ILITE, 00000240
16. C 1 IACT,IFP,IITOT,NUN,INPT 00000250
17. C COMMON/LUT/NUCL(800),TITLE(20),Q(800),FG(800),CUTOFF(7), 00000260
18. C 1 PCW,BURNUP,FLUX3,MSTAR,ALPHAN(100),SPONF(100),ABUND(500), 00000270
19. C 2 BASIS(10),TCNST,TUNIT 00000280
20. C COMMON/MPC/MPCTAB,AMPC(800),WMPC(800) 000008120
21. C COMMON/CONP/PWCONC(800)
22. C COMMON/CONP/BCONC(800)
23. C DIMENSION PCONC(300),DWCONC(800),CWCONC(800),CMCONC(800),
24. C IRIJV(200)
25. C DIMENSION TKCONC(800),PER(800)
26. C DIMENSION PCON(300),FRAC(800)
27. C DIMENSION SRTANK(6),DWTANK(6),CWTANK(6),RGTANK(6)
28. C DIMENSION WORD56(14),WORD24(6),REACTR(7)
29. C DATA PWR/' PWR'/,BWR/' BWR'/
30. C BCONC CONTAINS PRIMARY COOLANT CONCENTRATIONS FOR BWR'S.
31. C PWCONC CONTAINS PRIMARY COOLANT CONCENTRATIONS FOR PWR'S.
32. C 00000570
33. C READ NUCLEAR DATA AND CONSTRUCT TRANSITION MATRIX 00000580
33.1 10 CALL NUDATA(NLIBE)
34. C 00000590
43. C 00000610
44. C DO 20 I=2,ITOT 00000620
45. C NONO(I)=NONO(I)+NONO(I-1) 00000630
46. C 20 KD(I)=KD(I)+NONO(I-1) 00000640
47. C 30 CONTINUE
48. C INDEX=0 00000680
49. C QXN=0.001 00000730
50. C AXN=-ALDS(QXN) 00003640
51. C TCNST=86400. 00000740
52. C TRG=0.0
53. C TD=0.0
54. C TC=0.0
55. C REGENT=0.0
56. C HYTRM=0.0
57. C HYDF=0.0
58. C DWFLR=0.0
59. C RGWFR=0.0
60. C EVAPS=1.0
61. C EVAPD=1.0
62. C EVAPC=1.0
63. C EVAPR=1.0
64. C DO 40 J=1,800 00000840

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65.	PCONC(J)=0.0	00000850
66.	DWCONC(J)=0.0	
67.	RINV(J)=0.0	00000880
68.	CWCONC(J)=0.0	00000890
69.	CMCONC(J)=0.0	00000900
70.	TKCONC(J)=0.0	
71.	PWCON(J)=0.0	
72.	FRAC(J)=0.0	
73.	PER(J)=0.0	
74.	XZH(J)=0.0	00000910
75.	40 CONTINUE	00000920
76.	C	00000930
77.	C READ DESCRIPTION OF REACTOR AND RADWASTE TREATMENT PLANT	00000940
78.	C	00000950
79.	PRINT 9026	00000970
80.	READ 9010,REACTR,TYPE	00000980
81.	PRINT 9010,RFACTR,TYPE	00000990
82.	READ 9011,WORD56,POW1	00001000
83.	PRINT 9011,WORD56,POW1	00001010
84.	PF=0.80	00001020
85.	PRINT 9027	00001030
86.	IF(TYPE.EQ.BWR) GO TO 50	00001040
87.	C READ DATA FOR PWR NSSS PARAMETERS AND TANK PARAMETERS	
88.	READ 9022,WORD56,PCVOL	00001050
89.	PRINT 9022,WORD56,PCVOL	00001060
90.	700 FAILDB=1.0	
91.	FAILLA=0.12	
92.	FAILRA=FAILDR/FAILEA	
93.	PRINT 9028,FAILDB	
94.	READ 9022,WORD56,LETDWN	
95.	PRINT 9022,WORD56,LETDWN	
96.	READ 9022,WORD56,CHFLR	
97.	PRINT 9022,WORD56,CHFLR	
98.	READ 9085,WORD56,HYTRTM	
99.	PRINT 9085,WORD56,HYTRTM	
100.	READ 9090,WORD56,HYDF	
101.	PRINT 9090,WORD56,HYDF	
102.	READ 9013,WORD24,SHLDR	
103.	PRINT 9025,WORD24,SHLDR	
104.	CWA=1.0	
105.	READ 9013,WORD24,EDFLR,EDA	
106.	PRINT 9025,WORD24,EDFLR	
107.	READ 9023,SBTANK,SBTKSZ	
108.	READ 9086,KEVBTS	
109.	IF (KEVBTS.EQ.1) EVAPS=0.02	
110.	READ 9014,DFICW,DFCSCW,DFCW	
111.	READ 9013,WORD24,DWFLR,DWA	
112.	IF (DWFLR.EQ.0.0)GO TO 4446	
113.	PRINT 9025,WORD24,DWFLR	
114.	4446 CONTINUE	
115.	READ 9023,DWTANK,DWTKSZ	
116.	READ 9036,KEVBTD	
117.	IF (KEVBTD.EQ.1)EVAPD=0.02	
118.	READ 9014,DFIDW,DFCSDW,DFDW	
119.	K=1	
120.	PRINT 9045	00001520
121.	PRINT 9016	00001560
122.	IF (SBTKSZ.EQ.0.0)GO TO 45	
123.	PRINT 9024,SBTANK,SBTKSZ,DFICW,DFCSCW,DFCW	
124.	GO TO 46	

125.	45	K=2	
126.	46	CONTINUE	
127.		IF (DWTKSZ.EQ.0.0)GO TO 47	
128.		PRINT 9024,DWTANK,DWTKSZ,DFIOW,DFCSDW,DFDW	
129.	47	CONTINUE	
130.	C		00002300
131.	C	CONVERSION OF UNITS	00002310
132.	C		00002320
133.		DFRG=1.0	
134.		DFIRG=1.0	
135.		DFCSRG=1.0	
136.		GO TO 240	
137.	C		00002470
138.	C	READ DATA FOR BWR NSSS PARAMETERS AND TANK PARAMETERS	
139.	C		00002480
140.	50	READ 9022,WORD56,STMFR	00002490
141.		PRINT 9022,WORD56,STMFR	00002500
142.		READ 9022,WORD56,PCVOL	00002510
143.		PRINT 9022,WORD56,PCVOL	00002520
144.		OGDB=350000.	
145.		PRINT 9052,OGDB	
146.		OGEA=600000.	
147.		OGRTIG=OGDB/OGEA	
148.		FPEF=0.001	00002530
149.		HEF=0.020	
150.		PRINT 9030,FPEF,HEF	00002550
151.		READ 9022,WORD56,LETDWN	00002560
152.		PRINT 9022,WORD56,LETDWN	00002570
153.		READ 9022,WORD56,REGENT	00002650
154.		PRINT 9022,WORD56,REGENT	00002660
155.		READ 9022,WORD56,FFCDM	00002670
156.		PRINT 9022,WORD56,FFCDM	00002680
157.		READ 9085,WORD56,HYTRTM	
158.		PRINT 9085,WORD56,HYTRTM	
159.		READ 9090,WORD56,HYDF	
160.		PRINT 9090,WORD56,HYDF	
161.		K=1	
162.		READ 9013,WORD24,CWFLR,CWA	
163.		READ 9023,CWTANK,CWTKSZ	
164.		READ 9086,KEVBTC	
165.		IF (KEVBTC.EQ.1)EVAPC=0.01	
166.		READ 9014,DFICW,DFCSCW,DFCW	
167.		IF (CWTKSZ.EQ.0.0)GO TO 52	
168.		PRINT 9025,WORD24,CWFLR	
169.		GO TO 54	
170.	52	K=2	
171.	54	CONTINUE	
172.		READ 9013,WORD24,RGWFR	
173.		READ 9023,RGTANK,RGTKSZ	
174.		READ 9086,KEVBTR	
175.		IF (KEVBTR.EQ.1)EVAPR=0.05	
176.		READ 9014,DFIRG,DFCSRG,DFRG	
177.		IF (RGTKSZ.EQ.0.0) GO TO 56	
178.		PRINT 9025,WORD24,RGWFR	
179.	56	CONTINUE	
180.		PRINT 9045	00002710
181.		PRINT 9016	00002750
182.		IF (CWTKSZ.EQ.0.0)GO TO 58	
183.		PRINT 9024,CWTANK,CWTKSZ,DFICW,DFCSCW,DFCW	
184.	58	CONTINUE	

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185.      IF (RGTKSZ.EQ.0.0)GO TO 60
186.      PRINT 9024, RGTANK, RGTKSZ, DFIRG, DFCSR, DFRG
187.      60 CONTINUE
188.      77 DO 78 I=1, ITOT
189.      B(I)=0.0
190.      78 CONTINUE
191.      C
192.      DFIDW=1.0
193.      DFCSOW=1.0
194.      DFUW=1.0
195.      240 CONTINUE
196.      C
197.      C CALCULATE PRIMARY COOLANT CONCENTRATIONS FOR PWR
198.      C
199.      IF (TYPE.EQ.BWR)GO TO 251
200.      AFPTES=0.0
201.      DO 242 I=1, ITOT
202.      242 PCONC(I)=PWCONC(I)
203.      POWA=POW1
204.      PCVOA=PCVOL*1E3
205.      LETDWA=LETDWN*500.53
206.      SBLDA=SBLDR*.3476
207.      CBFLA=CBFLR*500.53
208.      C CHECK TO SEE IF PRIMARY PLANT PARAMETERS ARE WITHIN SPECIFIED
209.      C RANGES
210.      IF (ABS(POWA-3400).GT.400.1)GO TO 243
211.      IF (ABS(PCVOA-5.5E5).GT.0.5001E5)GO TO 243
212.      IF (ABS(LETDWA-3.7E4).GT.0.5001E4)GO TO 243
213.      IF (ABS(SBLDA-625.).GT.375.1)GO TO 243
214.      IF (ABS(CBFLA-3750.).GT.3750.1)GO TO 243
215.      GO TO 247
216.      C CALCULATE PWR PRIMARY COOLANT ADJUSTMENT FACTORS
217.      243 AFPTES=1.0
218.      RHAL2=(LETDWA*0.9+0.1*SBLDA)/PCVOA
219.      RCSR2=(LETDWA*0.5+0.5*(SBLDA+CBFLA*0.9))/PCVOA
220.      RCFP2=(LETDWA*0.9+0.1*(SBLDA+CBFLA*0.9))/PCVOA
221.      RK2=161.76*POWA/PCVOA
222.      DO 246 J=1, ITOT
223.      IF (PCONC(J).EQ.0.0) GO TO 246
224.      NZ=NUCL(J)/10000
225.      DL=DIS(J)*3600.
226.      IF (NZ.EQ.1) GO TO 246
227.      IF (NZ.EQ.53.OR.NZ.EQ.35)GO TO 244
228.      IF (NZ.EQ.37.OR.NZ.EQ.55)GO TO 245
229.      PCONC(J)=PCONC(J)*RK2*(0.0612+DL)/(RCFP2+DL)
230.      GO TO 246
231.      244 PCONC(J)=PCONC(J)*RK2*(0.0606+DL)/(RHAL2+DL)
232.      GO TO 246
233.      245 PCONC(J)=PCONC(J)*RK2*(0.0371+DL)/(RCSR2+DL)
234.      246 CONTINUE
235.      247 PCVOL=PCVOL*1000.*0.7/62.4
236.      DO 279 I=1, ITOT
237.      IF (PCONC(I).EQ.0.0)GO TO 279
238.      FAIL1=FAILRA
239.      IF (I.LE.ILITE)FAIL1=1.0
240.      PCONC(I)=PCONC(I)/(DIS(I)*1.6283E13)*FAIL1
241.      279 CONTINUE
242.      C
243.      GO TO 400
244.      C

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245. C
246. 251 CONTINUE
247. C CALCULATE BWR PRIMARY COOLANT CONCENTRATIONS
248. DO 2251 I=1,ITOT
249. 2251 PCONC(I)=BCONC(I)
250. POWA=POW1
251. PCVOA=PCVOL*1E6
252. LETDWA=LETDWN*1E6
253. STMFA=STMFR*1E6
254. FFCDA=FFCDM
255. C CHECK TO SEE IF PLANT PARAMETERS ARE WITHIN SPECIFIED RANGES
256. IF(ABS(POWA-3400).GT.400.1)GO TO 252
257. IF(ABS(PCVOA-3.8E5).GT.0.4001E5)GO TO 252
258. IF(ABS(LETDWA-1.3E5).GT.0.2001E5)GO TO 252
259. IF(ABS(STMFA-1.5E7).GT.0.2001E7)GO TO 252
260. IF(ABS(FFCDA-0.9).GT.0.1001)GO TO 252
261. GO TO 256
262. C CALCULATE BWR ADJUSTMENT FACTORS
263. 252 RHAL2=(LETDWA*0.9+FFCDA*STMFA*0.018)/PCVOA
264. RCSRB2=(LETDWA*0.5+FFCDA*STMFA*5E-4)/PCVOA
265. RCFP2=(LETDWA*0.9+FFCDA*STMFA*9E-4)/PCVOA
266. RK2=111.76*POWA/PCVOA
267. DO 255 J=1,ITOT
268. IF(PCONC(J).EQ.0.0) GO TO 255
269. NZ=NUCL(J)/10000
270. DL=DIS(J)*3600
271. IF (NZ.EQ.1) GO TO 255
272. IF (NZ.EQ.53.OR.NZ.EQ.35)GO TO 253
273. IF (NZ.EQ.37.OR.NZ.EQ.55)GO TO 254
274. PCONC(J)=PCONC(J)*RK2*(0.3434+DL)/(RCFP2+DL)
275. GO TO 255
276. 253 PCONC(J)=PCONC(J)*RK2*(0.1908+DL)/(RCSRB2+DL)
277. GO TO 255
278. 254 PCONC(J)=PCONC(J)*RK2*(0.1908+DL)/(RCSRB2+DL)
279. 255 CONTINUE
280. 256 PCVOL=PCVOL*1000000./62.4
281. LETDWN=LETDWN*2000. 00003340
282. STMFR=STMFR*2851. 00003350
283. DO 2255 J=1,ITOT
284. OGRTI1=OGRTI0
285. IF (J.LE.1LITE)OGRTI1=1.0
286. IF(PCONC(J).GT.0.0)PCONC(J)=PCONC(J)/(DIS(J)*1.6283E13)*OGRTI1
287. 2255 CONTINUE
288. IF(REGENT.GT.0.0) GO TO 257
289. GO TO 400 00005120
290. C
291. C COMPUTE REMOVAL CONSTANT FOR CONDENSATE DEMINERALIZER IN BWR
292. 257 CCBDM=0.9*STMFR*FPEF/(PCVOL*7.48*60.)*FFCDM
293. CSBDM=0.5*STMFR*FPEF/(PCVOL*7.48*60.)*FFCDM
294. DO 258 I=1,ITOT
295. NZ=NUCL(I)/10000
296. PR(I)=CCBDM
297. IF(NZ.EQ.53.OR.NZ.EQ.35)PR(I)=CCBDM*HEF/FPEF
298. IF(NZ.EQ.37.OR.NZ.EQ.55)PR(I)=CSBDM
299. XZHJ=PCCNC(I)*PR(I)*PCVOL*0.02832
300. B(I)=XZHJ
301. XZH(I)=XZHJ*86400.
302. 258 CONTINUE
303. XZERO(I)=0.
304. C CALCULATE INVENTORIES ON BWR CONDENSATE RESINS 00005130

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305.	290	T(I)=REGENT	00005420
306.		CALL SOLVE	
307.		DO 295 I=1,ITOT	
308.	295	RINV(I)=XTEMP(I)	
309.	C		
310.	C	THIS PORTION OF PROGRAM CALCULATES FAILED TANK CONCENTRATIONS	
311.	C		
312.	400	CONTINUE	
313.		RGWFRM=RGWFR*3785./1E6	
314.		DO 410 I=1,ITOT	
315.	410	D(I)=-DIS(I)	
316.	420	DO 430 J=1,ITOT	
317.		NZ=NUCL(J)/10000	00008320
318.		IF(NZ.EQ.36.OR.NZ.EQ.54) GO TO 430	
319.		IF (TYPE.EQ.PWR)GO TO 425	
320.		CWCONC(J)=PCONC(J)*CWA	00008340
321.		IF (NZ.EQ.1) CWCONC(J)=PCONC(J)	
322.		IF (RGWFR.EQ.0.0)GO TO 430	
323.		RINV(J)=RINV(J)/(REGENT*RGWFRM)	
324.		IF (NZ.EQ.1) RINV(J)=PCONC(J)	
325.		GO TO 430	
326.	425	DFCVCS=10.	
327.		IF(NZ.EQ.1)DFCVCS=1.0	
328.		IF(NZ.EQ.37.OR.NZ.EQ.55) DFCVCS=2.	
329.		CWCONC(J)=PCONC(J)*(CWA*SBLDR/DFCVCS+EDA*EDFLR)/(SBLDR+EDFLR)	
330.		DWCONC(J)=PCONC(J)*DWA	00008360
331.	430	CONTINUE	
332.	C		00008470
333.	C	CALCULATE RADIOACTIVITY AFTER COLLECTION AT A CONSTANT RATE	00008480
334.		IF (TYPE.EQ.BWR)GO TO 432	
335.		IF (SBLDR.GT.0.0)TC=SOTKSZ*0.8/((SBLDR+EDFLR)*EVAPS)	
336.		GO TO 434	
337.	432	CONTINUE	
338.		IF (CWFLR.GT.0.0)TC=CWTKSZ*0.8/(CWFLR*EVAPC)	
339.	434	CONTINUE	
340.		IF (DWFLR.GT.0.0)TD=DWTKSZ*0.8/(DWFLR*EVAPD)	
341.		IF (RGWFR.GT.0.0)TRG=(RGTKSZ*0.8-11900.*EVAPR)/(RGWFR*2.*EVAPR)	
342.		IF (TRG.LT.0.0) TRG=0.	
343.	C		00008490
344.		CALL COLLECT(TC*86400.,CWCONC,ILITE,ITOT)	00008500
345.		CALL COLLECT(TD*86400.,DWCONC,ILITE,ITOT)	00008520
346.	440	IF (REGENT.LE.0.0)GO TO 450	
347.		CALL STORAG(TRG*86400.,RINV,ILITE,ITOT)	
348.	450	DO 500 I=1,ITOT	
349.		NZ=NUCL(I)/10000	00008580
350.		IF (NZ.EQ.1) GO TO 500	
351.		IF (NZ.EQ.35.OR.NZ.EQ.53)GO TO 460	
352.		IF (NZ.EQ.37.OR.NZ.EQ.55)GO TO 470	
353.	C		00008650
354.	C	CHEMICAL TREATMENT FOR OTHER CATIONS	00008660
355.	C		00008670
356.		CWCONC(I)=CWCONC(I)/DFCW	00008680
357.		DWCONC(I)=DWCONC(I)/DFDW	00008700
358.		RINV (I)=RINV (I)/DFRG	
359.		GO TO 500	
360.	C		00008790
361.	C	CHEMICAL TREATMENT FOR ANIONS	00008800
362.	C		00008810
363.	460	CWCONC(I)=CWCONC(I)/DFICW	
364.		DWCONC(I)=DWCONC(I)/DFIDW	00008840

365.	RINV (I)=RINV (I)/DFIRG	
366.	GO TO 500	
367.	C	00008910
368.	C CHEMICAL TREATMENT FOR RB AND CS	00008920
369.	C	00008930
370.	470 CWCONC(I)=CWCONC(I)/DFCSW	
371.	DWCONC(I)=DWCONC(I)/DFCSW	00008960
372.	RINV (I)=RINV (I)/DFCSRG	
373.	500 CONTINUE	
374.	C	
375.	STS=SBTKSZ*0.8	
376.	DTS=DWTKSZ*0.8	
377.	CTS=CWTKSZ*0.8	
378.	RTS=RGTKSZ*0.8	
379.	C	00009410
380.	IF(REGENT.LT.0.001)GO TO 503	
381.	DO 502 I=1,ITOT	
382.	CMCUNC(I)=RINV(I)	
383.	502 CONTINUE	
384.	503 CONTINUE	
385.	IF (K.EQ.2) GO TO 508	
386.	CTKSZ=STS	
387.	IF (TYPE.EQ.BWR) CTKSZ=CTS	
388.	DO 507 I=1,ITOT	
389.	507 TKCONC(I)=CWCONC(I)	
390.	GO TO 512	
391.	508 DAN=1.6	
392.	IF(TYPE.EQ.BWR)GO TO 510	
393.	CTKSZ=DTS	
394.	DO 509 I=1,ITOT	
395.	509 TKCONC(I)=DWCONC(I)	
396.	GO TO 512	
397.	510 KATH=4.7	
398.	CTKSZ=RTS	
399.	DO 511 I=1,ITOT	
400.	511 TKCONC(I)=CMCUNC(I)	
401.	512 CONTINUE	
402.	DO 540 I=1,ITOT	
403.	NZ=NUCL(I)/10000	00009600
404.	IF(NZ.EQ.36.OR.NZ.EQ.54) GO TO 540	
405.	DISI=DIS(I)*1.6283E13	00009620
406.	TKCONC(I)=TKCONC(I)*DISI	
407.	IF (TKCONC(I).GT.0.0) GO TO 535	
408.	PWCON(I)=0.0	
409.	GO TO 540	
410.	535 V=DIS(I)*HYTRTM*86400.	
411.	IF (V.GT.75.) V=75.	
412.	PWCON(I)=(TKCONC(I)/HYDF)*EXP(-V)	
413.	540 CONTINUE	
414.	DO 545 I=1,ITOT	
415.	545 FRAC(I)=PWCON(I)/WMPC(I)	
416.	550 SAPRIM=0.0	
417.	STANK=0.0	
418.	SCRECN=0.0	
419.	SFRACT=0.0	
420.	PAPRIM=0.0	00010010
421.	PTANK=0.0	
422.	PCRECN=0.0	
423.	PFRACT=0.0	
424.	MCH3=TKCONC(3)/FRAC(3)	

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425.      MQH3=MCH3*CTKSZ*3785./1.0E6
426.      IF (MQH3.GT.5000.) MQH3=5000.
427.      IF (TYPE.EQ.BWR) GO TO 553
428.      IF (K.EQ.1) PRINT 9076,REACTR,SBTANK,STS,HYTRTM,HYDF
429.      IF (K.EQ.2) PRINT 9076,REACTR,DWTANK,DTS,HYTRTM,HYDF
430.      GO TO 555
431. 553 CONTINUE
432.      IF (K.EQ.1) PRINT 9076,REACTR,CWTANK,CTS,HYTRTM,HYDF
433.      IF (K.EQ.2) PRINT 9076,REACTR,RGTANK,RTS,HYTRTM,HYDF
434. 555 CONTINUE
435.      PRINT 9077
436.      PRINT 9081
437.      KOUNTR=1
438.      I1=ILITE+IACT+1
439.      L=1
440.      DO 580 I=1,ITDT
441.      IF (I.EQ.1)PRINT 9082
442.      NZ=NUCL(I)/10000
443.      IF (NZ.EQ.36.OR.NZ.EQ.54)GO TO 580
444.      DISI=DIS(I)*1.6283E+13
445.      APRIM=PCONC(I)*DISI
446.      WMPC1=WMPC(I)
447.      TANK=TKCONC(I)
448.      CRECN=PwCON(I)
449.      FRACT=FRAC(I)
450.      NUCL1=NUCL(I)
451.      L=L+1
452.      IF (NZ.EQ.1) GO TO 560
453.      SAPRIM=SAPRIM+APRIM
454.      STANK=STANK+TANK
455.      SCRECN=SCRECN+CRECN
456.      SFRACT=SFRACT+FRACT
457. 560 IF (FRACT.LT.0.001) GO TO 580
458.      IF (MOD(KOUNTR,50).NE.0) GO TO 570
459.      PRINT 9084, REACTR
460.      PRINT 9077
461. 570 CALL NOAAH(NUCL(I),NAME)
462.      THALF=8.0225F-6/DISI
463.      ISUB=2
464.      IF (TANK.GT.1.) ISUB=1
465.      DIV=10.**((INT(ALOG10(TANK))-ISUB)
466.      TANK1=AINT(TANK/DIV+0.5)*DIV
467.      ISUB=2
468.      IF (CRECN.GT.1.0) ISUB=1
469.      DIV=10.**((INT(ALOG10(CRECN))-ISUB)
470.      CRECN1=AINT(CRECN/DIV+0.5)*DIV
471.      ISUB=2
472.      IF (FRACT.GT.1.0) ISUB=1
473.      DIV=10.**((INT(ALOG10(FRACT))-ISUB)
474.      FRACT1=AINT(FRACT/DIV+0.5)*DIV
475.      ISUB=1
476.      PRINT 9078, NAME,THALF,APRIM,WMPC1,TANK1,CRECN1,FRACT1
477.      KOUNTR=KOUNTR+1
478.      IF (NZ.EQ.1) GO TO 580
479.      PAPRIM=PAPRIM+APRIM
480.      PTANK=PTANK+TANK
481.      PCRECN=PCRECN+CRECN
482.      PFRACT=PFRACT+FRACT
483. 580 CONTINUE
484.      PAPRIM=SAPRIM-PAPRIM

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00010260

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485.      PTANK=STANK-PTANK
486.      PCRECN=SCRECN-PCRECN
487.      PFRACT=SFRACT-PFRACT
488.      MCCFP=STANK/SFRACT
489.      MQCFP=MCCFP*CTKSZ*3785./1.0E6
490.      IF (MQCFP.GT.15.) MQCFP=15.
491.      ISUBP=2
492.      IF (PTANK.GT.1.0) ISUBP=1
493.      DIV=10.**{INT(ALOG10(PTANK))-ISUBP}
494.      PTANK=AINT(PTANK/DIV+0.5)*DIV
495.      ISUBP=2
496.      IF (PCRECN.GT.1.0) ISUBP=1
497.      DIV=10.**{INT(ALOG10(PCRECN))-ISUBP}
498.      PCRECN=AINT(PCRECN/DIV+0.5)*DIV
499.      IF (PFRACT.EQ.0.0) GO TO 585
500.      ISUBP=2
501.      IF (PFRACT.GT.1.0) ISUBP=1
502.      DIV=10.**{INT(ALOG10(PFRACT))-ISUBP}
503.      PFRACT=AINT(PFRACT/DIV+0.5)*DIV
504.  585  ISUBS=1
505.      IF (STANK.LT.1.0) ISUBS=2
506.      DIV=10.**{INT(ALOG10(STANK))-ISUBS}
507.      STANK=AINT(STANK/DIV+0.5)*DIV
508.      ISUBS=1
509.      IF (SCRECN.LT.1.0) ISUBS=2
510.      DIV=10.**{INT(ALOG10(SCRECN))-ISUBS}
511.      SCRECN=AINT(SCRECN/DIV+0.5)*DIV
512.      ISUBS=1
513.      IF (SFRACT.LT.1.0) ISUBS=2
514.      DIV=10.**{INT(ALOG10(SFRACT))-ISUBS}
515.      SFRACT=AINT(SFRACT/DIV+0.5)*DIV
516.      PRINT 9079,  PAPRIM,PTANK,PCRECN,PFRACT
517.      PRINT 9080,  SAPRIM,STANK,SCRECN,SFRACT
518.      PRINT 9100,  MQH3,MQCFP
519.      IF(TYPE.EQ.BWR)GO TO 600
520.      IF(K.EQ.2.OR.DWTKSZ.EQ.0.0)GO TO 30
521.      GO TO 610
522.  600  CONTINUE
523.      IF(K.EQ.2.OR.RGTKSZ.EQ.0.0)GO TO 30
524.  610  K=K+1
525.      GO TO 503
526.      C          00005630
527.      C  FORMATS          FORMATS          FORMATS          00005640
528.      C          00005650
529.      9010 FORMAT(32X,7A4,16X,A4)          00005760
530.      9011 FORMAT(16X,13A4,A3,F9.4)        00005770
531.      9012 FORMAT(16X,14A4,F8.4)          00005780
532.      9013 FORMAT(16X,6A4,1X,F8.0,7X,F5.3)
533.      9014 FORMAT(20X,F9.0,2(5X,F8.0))
534.      9016 FORMAT('0',70X,'TANK FACTORS'/34X,'FAILED TANK',13X,'VOLUME',6X,
535.      1      'I',9X,'CS',7X,'OTHERS')
536.      9022 FORMAT(16X,14A4,F8.4)          00005890
537.      9023 FORMAT(26X,6A4,14X,F9.0)
538.      9024 FORMAT(30X,6A4,3X,F9.0,2X,3(1PE9.2,1X))
539.      9025 FORMAT(16X,6A4,' GPD',28X,1PE8.2)
540.      9026 FORMAT(1H1)                    00006010
541.      9027 FORMAT(16X,'PLANI CAPACITY FACTOR',T75,'0.80') 00006020
542.      9028 FORMAT(16X,'PERCENT FUEL WITH CLADDING DEFECTS',T75,F6.4) 00006030
543.      9030 FORMAT(16X,'FISSION PRODUCT CARRY-OVER FRACTION',T75,F6.4/16X, 00006060
544.      1'HALOGEN CARRY-OVER FRACTION',T75,F6.4) 00006070

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9045 FORMAT(/,15X,'FAILED TANK PARAMETERS')
546. 9052 FORMAT(16X,'OFF-GAS RELEASE RATE(UC/SEC)',28X,F8.0)
547. 9076 FORMAT (1H1,20X,7A4,' LIQUID TANK FAILURE'/1H ,21X,'NAME OF TANK F
548. 1AILED: ',6A4/1H ,21X,'VOLUME OF TANK FAILED: ',F9.0,' GAL. (80
549. 2% OF TANK CAPACITY)'/1H ,21X,'HYDROLOGICAL TRAVEL TIME (DAYS):
550. 3',F8.2/1H ,21X,'HYDROLOGICAL DILUTION FACTOR: ',F8.0)
551. 9077 FORMAT (1H0,28X,'PRIMARY',22X,'FAILED',7X,'CRITICAL'/29X,'COOLANT'
552. 1,7X,'1CCFR20',9X,'TANK',8X,'RECEPTOR',6X,'FRACTION'/4X,'NUCLIDE',
553. 24X,'HALF-LIFE',5X,'CONC.',9X,'LIMITS',10X,'CONC.',7X,'CONC.',9X,
554. 3'10CFR20'/15X,'(DAYS)',2X,416X,'(UCI/ML)')
555. 9078 FORMAT (4X,A2,I3,A1,4X,1PE9.2,4(5X,1PE9.2),3X,0PF12.4)
556. 9079 FORMAT (4X,'ALL OTHERS',14X,1PE9.2,19X,1PE9.2,5X,1PE9.2,3X,0PF12.4
557. 1)
558. 9080 FORMAT (4X,'TOTAL'/4X,'EXCEPT TRITIUM',10X,1PE9.2,19X,1PE9.2,5X,1P
559. 1E9.2,3X,0PF12.4)
560. 9081 FORMAT (4X,'CORROSION AND ACTIVATION PRODUCTS')
561. 9082 FORMAT (1H0,4X,'FISSION PRODUCTS')
562. 9084 FDRMAT (1H1,20X,7A4,' LIQUID TANK FAILURE (CONTINUED)')
563. 9085 FORMAT(16X,14A4,F8.2)
564. 9086 FDRMAT (79X,I1)
565. 9090 FORMAT(16X,14A4,F8.0)
566. 9100 FORMAT (1H0,3X,'THE MAXIMUM QUANTITY OF TRITIUM IN THE TANK IS ',1
567. 1PE7.1,' CURIES.'/1H0,3X,'THE MAXIMUM QUANTITY OF CORROSION AND FIS
568. 2SION PRODUCTS (EXCLUDING TRITIUM) IN THE TANK IS ',1PE7.1,' CURIES
569. 3.')
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00006230

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570. END
571. BLOCK DATA
572. COMMON /CONB/BCONC(800)
573. COMMON/CONP/PWCONC(800)
574. DATA BCONC/2*0,0.01,33*0,
575. 1 9E-3,13*0,2E-4,53*0,5E-3,4*0,6E-5,0.0,5E-2,3*0,
576. 11E-3,3*0,3E-5,0.0,2E-4,2*0,4E-4,7*0,1E-6,0.0,3E-4,2*0,3E-2,4*0,
577. 22E-4,3*0,2E-3,98*0,3E-4,64*0,7E-3,63*0,3E-3,4*0,5E-3,2*0,3E-3,
578. 319*0,5E-3,1E-4,3*0,6E-6,5*0,4E-3,0.0,4E-5,3*0,1E-2,6E-3,4*0,4E-3,
579. 411*0,7E-6,0.0,7E-6,6*0,5E-6,5*0,4E-3,2*0,2E-3,2E-2,8*0,9E-2,7*0,
580. 52E-5,3*0,8E-2,6*0,2E-3,4*0,3E-6,21*0,1E-6,104*0,4E-5,13*0,1E-4,
581. 60.0,5E-3,5*0,1E-5,3E-2,4*0,2E-2,5*0,7E-2,2*0,3E-5,2*0,2E-2,8*0,
582. 72E-5,3*0,7E-5,4*0,1E-2,4*0,1E-2,3*0,4E-4,4*0,1E-2,0.0,3E-5,3*0,
583. 86E-3,5E-3,7*0,3E-5,4E-5,2*0,3E-6,10*0,3E-6,81*0/
584. DATA PWCONC/2*0,1.0,101*0,
585. 1 1.9E-3,4*0,3.1E-4,5*0,1.6E-3,3*0,1E-3,0.0, .016,
586. 12*0,2E-3,185*0,1.2E-3,63*0,4.8E-3,4*0,2.6E-3,2*0,3E-4,6*0,8.5E-5,
587. 28*0,.2,4*0,3.5E-4,3*0,1E-5,0.0,1.2E-6,3*0,6.5E-4,3.6E-4,6.4E-5,9*000010680
588. 3,3.4E-5,11*0,6E-5,0.0,5E-5,15*0,.084,.048,16*0,4.5E-5,4.5E-5,14*0, 00010690
589. 41E-5,0.0,1E-5,103*0,2.9E-5,8*0,2.8E-4,8.5E-4,10*0,1.4E-3,1.6E-3,
590. 58*0,2.1E-3,3*0,2.5E-3,1.1E-3,.27,5*0,.027,.1,4*0,.38,5*0,.047,2*0,
591. 6.025,2*0,.19,8*0,.313,3*0,.018,.016,12*0,2.2E-4,1.5E-4,5*0,7E-5,
592. 712*0,4E-5,5E-5,2*0,3.3E-5,3.3E-5,91*0/
593. END
594. SUBROUTINE SOLVE
595. COMMON/EC/XZFRO(800), XZH(800),XTEMP(800),XNEW(10,800),
596. 1 B(800),D(800)
597. COMMON/FLEX/FLUX(10),MMN,MOUT,INDEX,QXN,AXN,ERR,NOBLND,MZERO
598. COMMON/PROCSS/ MPROS,PRATE(8),NOPROS(8),NZPROS(8,20),PR(800)
599. COMMON/FLUXN/T(20),POWER(10),TOCAP(800),FISS(100),DIS(800),LLITE,
600. 1 IACT,IFP,ITOT,NON,INPT
601. COMMON/OUT/NUCL(800),TITLE(20),Q(800),FG(800),CUTOFF(7),
602. 1 POW,BURNUP,FLUXB,MSTAR,ALPHAN(100),SPONF(100),ABUND(500),
603. 2 BASIS(10),TCNST,TUNIT
604. DD 10 I=1,ITOT
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00010990
00011000
00011010
00011020
00011030
00011040
00011050
00011060
00011070
00011080
00011090

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605.      D(I)=-DIS(I)                                00011100
606.      10 XTEMP(I)=0.0                            00011110
607.      DELT=T(1)*TCONST                          00011120
608.      CALL DECAY(1,DELT,ITOT)                    00011130
609.      CALL TERM(DELT,1,ILITE,ITOT)              00011140
610.      CALL EQUIL(1,ITOT)                        00011150
611.      DO 30 I=1,ITOT                             00011160
612.      30 XTEMP(I)=XNEW(1,I)                     00011170
613.      RETURN                                     00011180
614.      END                                         00011190
615.      SUBROUTINE TERM(T,M,ILITE,ITOT)           00011200
616.      C                                           00011210
617.      C      TERM ADDS ONE TERM TO EACH ELEMENT OF THE SOLUTION VECTOR 00011220
618.      C      CSUM(J) IS THE CURRENT APPROXIMATION TO XNEW(M,J)      00011230
619.      C      CIMO(J) IS THE VECTOR CONTAINING THE LAST TERM ADDED TO EACH 00011240
620.      C      ELEMENT OF CSUM(J)                                     00011250
621.      C      CIMN(J) IS THE VECTOR CONTAINING 1/TOTN TIMES THE NEW TERM TO BE 00011260
622.      C      ADDED TO CSUM(J)                                       00011270
623.      C      CIMN(J) IS GENERATED FROM CIMO(J) BY A RECURSION RELATION: 00011280
624.      C      CIMN(J)= SUM OVER L OF (AP(J,L)*CIMO(L))                00011290
625.      C      AP(I,J) IS THE REDUCED TRANSITION MATRIX FOR THE LONG-LIVED 00011300
626.      C      NUCLIDES                                             00011310
627.      C                                                           00011320
628.      LOGICAL*1 LONG                                           00011330
629.      INTEGER*2 LOC,NON0,KD                                     00011340
630.      INTEGER*2 LOCP(2500)                                    00011350
631.      INTEGER*2 NONP(800)                                     00011360
632.      INTEGER*2 NQ,NQU,NQUEUE                                00011370
633.      REAL*8 BATE,RATM                                        00011380
634.      REAL*8 CIMN(800),CSUM(800),CIMNI                      00011390
635.      DIMENSION AP(2500),CIMB(800),CIMO(800)                00011400
636.      DIMENSION QUR(50)                                       00011410
637.      COMMON/SERIES/ XP(800),XPAR(800),LONG(800)            00011420
638.      COMMON/FLEX/FLUX(10),MMN,MOUT,INDEX,QXN,AXN,ERR,NOBLND,MZERO 00011430
639.      COMMON/EQ/XZFRD(800),XZH(800),XTEMP(800),XNEW(10,800), 00011440
640.      1      B(800),D(800)                                     00011450
641.      COMMON/MATRIX/A(2500),LOC(2500),NON0(800),KD(800)     00011460
642.      COMMON/DEBUGG/AP                                         00011470
643.      COMMON/TERMD/DD(100),DXP(100),QUEUE(50),NQU(50),NQUEUE(50),NQ(800) 00011480
644.      NUL=0                                                    00011490
645.      NN=0                                                    00011500
646.      C      FIRST CONSTRUCT REDUCED TRANSITION MATRIX FOR LONG-LIVED ISOTOPES 00011510
647.      DO 220 L=1,ITOT                                         00011520
648.      IF(.NOT.LONG(L)) GO TO 210                             00011530
649.      NUM=NON0(L)                                             00011540
650.      IF(M.GT.MMN.OR.M.EQ.MZERO) NUM=KD(L)                  00011550
651.      CIMB(L)=B(L)                                           00011560
652.      IF(NUM.LE.NUL) GO TO 210                               00011570
653.      NS=NN+1                                                00011580
654.      N=NUL                                                  00011590
655.      NL=NUM-NUL                                             00011600
656.      DO 200 N1=1,NL                                         00011610
657.      N=N+1                                                  00011620
658.      J=LOC(N)                                               00011630
659.      DJ=-D(J)                                               00011640
660.      C                                                           00011650
661.      C      THIS IS A TEST TO SEE IF ONE OF THE ASSYMPOTIC SOLUTIONS APPLIES 00011660
662.      C                                                           00011670
663.      C      IF(.NOT.LONG(J)) GO TO 10                       00011680
664.      C      NN=NN+1                                         00011690

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666.		AP(NN)=A(N)	00011700
667.		LOCP(NN)=J	00011710
668.		GO TO 200	00011720
669.	C		00011730
670.	C	GOING BACK UP THE CHAIN TO FIND A PARENT WHICH IS NOT IN	00011740
671.	C	EQUILIBRIUM	00011750
672.	10	NSAVE=0	00011760
673.		QUE=A(N)/DJ	00011770
674.		DRB=1.0	00011780
675.		CIMB(L)=CIMB(L)+QUE*B(J)	00011790
676.		NQ(L)=0	00011800
677.		NQ(J)=L	00011810
678.	20	NUX=NONO(J)	00011820
679.		IF(M.GT.MMN.OR.M.EQ.MZERO) NUX=KD(J)	00011830
680.		NUF=J	00011840
681.		IF(J.GT.1) NUF=NONO(J-1)	00011850
682.		NX=NUX-NUF	00011860
683.		IF(NX.LT.1) GO TO 190	00011870
684.		K=NUF	00011880
685.		DO 180 KK=1,NX	00011890
686.		K=K +1	00011900
687.		J1=LCC(K)	00011910
688.		DJ=-D(J1)	00011920
689.		KP=J	00011930
690.	30	IF(J1.EQ.NQ(KP)) GO TO 180	00011940
691.		KP=NQ(KP)	00011950
692.		IF(KP.NE.0) GO TO 30	00011960
693.		AKDJQ=QUE*A(K)/DJ	00011970
694.		IF(.NOT.LONG(J1)) GO TO 160	00011980
695.		TRM=1.0-XP(J1)	00011990
696.		IF(TRM.LT.1.0E-6) GO TO 120	00012000
697.		NQ(J1)=J	00012010
698.		I=1	00012020
699.		KP=J1	00012030
700.	40	DD(I)=-D(KP)	00012040
701.		DXP(I)=XP(KP)	00012050
702.		KP=NQ(KP)	00012060
703.		IF(KP.EQ.0) GO TO 50	00012070
704.		I=I+1	00012080
705.		IF(I.LE.100) GO TO 40	00012090
706.	C	IF QUEUE OF SHORT-LIVED NUCLIDES EXCEEDS 100 ISOTOPES, TERMINATE	00012100
707.	C	CHAIN AND WRITE MESSAGE	00012110
708.		PRINT 9000, M,L,J1,J,AKDJQ	00012120
709.	9000	FORMAT('ITOD LONG A QUEUE HAS BEEN FORMED IN TERM',4I5,E12.5)	00012130
710.		GO TO 190	00012140
711.	50	BATM=0.00	00012150
712.		IM=I-1	00012160
713.		DO 110 I=2,IM	00012170
714.		DL=DD(I)	00012180
715.		XPL=DXP(I)	00012190
716.		BATE=0.00	00012200
717.		I1=I-1	00012210
718.	C	D R VONDI FORM OF BATEMAN EQUATIONS -- ORNL-TM-361	00012220
719.		DO 100 KB=1,I1	00012230
720.		XPJ=DXP(KB)	00012240
721.		IF(XPL+XPJ.LT.ERR) GO TO 100	00012250
722.		DK=DD(KB)	00012260
723.		PROD=(DL/DK-1.0)	00012270
724.		DKR=PROD	00012280
			00012290

725.		IF(ABS(PROD).GT.1.E-4) GO TO 60	00012300
726.	C	USE THIS FORM FOR TWO NEARLY EQUAL HALF-LIVES	00012310
727.		PROD=T*DK*XPJ*(1.0-0.5*(DL-DJ)*T)	00012320
728.		GO TO 70	00012330
729.	60	PROD=(XPJ-XPL)/PROD	00012340
730.		PRO1=XPJ/DKR	00012350
731.	70	PI=1.0	00012360
732.		S1=2./(DK*T)	00012370
733.		DO 90 JK=1,11	00012380
734.		IF(JK.EQ.KB) GO TO 90	00012390
735.		S=1.0-DK/CD(JK)	00012400
736.		IF(ABS(S).GT.1.E-4) GO TO 80	00012410
737.		IF(ABS(DKR).GT.1.0E-4) PROD=PRO1	00012420
738.		S=S1	00012430
739.	80	PI=PI*S	00012440
740.		IF(ABS(PI).GT.1.E25) GO TO 100	00012450
741.	90	CONTINUE	00012460
742.		BATE=BATE+PROD/PI	00012470
743.	100	CONTINUE	00012480
744.	C	IF SUMMATION IS NEGATIVE, SET EQUAL TO ZERO AND PRINT MESSAGE	00012490
745.		IF(BATE.LT.0.DO) PRINT 9001, L,IM,BATE,BATM	00012500
746.	9001	FORMAT('IBATE IS NEGATIVE IN TERM. THERE ARE MORE THAN TWO SHORT-L	00012510
747.		IIVED NUCLIDES IN A CHAIN WITH NEARLY EQUAL DIAGONAL ELEMENTS')/	00012520
748.		2' L,IM,BATE,BATM = ',2I5,1P2E12.5)	00012530
749.		IF(BATE.LT.0.DO) BATL=0.DO	00012540
750.		BATM=BATM+BATE	00012550
751.	110	CONTINUE	00012560
752.		DRA=AKDJQ*DJ*(TRM-BATM)/TRM	00012570
753.		GO TO 130	00012580
754.	120	DRA=AKDJQ*AMAX1(DRH,0.0)*DJ	00012590
755.	130	IF(NS.GT.NN) GO TO 150	00012600
756.		DO 140 LJ=J5,NN	00012610
757.		IF(LOCP(LJ).NE.J1) GO TO 140	00012620
758.		AP(LJ)=AP(LJ)+DRA	00012630
759.		GO TO 180	00012640
760.	140	CONTINUE	00012650
761.	150	NN=NN+1	00012660
762.		AP(NN)=DRA	00012670
763.		LOCP(NN)=J1	00012680
764.		GO TO 180	00012690
765.	160	IF(AKDJQ.LE.1.0E-06) GO TO 180	00012700
766.		IF(NSAVE.GE.50) GO TO 180	00012710
767.	170	NSAVE=NSAVE+1	00012720
768.		NQUEUL(NSAVE)=J1	00012730
769.		QUEUE(NSAVE)=AKDJQ	00012740
770.		NQU(NSAVE)=J	00012750
771.		QUB(NSAVE)=DRB-1./(DJ*T)	00012760
772.	180	CONTINUE	00012770
773.	190	IF(NSAVE.LE.0) GO TO 200	00012780
774.		J=JQUEUL(NSAVE)	00012790
775.		QUE=QUEUE(NSAVE)	00012800
776.		NQ(J)=NQU(NSAVE)	00012810
777.		DRB=QUB(NSAVE)	00012820
779.		CIMB(L)=CIMB(L)+QUE*B(J)*AMAX1(DRB,0.0)	00012830
779.		NSAVE=NSAVE-1	00012840
780.		GO TO 200	00012850
781.	200	CONTINUE	00012860
782.	210	NUL=NGNO(L)	00012870
783.		NQIP(L)=NN	00012880
784.	220	CONTINUE	00012890

785.	C	FIND NORM OF MATRIX AND ESTIMATE ERROR AS DESCRIBED IN LAPIDUS	00012900
786.	C	AND LUUS, OPTIMAL CONTROL OF ENGINEERING PROCESSES BLAISDELL 1967	00012910
787.	C	FIND THE MINIMUM OF THE MAXIMUM ROW SUM AND THE MAXIMUM COLUMN SUM	00012920
788.		ASUM =0.0	00012930
789.		ASUMJ=0.0	00012940
790.		NUL=1	00012950
791.		DO 250 I=1,ITOT	00012960
792.		IF(.NOT.LONG(I)) GO TO 250	00012970
793.		DI=-D(I)*T	00012980
794.		AJ=DI	00012990
795.		NUM=NONP(I)	00013000
796.		IF(NUL.GT.NUM) GO TO 240	00013010
797.		DO 230 N=NUL,NUM	00013020
798.	230	AJ=AJ+AP(N)	00013030
799.	240	AI=DI+DI	00013040
800.		IF(AI.GT.ASUM) ASUM =AI	00013050
801.		IF(AJ.GT.ASUMJ) ASUMJ=AJ	00013060
802.	250	NUL=NONP(I)+1	00013070
803.		IF(ASUMJ.LT.ASUM) ASUM=ASUMJ	00013080
804.	C	USE ASUM TO DECIDE HOW MANY TERMS ARE REQUIRED AND ESTIMATE ERROR	00013090
805.		NLARGE=3.5*ASUM +5.	00013100
806.		XLARGE=NLARGE ²	00013110
807.		ERR1=EXP(ASUM)*(ASUM*2.71828/XLARGE)**NLARGE/SQRT(6.2832*XLARGE)	00013120
808.		IF(ERR1.GT.1.E-3) PRINT 9002, ERR1,ASUM,NLARGE	00013130
809.	9002	FORMAT('O MAXIMUM ERROR GT 0.001, ='F10.6,', TRACE = 'F10.4,	00013140
810.	1	' NLARGE = 'I6)	00013150
811.	C	NEXT GENERATE MATRIX EXPONENTIAL SOLUTION	00013160
812.		DO 260 I=1,ITOT	00013170
813.		CSUM(I)=XTCMP(I)	00013180
814.		CIMN(I)=XTEMP(I)	00013190
815.	260	CONTINUE	00013200
816.		FRR3=0.001*EPR	00013210
817.		DO 310 NT=1,NLARGE	00013220
818.		DO 270 I=1,ITOT	00013230
819.		CIMO(I)=CIMN(I)	00013240
820.	270	CONTINUE	00013250
821.		TON=T/NT	00013260
822.		NUL=1	00013270
823.		DO 300 I=1,ITOT	00013280
824.		IF(.NOT.LONG(I)) GO TO 300	00013290
825.		NUM=NONP(I)	00013300
826.		CIMNI=0.0	00013310
827.		IF(NT.EC.1) CIMNI=CIM3(I)	00013320
828.		IF(NUL.GT.NUM) GO TO 290	00013330
829.		DO 280 N=NUL,NUM	00013340
830.		J=LOCP(N)	00013350
831.	280	CIMNI=CIMNI+AP(N)*CIMO(J)	00013360
832.	290	CIMNI=CIMNI+D(I)*CIMO(I)	00013370
833.		CIMNI=TON*CIMNI	00013380
834.		IF(DABS(CIMNI).LT.ERR3) CIMNI=0.00	00013390
835.		CIMN(I)=CIMNI	00013400
836.		CSUM(I)=CSUM(I)+CIMNI	00013410
837.	300	NUL=NONP(I)+1	00013420
838.	310	CONTINUE	00013430
839.		DO 320 I=1,ITOT	00013440
840.		IF(CSUM(I).LT.ERR) CSUM(I)=0.0	00013450
841.		IF(LONG(I)) XNEW(M,I)=CSUM(I)	00013460
842.	320	CONTINUE	00013470
843.		RETURN	00013480
844.		END	00013490

845.		SUBROUTINE DFCAY(M,T,ITOT)	00013500
846.	C	DECAY TREATS SHORT-LIVED ISOTOPES AT BEGINNING OF CHAINS USING	00013510
847.	C	BATEMAN EQUATIONS	00013520
848.		LOGICAL*1 LONG	00013530
849.		REAL*8 BATE	00013540
850.		INTEGER*2 LOC,NONO,KD	00013550
851.		INTEGER*2 NQ,NQU,NQUEUE	00013560
852.		COMMON/DEBUGG/AP(2500)	00013570
853.		COMMON/SERIES/ XP(800),XPAR(800),LONG(800)	00013580
854.		COMMON/FLEX/FLUX(10),MMN,MOUT,INDEX,QXN,AXN,ERR,NOBLND,MZERO	00013590
855.		COMMON/FG/XZFRU(800),XZH(800),XTEMP(800),XNEW(10,800),	00013600
856.		1 B(800),D(800)	00013610
857.		COMMON/MATRIX/A(2500),LOC(2500),NONO(800),KD(800)	00013620
858.		COMMON/TERM/D(100),DXP(100),QUEUE(50),NQU(50),NQUEUE(50),NQ(800)	00013630
859.		DO 10 I=1,ITOT	00013640
860.		XPAR(I)=C.O	00013650
861.		LONG(I)=.FALSE.	00013660
862.		XPI=0.0	00013670
863.		DT=D(I)*T	00013680
864.		IF(DT.LT.-50.) GO TO 10	00013690
865.		IF(ABS(DT).LF.AXN) LONG(I)=.TRUE.	00013700
866.		XPI=EXP(DT)	00013710
867.	10	XP(I)=XPI	00013720
868.		NUL=1	00013730
869.		DO 160 L=1,ITOT	00013740
870.		XTEM=0.C	00013750
871.		DL=-D(L)	00013760
872.		NUM=NONJ(L)	00013770
873.		IF(M.GT.MMN.OR.M.EQ.MZERO) NUM=KD(L)	00013780
874.		IF(NUM.LT.NUL) GO TO 150	00013790
875.		DO 140 N=NUL,NUM	00013800
876.		J=LOC(N)	00013810
877.		DJ=-D(J)	00013820
878.		IF(LONG(J)) GO TO 140	00013830
879.	C	USE THIS FORM FOR TWO NEARLY EQUAL HALF-LIVES	00013840
880.		IF(ABS(DL/DJ-1.0).LE.1.0E-5) XTEM=XTEM+XTEMP(J)*A(N)*XP(J)*T	00013850
881.		IF(ABS(DL/DJ-1.0).GT.1.0E-5)	00013860
882.	1	XTEM=XTEM+XTEMP(J)*A(N)*(XP(J)-XP(L))/(DL-DJ)	00013870
883.		QUE=A(N)/DJ	00013880
884.		NQ(L)=0	00013890
885.		NQ(J)=L	00013900
886.		NSAVE=0	00013910
887.	20	NUX=NONO(J)	00013920
888.		IF(M.GT.MMN.OR.M.EQ.MZERO) NUX=KD(J)	00013930
889.		NUF=1	00013940
890.		IF(J.GT.1) NUF=NONO(J-1)+1	00013950
891.		IF(NUF.GT.NUX) GO TO 130	00013960
892.		DO 120 K=NUF,NUX	00013970
893.		J1=LOC(K)	00013980
894.		IF(LONG(J1)) GO TO 120	00013990
895.		KP=J	00014000
896.	30	IF(J1.EQ.NQ(KP)) GO TO 120	00014010
897.		KP=NQ(KP)	00014020
898.		IF(KP.NE.0) GO TO 30	00014030
899.		DJ=-D(J1)	00014040
900.		AKDJQ=A(K)/DJ*QUE	00014050
901.		IF(AKDJQ.LE.1.0E-06) GO TO 120	00014060
902.		NQ(J1)=J	00014070
903.		I=1	00014080
904.		KP=J1	00014090

905.	40	DD(I)=-D(KP)	00014100
906.		DXP(I)=XP(KP)	00014110
907.		KP=NQ(KP)	00014120
908.		IF(KP.EQ.0) GO TO 50	00014130
909.		I=I+1	00014140
910.		IF(I.LE.100) GO TO 40	00014150
911.		PRINT 9000, M,L,J1,J,AKDJQ	00014160
912.	9000	FORMAT('1',4I5,E12.5)	00014170
913.		GO TO 130	00014180
914.	50	BATE=0.DO	00014190
915.		I1=I-1	00014200
916.		XPL=XP(L)	00014210
917.	C	D R VONDY FORM OF BATEMAN EQUATIONS -- DRNL-TM-361	00014220
918.		DO 100 KB=1,I1	00014230
919.		XPJ=DXP(KB)	00014240
920.		IF(XPL+XPJ.LT.ERR) GO TO 100	00014250
921.		DK=DD(KB)	00014260
922.		PROD=(DL/DK-1.0)	00014270
923.		DKR=PRCD	00014280
924.		IF(ABS(PROD).GT.1.E-4) GO TO 60	00014290
925.		PROD=T*CK*XPJ*(1.0-0.5*(DL-DJ)*T)	00014300
926.		GO TO 70	00014310
927.	60	PROD=(XPJ-XPL)/PROD	00014320
928.		PRO1=XPJ/DKR	00014330
929.	70	PI=1.0	00014340
930.		S1=2./(DK*T)	00014350
931.		DO 90 JK=1,I1	00014360
932.		IF(JK.EQ.KB) GO TO 90	00014370
933.		S=1.0-DK/DD(JK)	00014380
934.		IF(ABS(S).GT.1.E-4) GO TO 80	00014390
935.	C	USE THIS FORM FOR TWO NEARLY EQUAL HALF-LIVES	00014400
936.		IF(ABS(DKR).GT.1.0E-4) PROD=PRO1	00014410
937.		S=S1	00014420
938.	80	PI=PI*S	00014430
939.		IF(ABS(PI).GT.1.E25) GO TO 100	00014440
940.	90	CONTINUE	00014450
941.		BATE=BATE+PROD/PI	00014460
942.	100	CONTINUE	00014470
943.		IF(BATE.LT.0.DO) PRINT 9001, L,I,BATE,XTEM,XTEMP(J1),AKDJQ	00014480
944.	9001	FORMAT(' L,I,BATE,XTEM,XTEMP(J1),AKDJQ = ',2I5,1P4E12.5)	00014490
945.		IF(BATE.LT.0.DO) BATE=0.DO	00014500
946.		XTEM=XTEM+XTEMP(J1)*AKDJQ*BATE	00014510
947.		IF(NSAVE.GE.50) GO TO 120	00014520
948.	110	NSAVE=NSAVE+1	00014530
949.		NQUEUE(NSAVE)=J1	00014540
950.		QUEUE(NSAVE)=AKDJQ	00014550
951.		NQU(NSAVE)=J	00014560
952.	120	CONTINUE	00014570
953.	130	IF(NSAVE.LE.0) GO TO 140	00014580
954.		J=NQUEUE(NSAVE)	00014590
955.		QUE=QUEUE(NSAVE)	00014600
956.		NQ(J)=NQU(NSAVE)	00014610
957.		NSAVE=NSAVE-1	00014620
958.		GO TO 20	00014630
959.	140	CONTINUE	00014640
960.		IF(LONG(L)) XPAR(L)=XTEM/XP(L)	00014650
961.	150	NUL=NONO(L)+1	00014660
962.		IF(.NOT.LONG(L)) XNEW(M,L)=XTEM+XTEMP(L)*XP(L)	00014670
963.	160	CONTINUE	00014680
964.		DO 170 I=1,ITOT	00014690

965.		IF(LONG(I)) XTEMP(I)=XTEMP(I)+XPAR(I)	00014700
966.		IF(.NOT.LONG(I)) XTEMP(I)=0.0	00014710
967.	170	CONTINUE	00014720
968.		RETURN	00014730
969.		END	00014740
970.		SUBROUTINE EQUIL(M,ITOT)	00014750
971.	C		00014760
972.	C	EQUIL PUTS SHORT-LIVED DAUGHTERS IN EQUILIBRIUM WITH PARENTS	00014770
973.	C	EQUIL USES GAUSS-SEIDEL ITERATION TO GENERATE STEADY STATE	00014780
974.	C	CONCENTRATIONS	00014790
975.	C		00014800
976.		LOGICAL*1 LONG	00014810
977.		INTEGER*2 LOC,NONO,KD	00014820
978.		COMMON/EG/XZFRO(800),XZH(800),XTEMP(800),XNEW(10,800),	00014830
979.	1	B(800),D(800)	00014840
980.		COMMON/MATRIX/A(2500),LOC(2500),NONO(800),KD(800)	00014850
981.		COMMON/FLFX/FLUX(10),MMN,MOUT,INDEX,QXN,AXN,ERR,NOBLND,MZERO	00014860
982.		COMMON/SERIS/ XP(800),XPAR(800),LONG(800)	00014870
983.		DO 10 I=1,ITOT	00014880
984.		XPAR(I)=0.0	00014890
985.		IF(.NOT.LONG(I)) GC TO 10	00014900
986.		XTEMP(I)=XTEMP(I)*XP(I)	00014910
987.		XPAR(I)=AMAX1(XNEW(M,I)-XTEMP(I),0.0)	00014920
988.	10	CONTINUE	00014930
989.		ITER=1	00014940
990.	20	N=0	00014950
991.		BIG=0.0	00014960
992.		DO 60 I=1,ITOT	00014970
993.		NUM=NONO(I)-N	00014980
994.		DI=-D(I)	00014990
995.		IF(LONG(I)) GO TO 50	00015000
996.		XNW=B(I)	00015010
997.		IF(M.GT.MMN.OR.M.EQ.MZERO) NUM=KD(I)-N	00015020
998.		IF(NUM.EQ.0) GO TO 31	00015030
999.		DO 30 K=1,NUM	00015040
1000.		N=N+1	00015050
1001.		J=LOC(N)	00015060
1002.		DJ=-D(J)	00015070
1003.		XJ=XPAR(J)	00015080
1004.		IF(LONG(J)) XJ=XJ+XTEMP(J)/(1.0-DJ/DI)	00015090
1005.		XNW=XNW+A(N)*XJ	00015100
1006.	30	CONTINUE	00015110
1007.	31	XNW=XNW/DI	00015120
1008.		IF(XNW.LT.1.0E-50) GO TO 40	00015130
1009.		ARG=ABS((XNW-XPAR(I))/XNW)	00015140
1010.		IF(ARG.GT.BIG) BIG=ARG	00015150
1011.	40	XPAR(I)=XNW	00015160
1012.	50	N=NONO(I)	00015170
1013.	60	CONTINUE	00015180
1014.		IF(BIG.LT.QXN) GOTO 70	00015190
1015.		ITER=ITER+1	00015200
1016.		IF(ITER.LT.100) GO TO 20	00015210
1017.		PRINT 9000	00015220
1018.		STOP	00015230
1019.	70	DO 80 I=1,ITOT	00015240
1020.		IF(.NOT.LONG(I)) XNEW(M,I)=XNEW(M,I)+XPAR(I)	00015250
1021.	80	CONTINUE	00015260
1022.		RETURN	00015270
1023.	9000	FORMAT(' GAUSS SEIDEL ITERATION DID NOT CONVERGE IN EQUIL')	00015280
1024.		END	00015290

102.		SUBROUTINE NUDATA(NLIBE)	00015300
1026.	C	NUDATA VERSION TO HANDLE THREE TYPES OF NUCLEAR DATA LIBRARIES	00015310
1027.	C	HAS POINTER, NLIBE, = 1 FOR HTGR	00015320
1028.	C	= 2 FOR LIGHT WATER REACTOR	00015330
1029.	C	= 3 FOR LMFBR	00015340
1030.	C	= 4 FOR MSBR	00015350
1031.		INTEGER*2 LOC,NONO,KD	00015360
1032.		INTEGER*2 ELF(99),STA(2)	00015370
1033.		INTEGER*2 KAP(800),MMAX(800)	00015380
1034.		INTEGER*2 NAME(3)	00015390
1035.		DIMENSION COEFF(7,800),NPROD(7,800),CAPT(6),	00015400
1036.	1	NUCAL(6),NSORS(5), YIELD(5,500),TYLD(5)	00015410
1037.		DIMENSION Y(5)	00015420
1038.		DIMENSION SKIP(20)	00015430
1039.		DIMENSION MSPS(20)	00015440
1040.		COMMON/LABEL/ELE,STA	00015450
1041.		COMMON/FLEX/FLUX(10),MMN,MOUT,INDEX,QXN,AXN,ERR,NOBLND,MZERO	00015460
1042.		COMMON/EQ/XZFRD(800),XZH(800),XTEMP(800),XNEW(10,800),	00015470
1043.	1	B(800),D(800)	00015480
1044.		COMMON/MPC/MPCTAB,AMPC(800),WMPC(800)	00015490
1045.		COMMON/FLUXN/T(20),POWER(10),TOCAP(800),FISS(100),DIS(800),ILITE,	00015500
1046.	1	IACT,IFP,ITOT,NON,INPT	00015510
1047.		COMMON/CUT/NUCL(800),TITLE(20),Q(800),FG(800),CUTOFF(7),	00015520
1048.	1	POW,BURNUP,FLUXB,MSTAR,ALPHA(100),SPONF(100),ABUND(500),	00015530
1049.	2	BASIS(10),TCNST,TUNIT	00015540
1050.		COMMON/MATRIX/A(2500),LOC(2500),NONO(800),KD(800)	00015550
1051.		EQUIVALENCE (XZFRD(1),KAP(1)),(XZFRD(401),MMAX(1)),	00015560
1052.	1	(XZH(1),COEFF(1,1)),(XNEW(1,401),NPROD(1,1))	00015570
1053.		EQUIVALENCE (A1,DLAM)	00015580
1054.		DATA NUCAL/-20030,-10000,10,11,-10,-9/	00015590
1055.		DATA MSRS/922330,922350,902320,922380,942390,922330,922350,942410,	00015600
1056.	1	922380,942390,942410,922350,942400,922380,942390,922330,	00015610
1057.	2	922350,902320,922380,942390/	00015620
1058.			00015630
1059.	C	PROGRAM TO COMPUTE A MATRIX (TRANSITION MATRIX) FROM NUCLEAR DATA	00015640
1060.	C		00015650
1061.		READ 9011, (TITLE(I),I=1,18),NLIBE	00015660
1062.	C	IF(NLIBE.LT.0) PROGRAM WILL READ TAPE IN CASDAR FORMAT	00015670
1063.		IGWC=0	00015680
1064.		IF(NLIBE.GT.0) GO TO 10	00015690
1065.		IGWC=1	00015700
1066.		NLIBE=-NLIBE	00015710
1067.		PRINT 9000	00015720
1068.	9000	FORMAT(1H0,'WILL READ TAPE GENERATED BY CASDAR')	00015730
1069.	10	N1=4-NLIBE	00015740
1070.	20	READ 9001, THERM,RES,FAST,ERR,NMO,NDAY,NYR,MPCTAB,INPT,IR	00015750
1071.		PRINT 9005, NMO,NDAY,NYR	00015760
1072.		PRINT 9006	00015770
1073.		PRINT 9007	00015780
1074.		PRINT 9008	00015790
1075.		PRINT 9009	00015800
1076.		PRINT 9010	00015810
1077.		PRINT 9013	00015820
1078.		PRINT 9014	00015830
1079.	C		00015840
1080.	C	THERM = RATIO OF THERMAL FLUX TO TOTAL FLUX	00015850
1081.	C	RES = RATIO OF RESONANCE FLUX TO TOTAL FLUX	00015860
1082.	C	FAST = RATIO OF FAST FLUX TO TOTAL FLUX	00015870
1083.	C	ERR = TRUNCATION ERROR LIMIT	00015880
1084.	C		00015890

1085.	C	READ DATA FOR LIGHT ELEMENTS	00015900
1086.	C		00015910
1087.		K=5*(NLIBE-1)	00015920
1088.		DO 30 K1=1,5	00015930
1089.		K2=K+K1	00015940
1090.	30	NSORS(K1)=MSRS(K2)	00015950
1091.		PRINT 9018, THERM,RES,FAST,(NSORS(K),K=1,5),NLIBE	00015960
1092.		I=0	00015970
1093.		NUTAPE=0	00015980
1094.	40	I=I+1	00015990
1095.	50	READ(8,9034,END=260)NUCL(I),DLAM,IU,FB1,FP,FP1,FT,FA,FSF,	00016000
1096.		1Q(I),FG(I),ABUND(I),WPC(I),AMPC(I)	00016010
1097.		IF(IGWC.GT.0) GO TO 70	00016020
1098.		DO 60 N=1,NLIBE	00016030
1099.	60	READ(8,9035) SIGTH,FNG1,FNA,FNP,RITH,FINA,FINP,SIGMEV,FN2N1,FFNA,	00016040
1100.	1	FFNP,IT	00016050
1101.		GO TO 90	00016060
1102.	70	DO 80 N=1,NLIBE	00016070
1103.	80	READ(8,9040) SIGTH,FNG1,FNA,FNP,RITH,FINA,FINP,SIGMEV,FN2N1,FFNA,	00016080
1104.	1	FFNP,IT	00016090
1105.	90	IF(N1.EQ.0) GO TO 110	00016100
1106.		DO 100 N=1,N1	00016110
1107.	100	READ(8,9036) SKIP	00016120
1108.	110	IF(IT.EQ.0) GO TO 50	00016130
1109.	120	M=0	00016140
1110.		CALL HALF(A1,IU)	00016150
1111.		NUCLI=NUCL(I)	00016160
1112.		IF(NUCLI.EQ.0) GO TO 260	00016170
1113.		CALL NCAH(NUCLI,NAME)	00016180
1114.		IF(MOD(I-1,50) .EQ. 0) PRINT 9012, (TITLE (N),N=1,18	00016190
1115.		IF(MOD(I-1,50) .EQ. 0) PRINT 9016	00016200
1116.		SIGTH=THERM*SIGTH	00016210
1117.		RITH=RES*RITH	00016220
1118.		SIGMEV=FAST*SIGMEV	00016230
1119.		SIGNA=SIGTH*FNA+RITH*FINA+SIGMEV*FFNA	00016240
1120.		SIGNP=SIGTH*FNP+RITH*FINP+SIGMEV*FFNP	00016250
1121.		FNG=1.0-FNA-FNP	00016260
1122.		IF(FNG.LT.1.0E-4)FNG=0.	00016270
1123.		FING=1.0-FINA-FINP	00016280
1124.		IF(FING.LT.1.0E-4)FING=0.	00016290
1125.		FN2N=1.0-FFNA-FFNP	00016300
1126.		IF(FN2N.LT.1.0E-4)FN2N=0.	00016310
1127.		SIGNG=SIGTH*FNG+RITH*FING	00016320
1128.		SIGN2N=SIGMEV*FN2N	00016330
1129.	130	PRINT 9033, NAME, DLAM,FB1,FP,FP1,FT,FA, SIGNG,	00016340
1130.	1	FNG1, SIGN2N,FN2N1,SIGNA,SIGNP,Q(I),FG(I),ABUND(I)	00016350
1131.	C	TEST RADIOACTIVITY	00016360
1132.	C		00016370
1133.	140	IF(A1.LE.ERR) GO TO 180	00016380
1134.		ABETA=1.0	00016390
1135.	C		00016400
1136.	C	TEST POSITRON EMISSION	00016410
1137.	C		00016420
1138.		IF(FP .LT. ERR) GO TO 150	00016430
1139.		M=M+1	00016440
1140.		COEFF(M,I)=FP*A1	00016450
1141.		NPROD(M,I)=NUCLI-10000	00016460
1142.		ABETA=ABETA-FP	00016470
1143.	C		00016480
1144.	C	TEST POSITRON EMISSION TO EXCITED STATE OF PRODUCT NUCLIDE	00016490

1145.	C		00016500
1146.		IF(FP1 .LT. ERR) GO TO 150	00016510
1147.		M=M+1	00016520
1148.		COEFF(M,I)=FP1*COEFF(M-1,I)	00016530
1149.		NPROD(M,I)=NPROD(M-1,I)+1	00016540
1150.		COEFF(M-1,I)=COEFF(M-1,I)-COEFF(M,I)	00016550
1151.	C		00016560
1152.	C	TEST ISOMERIC TRANSITION	00016570
1153.	C		00016580
1154.	150	IF(FT .LT.ERR) GO TO 160	00016590
1155.		M=M+1	00016600
1156.		COEFF(M,I)=FT*A1	00016610
1157.		NPROD(M,I)=NUCLI	00016620
1158.		ABETA=ABETA-FT	00016630
1159.	C		00016640
1160.	C	TEST ALPHA EMISSION	00016650
1161.	C		00016660
1162.	160	IF(FA .LT. ERR) GO TO 170	00016670
1163.		M=M+1	00016680
1164.		COEFF(M,I)=FA*A1	00016690
1165.		NPROD(M,I)=NUCLI-20040	00016700
1166.		M=M+1	00016710
1167.		COEFF(M,I)=COEFF(M-1,I)	00016720
1168.		NPROD(M,I)=20040	00016730
1169.		ABETA=ABETA-FA	00016740
1170.	C		00016750
1171.	C	TEST NEGATRON EMISSION	00016760
1172.	C		00016770
1173.	170	IF(ABETA.LT.1.E-4) GO TO 180	00016780
1174.		M=M+1	00016790
1175.		COEFF(M,I)=ABETA*A1	00016800
1176.		NPROD(M,I)=NUCLI+10000	00016810
1177.	C		00016820
1178.	C	TEST NEGATRON EMISSION TO EXCITED STATE OF PRODUCT NUCLIDE	00016830
1179.	C		00016840
1180.		IF(FB1 .LT. FRR)GO TO 180	00016850
1181.		M=M+1	00016860
1182.		COEFF(M,I)=FB1*COEFF(M-1,I)	00016870
1183.		NPROD(M,I)=NPROD(M-1,I)+1	00016880
1184.		COEFF(M-1,I)=COEFF(M-1,I)-COEFF(M,I)	00016890
1185.	C		00016900
1186.	C	COMPUTE NEUTRON CAPTURE CROSS SECTIONS IN THREE REGIONS	00016910
1187.	C		00016920
1189.	180	KAP(I)=M	00016930
1189.		DO 190 KI=1,6	00016940
1190.	190	CAPT(KI) =0.0	00016950
1191.		CAPT(1)=SIGNA	00016960
1192.		CAPT(2)=SIGNP	00016970
1193.		CAPT(4)=SIGNG*FNGL	00016980
1194.		CAPT(3)=SIGNG-CAPT(4)	00016990
1195.		CAPT(6)=SIGN2N*FN2N1	00017000
1196.		CAPT(5)=SIGN2N-CAPT(6)	00017010
1197.	200	TOCAP(I)=0.0	00017020
1198.	C	TOTAL NEUTRON CROSS SECTION FOR NUCLIDE(I)	00017030
1199.		DO 220 K=1,6	00017040
1200.		CAPKI=CAPT(K)	00017050
1201.		IF(CAPKI.LT.ERR) GO TO 220	00017060
1202.		M=M+1	00017070
1203.		NPROD(M,I)=NUCLI+NUCAL(K)	00017080
1204.		COEFF(M,I)=CAPKI	00017090

1205.		TOCAP(I)=TOCAP(I)+CAPKI	00017100
1206.		IF(K.NE.1) GO TO 210	00017110
1207.		M=M+1	00017120
1208.		COEFF(M,I)=COEFF(M-1,I)	00017130
1209.		NPROD(M,I)=20040	00017140
1210.	210	IF(K.NE.2) GO TO 220	00017150
1211.		M=M+1	00017160
1212.		COEFF(M,I)=COEFF(M-1,I)	00017170
1213.		NPROD(M,I)=10010	00017180
1214.	220	CONTINUE	00017190
1215.	230	IF(MOD(NUCLI, 10).EQ.0) GO TO 250	00017200
1216.		DO 240 K=1,M	00017210
1217.	240	NPROD(K,I)=NPROD(K,I)-1	00017220
1218.	250	MMAX(I) =M	00017230
1219.		IF(M.GT.7) PRINT 9039, M	00017240
1220.		DIS(I)=A1	00017250
1221.		GO TO 40	00017260
1222.	260	ILITE = I-1	00017270
1223.		IACT=0	00017280
1224.	C		00017290
1225.	C	READ DATA ON ACTINIDES	00017300
1226.	C		00017310
1227.	270	READ(8,9034,FND=450)NUCL(I),DLAM,IU,FB1,FP,FP1,FT,FA,FSF,	00017320
1228.		IQ(I),FG(I),DUMMY,WMPK(I),AMPC(I)	00017330
1229.		DO 280 N=1,NLIBE	00017340
1230.		READ(8,9037) SIGNG,RING,FNG1,SIGF,RIF,SIGFF,SIGN2N,FN2N1,SIGN3N,IT	00017350
1231.	280	CONTINUE	00017360
1232.		IF(N1.EQ.0) GO TO 300	00017370
1233.		DO 290 N=1,N1	00017380
1234.	290	READ(8,9036) SKIP	00017390
1235.	300	IF(IT .EQ. 0) GO TO 270	00017400
1236.	310	M=0	00017410
1237.		NUCLI=NUCL(I)	00017420
1238.		IF(NUCLI.EQ.0) GO TO 450	00017430
1239.		DO 320 K=1,5	00017440
1240.		IF(NUCLI.EQ.NSORS(K)) NSORS(K)=I	00017450
1241.	320	CONTINUE	00017460
1242.		CALL HALF(A1,IU)	00017470
1243.		CALL NOAA(NUCLI,NAME)	00017480
1244.		SIGNG=THERM*SIGNG+RES*RING	00017490
1245.		SIGF =THERM*SIGF +RES*RIF +FAST*SIGFF	00017500
1246.		SIGN2N=SIGN2N*FAST	00017510
1247.		SIGN3N=SIGN3N*FAST	00017520
1248.		IF(MOD(IACT,50).EQ.0) PRINT 9012, (TITLE (N),N=1,18)	00017530
1249.	330	IF(MOD(IACT,50).EQ.0) PRINT 9024	00017540
1250.		PRINT 9026, NAME, DLAM,FB1,FP,FP1,FT,FA,FSF,SIGNG,	00017550
1251.	1	FNG1,SIGF,SIGN2N,SIGN3N,Q(I),FG(I)	00017560
1252.	340	IACT=IACT+1	00017570
1253.	C		00017580
1254.	C	TEST RADIOACTIVITY	00017590
1255.	C		00017600
1256.		IF(A1.LT.ERR) GO TO 380	00017610
1257.		ABETA=1.0	00017620
1258.	C	TEST POSITRON EMISSION	00017630
1259.		IF(FP .LT. ERR) GO TO 350	00017640
1260.		ABETA=ABETA-FP	00017650
1261.		M=M+1	00017660
1262.		COEFF(M,I)=FP*A1	00017670
1263.		NPROD(M,I)=NUCLI-10000	00017680
1264.	C	POSITRON EMISSION TO EXCITED STATE	00017690

1265.		IF(FP1 .LT. ERR)GO TO 350	00017700
1266.		M=M+1	00017710
1267.		COEFF(M,I)=FP1*COEFF(M-1,I)	00017720
1268.		NPROD(M,I)=NPROD(M-1,I)+1	00017730
1269.		COEFF(M-1,I)=COEFF(M-1,I)-COEFF(M,I)	00017740
1270.	C	ISOMERIC TRANSITION	00017750
1271.	350	IF(FT .LT.ERR)GO TO 360	00017760
1272.		M=M+1	00017770
1273.		COEFF(M,I)=FT*A1	00017780
1274.		NPROD(M,I)=NUCLI	00017790
1275.		ABETA=ABETA-FT	00017800
1276.	C	ALPHA EMISSION	00017810
1277.	360	IF(FA .LT.ERR)GO TO 370	00017820
1278.		M=M+1	00017830
1279.		COEFF(M,I)=FA*A1	00017840
1280.		NPROD(M,I)=NUCLI-20040	00017850
1281.		M=M+1	00017860
1282.		COEFF(M,I)=COEFF(M-1,I)	00017870
1283.		NPROD(M,I)=20040	00017880
1284.		ABETA=ABETA-FA	00017890
1285.	C	PETA DECAY	00017900
1286.	370	IF(ABETA.LT.1.E-4) GO TO 380	00017910
1287.		M=M+1	00017920
1288.		COEFF(M,I)=ABETA*A1	00017930
1289.		NPROD(M,I)=NUCLI+10000	00017940
1290.		IF(FB1 .LT. FRR)GO TO 380	00017950
1291.		M=M+1	00017960
1292.		COEFF(M,I)=COEFF(M-1,I)*FB1	00017970
1293.		COEFF(M-1,I)=COEFF(M-1,I)-COEFF(M,I)	00017980
1294.		NPROD(M,I)=NPROD(M-1,I)+1	00017990
1295.	C		00018000
1296.	C	NEUTRON CAPTURE CROSS SECTIONS	00018010
1297.	C		00018020
1298.	380	KAP(I)=M	00018030
1299.		DO 390 K=1,6	00018040
1300.	390	CAPT(K)=0.0	00018050
1301.		CAPT(2)=SIGNG*FNG1	00018060
1302.		CAPT(1)=SIGNG-CAPT(2)	00018070
1303.		CAPT(4)=SIGN2N*FN2N1	00018080
1304.		CAPT(3)=SIGN2N-CAPT(4)	00018090
1305.	400	FISS(IACT)=SIGF	00018100
1306.		TOCAP(I)=0.0	00018110
1307.		DO 410 K=1,4	00018120
1308.		CAPKI=CAPT(K)	00018130
1309.		IF(CAPKI.LT.FRR) GO TO 410	00018140
1310.		M=M+1	00018150
1311.		TOCAP(I)=TOCAP(I)+CAPKI	00018160
1312.		COEFF(M,I)=CAPKI	00018170
1313.		NPROD(M,I)=NUCLI+NUCAL(K+2)	00018180
1314.	410	CONTINUE	00018190
1315.		TOCAP(I)=TOCAP(I)+FISS(IACT)	00018200
1316.	C	N-3N CROSS SFCTION	00018210
1317.		A17=SIGN3N	00018220
1318.		IF(A17.LT.ERR) GO TO 420	00018230
1319.		M=M+1	00018240
1320.		COEFF(M ,I)= A17	00018250
1321.		NPROD(M ,I)= NUCLI-20	00018260
1322.		TOCAP(I)=TOCAP(I)+A17	00018270
1323.	420	IF(MOD(NUCLI,10).EQ.0) GO TO 440	00018280
1324.		DO 430 K=1,M	00018290

1325.	430	NPROD(K,I)=NPROD(K,I)-1	00018300
1326.	440	MMAX(I)=M	00018310
1327.		IF(M.GT.7) PRINT 9039, M	00018320
1328.		SPONF(I,ACT)=FSF*A1*6.023E23	00018330
1329.		ALPHA*(I,ACT)=FA*A1*6.023E13*Q(I)**3.65	00018340
1330.		DIS(I)=A1	00018350
1331.		I=I+1	00018360
1332.		GO TO 270	00018370
1333.	450	IL=0	00018380
1334.		DO 460 K=1,5	00018390
1335.	460	TYLD(K)=0.0	00018400
1336.			00018410
1337.	C	READ DATA FOR FISSION PRODUCTS	00018420
1338.	C		00018430
1339.	470	READ(8,9034,END=690)NUCL(I),DLAM,IU,FB1,FP,FP1,FT,FA,FSF,	00018440
1340.		IQ(I),FG(I),DUMMY,WMP(I),AMPC(I)	00018450
1341.		DO 480 N=1,NLIBE	00018460
1342.	480	READ(8,9038) SIGNG,RING,FNG1,Y,IT	00018470
1343.		IF(N1.EQ.0) GO TO 500	00018480
1344.		DO 490 N=1,N1	00018490
1345.	490	READ(8,9036) SKIP	00018500
1346.	500	IF(IT.EQ.0) GO TO 470	00018510
1347.	510	M=0	00018520
1348.		CALL HALF(A1,IU)	00018530
1349.	520	NUCLI=NUCL(I)	00018540
1350.		IF(NUCLI.EQ.0) GO TO 690	00018550
1351.		CALL NOAH(NUCLI,NAME)	00018560
1352.		IF(MOD(IL,50).EQ.0) PRINT 9012, (TITLE(N),N=1,18)	00018570
1353.		SIGNG=THERM*SIGNG+RES*RING	00018580
1354.		IF(NLIBE.EQ.3) GO TO 540	00018590
1355.	530	IF(MOD(IL,50).EQ.0) PRINT 9019	00018600
1356.		PRINT 9021, NAME, DLAM,FB1,FP,FP1,FT,SIGNG,	00018610
1357.	1	FNG1,Y,Q(I),FG(I)	00018620
1358.		GO TO 550	00018630
1359.	540	IF(MOD(IL,50).EQ.0) PRINT 9020	00018640
1360.		PRINT 9022, NAME, DLAM,FB1,FP,FP1,FT,SIGNG,FNG1,	00018650
1361.	1	Y(2),Y(4),Y(5),Q(I),FG(I)	00018660
1362.	C		00018670
1363.	C	TEST RADIOACTIVITY	00018680
1364.	C		00018690
1365.	550	IF(A1.LT.ERR) GO TO 600	00018700
1366.		ABETA=1.0	00018710
1367.	C	POSITRON EMISSION	00018720
1368.		A3=FP	00018730
1369.		IF(A3.LT.ERR) GO TO 570	00018740
1370.		ABETA=ABETA-A3	00018750
1371.		AP1=A3*FP1	00018760
1372.		AP=A3-AP1	00018770
1373.		IF(AP.LT.ERR) GO TO 560	00018780
1374.		M=M+1	00018790
1375.		COEFF(M,I)=AP*A1	00018800
1376.		NPROD(M,I)=NUCLI-10000	00018810
1377.	560	IF(AP1.LT.ERR) GO TO 570	00018820
1378.		M=M+1	00018830
1379.		COEFF(M,I)=AP1*A1	00018840
1380.		NPROD(M,I)=NUCLI-9999	00018850
1381.	C	ISOMERIC TRANSITION	00018860
1382.	570	IF(FT.LT.ERR) GO TO 580	00018870
1383.		M=M+1	00018880
1384.		COEFF(M,I)=FT*A1	00018890

1385.		NPROD(M,I)=NUCLI	00018900
1386.		ABETA=ABETA-FT	00018910
1387.	C	NEGATRON EMISSION	00018920
1388.	580	IF(ABETA.LT.1.0E-4) GO TO 600	00018930
1389.		A2=FB1	00018940
1390.		AB1=ABETA*A2	00018950
1391.		AB=ABETA-AB1	00018960
1392.		IF(AB.LT.1.E-4) GO TO 590	00018970
1393.		M=M+1	00018980
1394.		COEFF(M,I)=AR*A1	00018990
1395.		NPROD(M,I)=NUCLI+1C000	00019000
1396.	590	IF(AB1.LT.1.E-6) GO TO 600	00019010
1397.		M=M+1	00019020
1398.		COEFF(M,I)=AB1*A1	00019030
1399.		NPROD(M,I)=NUCLI+1C001	00019040
1400.	C		00019050
1401.	C	NEUTRON CAPTURE CROSS SECTIONS FOR FISSION PRODUCTS USING THREE	00019060
1402.	C	REGION APPROXIMATION	00019070
1403.	C		00019080
1404.	600	KAP(I)=M	00019090
1405.		DO 610 K=1,6	00019100
1406.	610	CAPT(K)=0.0	00019110
1407.		CAPT(2)=SIGNG*FNG1	00019120
1408.		CAPT(1)=SIGNG-CAPT(2)	00019130
1409.		TOCAP(I)=0.0	00019140
1410.		DO 620 K=1,2	00019150
1411.		CAPKI=CAPT(K)	00019160
1412.		IF(CAPKI.LT.ERR) GO TO 620	00019170
1413.		M=M+1	00019180
1414.		TOCAP(I)=TOCAP(I)+CAPKI	00019190
1415.		COEFF(M,I)=CAPKI	00019200
1416.		NPROD(M,I)=NUCLI+NUCAL(K+2)	00019210
1417.	620	CONTINUE	00019220
1418.	630	IF(MUC(NUCLI,10).EQ.0) GO TO 650	00019230
1419.		DO 640 K=1,M	00019240
1420.	640	NPROD(K,I)=NPROD(K,I)-1	00019250
1421.	650	IL=IL+1	00019260
1422.		DO 660 J=1,5	00019270
1423.		YJ=Y(J)*0.010	00019280
1424.		TYLD(J)=TYLD(J)+YJ	00019290
1425.	660	YIELD(J,IL)=YJ	00019300
1426.		IF(NLIBE.EQ.1.OR.NLIBE.EQ.4) GO TO 680	00019310
1427.	670	IF(NLIBE.EQ.3) YIELD(1,IL)=YJ	00019320
1428.		YIELD(3,IL)=YJ	00019330
1429.	680	MMAX(I)=M	00019340
1430.		IF(M.GT.7) PRINT 9039, M	00019350
1431.		DIS(I)=A1	00019360
1432.		I=I+1	00019370
1433.		GO TO 470	00019380
1434.	690	IFP=IL	00019390
1435.	C		00019400
1436.	C	ALL DATA ON NUCLIDES HAS BEEN READ, BEGIN TO COMPUTE MATRIX COEFF	00019410
1437.	C		00019420
1438.		ITOT=I-1	00019430
1439.	C		00019440
1440.	C	FIND PRODUCT NUCLIDES FOR REACTIONS OF LIGHT ELEMENTS	00019450
1441.	C		00019460
1442.		NON=0	00019470
1443.		DO 700 K=1,ITOT	00019480
1444.	700	NONO(K)=0	00019490

1445.		IF(ILITE.LT.1) GO TO 760	00019500
1446.		DO 750 I=1,ILITE	00019510
1447.		NUCLI=NUCL(I)	00019520
1448.		DO 720 J=1,ILITE	00019530
1449.		KMAX=KAP(J)	00019540
1450.		IF(KMAX.LT.1) GO TO 720	00019550
1451.		DO 710 M=1,KMAX	00019560
1452.		IF(NUCLI.NE.NPROD(M,J)) GO TO 710	00019570
1453.		NONO(I)=NONO(I)+1	00019580
1454.		NON=NON+1	00019590
1455.		IF(NON.GT.2500) PRINT 9041, NON,NUCL(I)	00019600
1456.		A(NON)=COEFF(M,J)	00019610
1457.		JT=J	00019620
1458.		LOC(NON)=JT	00019630
1459.	710	CONTINUE	00019640
1460.	720	CONTINUE	00019650
1461.		KD(I)=NONO(I)	00019660
1462.		DO 740 J=1,ILITE	00019670
1463.		K1=KAP(J)+1	00019680
1464.		KMAX=MMAX(J)	00019690
1465.		IF(KMAX.LT.K1) GO TO 740	00019700
1466.		DO 730 M=K1,KMAX	00019710
1467.		IF(NUCLI.NE.NPROD(M,J)) GO TO 730	00019720
1468.		NONO(I)=NONO(I)+1	00019730
1469.		NON=NON+1	00019740
1470.		IF(NON.GT.2500) PRINT 9041, NON,NUCL(I)	00019750
1471.		A(NON)=COEFF(M,J)	00019760
1472.		JT=J	00019770
1473.		LOC(NON)=JT	00019780
1474.	730	CONTINUE	00019790
1475.	740	CONTINUE	00019800
1476.	750	CONTINUE	00019810
1477.	C		00019820
1478.	C	NON ZERO MATRIX ELEMENTS FOR THE ACTINIDES	00019830
1479.	C		00019840
1480.	760	IF(IACT.LT.1) GO TO 820	00019850
1481.		I0=ILITE+1	00019860
1482.		I1=ILITE+IACT	00019870
1483.		DO 810 I=I0,I1	00019880
1484.		NUCLI=NUCL(I)	00019890
1485.		DO 780 J=I0,I1	00019900
1486.		MAX=KAP(J)	00019910
1487.		IF(MAX.LT.1) GO TO 780	00019920
1488.		DO 770 M=1,MAX	00019930
1489.		IF(NUCLI.NE.NPROD(M,J)) GO TO 770	00019940
1490.		NONO(I)=NONO(I)+1	00019950
1491.		NON=NON+1	00019960
1492.		IF(NON.GT.2500) PRINT 9041, NON,NUCL(I)	00019970
1493.		A(NON)=COEFF(M,J)	00019980
1494.		JT=J	00019990
1495.		LOC(NON)=JT	00020000
1496.	770	CONTINUE	00020010
1497.	780	CONTINUE	00020020
1498.		KD(I)=NONO(I)	00020030
1499.		DO 800 J=I0,I1	00020040
1500.		M1=KAP(J)+1	00020050
1501.		M2=MMAX(J)	00020060
1502.		IF(M2.LT.M1) GO TO 800	00020070
1503.		DO 790 M=M1,M2	00020080
1504.		IF(NUCLI.NE.NPROD(M,J)) GO TO 790	00020090

1505.		NONO(I)=NONO(I)+1	00020100
1506.		NON=NON+1	00020110
1507.		IF(NON.GT.2500) PRINT 9041, NON,NUCL(I)	00020120
1508.		A(NON)=COEFF(M,J)	00020130
1509.		JT=J	00020140
1510.		LOC(NON)=JT	00020150
1511.	790	CONTINUE	00020160
1512.	800	CONTINUE	00020170
1513.	810	CONTINUE	00020180
1514.	C		00020190
1515.	C	MATRIX ELEMENTS FOR FISSION PRODUCTS	00020200
1516.	C		00020210
1517.	820	IF(IFP.LT.1) GO TO 900	00020220
1518.		IM=ILITE+IACT	00020230
1519.		IO=IM+1	00020240
1520.		IF(ITCT.LT.10) GO TO 900	00020250
1521.		DO 880 I=IO,ITOT	00020260
1522.		NUCLI=NUCL(I)	00020270
1523.		I2=MAXO(IO,I-10)	00020280
1524.		I3=MINO(ITOT,I+10)	00020290
1525.		DO 840 J=I2,I3	00020300
1526.		KMAX=KAP(J)	00020310
1527.		IF(KMAX.LT.1) GO TO 840	00020320
1528.		DO 830 M=1,KMAX	00020330
1529.		IF(NUCLI.NE.NPROD(M,J)) GO TO 830	00020340
1530.		NONO(I)=NONO(I)+1	00020350
1531.		NON=NON+1	00020360
1532.		IF(NON.GT.2500) PRINT 9041, NON,NUCL(I)	00020370
1533.		A(NON)=COEFF(M,J)	00020380
1534.		JT=J	00020390
1535.		LOC(NON)=JT	00020400
1536.	830	CONTINUE	00020410
1537.	840	CONTINUE	00020420
1538.		KO(I)=NONO(I)	00020430
1539.		DO 860 J=I2,I3	00020440
1540.		K1=KAP(J)+1	00020450
1541.		KMAX=MAX(J)	00020460
1542.		IF(KMAX.LT.K1) GO TO 860	00020470
1543.		DO 850 M=K1,KMAX	00020480
1544.		IF(NUCLI.NE.NPROD(M,J)) GO TO 850	00020490
1545.		NONO(I)=NONO(I)+1	00020500
1546.		NON=NON+1	00020510
1547.		IF(NON.GT.2500) PRINT 9041, NON,NUCL(I)	00020520
1548.		A(NON)=COEFF(M,J)	00020530
1549.		JT=J	00020540
1550.		LOC(NON)=JT	00020550
1551.	850	CONTINUE	00020560
1552.	860	CONTINUE	00020570
1553.		IF(IACT.LT.1) GO TO 880	00020580
1554.		DO 870 K=1,5	00020590
1555.		IL=I-IM	00020600
1556.		IF(YIELD(K,IL).LT.ERR) GO TO 870	00020610
1557.		NON=NON+1	00020620
1558.		IF(NON.GT.2500) PRINT 9041, NON,NUCL(I)	00020630
1559.		NONO(I)=NONO(I)+1	00020640
1560.		KK=NSORS(K)	00020650
1561.		LOC(NON)=KK	00020660
1562.		KF=KK-ILITE	00020670
1563.		A(NON)=YIELD(K,IL)*FISS(KF)	00020680
1564.	870	CONTINUE	00020690

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1565. 880 CONTINUE                                00020700
1566. IF(IFP.LE.0) GO TO 900                      00020710
1567. IF(NLIBE.NE.3) GO TO 890                    00020720
1568. PRINT 9027, TYLD(2),TYLD(4),TYLD(5)        00020730
1569. GO TO 900                                  00020740
1570. 890 PRINT 9030, (TYLD(I),I=1,5)            00020750
1571. C                                          00020760
1572. C ALL MATRIX ELEMENTS ARE NOW COMPUTED    00020770
1573. C BEGIN TRANSIENT SOLUTION                00020780
1574. C                                          00020790
1575. C                                          00020800
1576. C TEMPORARILY WRITE OUT MATRIX ELEMENTS  00020810
1577. C                                          00020820
1578. 900 IF(IR.EQ.0) RETURN                      00020830
1579. PRINT 9029                                  00020840
1580. N=0                                          00020850
1581. DO 910 I=1,ITOT                             00020860
1582. NUM=NONO(I)                                  00020870
1583. IF(NUM.LE.0) GO TO 910                      00020880
1584. N1=N+NUM                                     00020890
1585. N=N+1                                        00020900
1586. PRINT 9028, I,DIS (I),TOCAP(I),(A(K),LOC(K),K=N,N1) 00020910
1587. N=N1                                        00020920
1588. 910 CONTINUE                               00020930
1589. RETURN                                      00020940
1590. 920 STOP                                    00020950
1591. C                                          00020960
1592. C FORMATS FORMATS FORMATS FORMATS          00020970
1593. C                                          00020980
1594. 9001 FORMAT(4F10.5,6I2)                     00020990
1595. 9002 FORMAT(I6,F5.3,I1,5F3.3,E5.2,F3.3, 13X,E5.2,F3.3,2E5.2 00021000
1596. 1 ,F4.3,F3.3,F6.4)                          00021010
1597. 9003 FORMAT(I6,F5.3,I1,3X,4F3.3,2E5.2,F3.3,5E5.2,F4.3,F3.3) 00021020
1598. 9004 FORMAT(I6,F5.3,I1,5F3.3,2E5.2,F3.3,4E5.2,F3.3,F4.3,F3.3,2E5.2) 00021030
1599. 9005 FORMAT(1H1,43X,'NUCLEAR TRANSMUTATION DATA REVISED ',I2,'/',I2,'00021040
1600. 1/',I2,'/','ONUCL = NUCLIDE = 10000 * ATOMIC NO + 10 * MASS NO + ISOM'00021050
1601. 2ERIC STATE (0 OR 1)',10X,'DLAM = DECAY CONSTANT (1/SEC).',/, ' FB, 00021060
1602. 3FP, FA, FT = FRACTIONAL DECAY BY BETA, POSITRON (OR ELECTRON CAPTURE'00021070
1603. 4RE), ALPHA, INTERNAL TRANSITION. FB = 1 - FP - FA - FT',/, ' FB1,00021080
1604. 5 FPI, FPG1, FPN2N1 = FRACTION OF BETA, POSITRON, N-GAMMA, N-2N TRAN'00021090
1605. 6SITIONS TO EXCITED STATE OF PRODUCT NUCLIDE',/, ' SIGTH, SIGNG, SIGO'00021100
1606. 7F, SIGNA, SIGNP = THERMAL CROSS SECTIONS (BARN) FOR ABSORPTION, N'00021110
1607. 8-GAMMA, FISSION, N-ALPHA, N-PROTON.') 00021120
1608. 9006 FORMAT(' SIGNG = SIGTH * (1 - FNA - FNP). SIGNA = SIGTH * FNA. 00021130
1609. 1SIGNP = SIGTH * FNP. FNA, FNP = FRACTION THERMAL N-ALPHA, N-PROT'00021140
1610. 2N.',/, ' RITH, RING, RIF, RINA, RINP = RESONANCE INTEGRAL FOR ABSOR'00021150
1611. 3PTION, N-GAMMA, FISSION, N-ALPHA, N-PROTON.',/, ' RING = RITH * (00021160
1612. 41 - FINA - FINP). RINA = RITH * FINA. RINP = RITH * FINP. FINA, F'00021170
1613. 5INP = FRACTION RESONANCE N-ALPHA, N-PROTON.',/, ' SIGMEV, SIGFF, S'00021180
1614. 6GN2N, SIGNAF, SIGNPF = FAST CROSS SECTIONS (BARN) FOR ABSORPTION,00021190
1615. 7FISSION, N-2N, N-ALPHA, N-PROTON.',/, ' SIGN2N = SIGMEV * (1 - FF'00021200
1616. 8NA - FFNP). SIGNAF = SIGMEV * FFNA. SIGNPF = SIGMEV * FFNP. FFN'00021210
1617. 9A, FFNP = FRACTION FAST N-ALPHA, N-P.') 00021220
1618. 9007 FORMAT(' Y23, Y25, Y92, Y28, Y49 = FISSION YIELD (PERCENT) FROM 2300021230
1619. 13-U, 235-U, 232-TH, 238-U, 239- PU.',/, ' Q = HEAT PER DISINTEGRATI'00021240
1620. 2CN. FG = FRACTION OF HEAT IN GAMMAS OF ENERGY GREATER THAN 0.2 ME'00021250
1621. 3V.',/, '0 EFFECTIVE CROSS SECTIONS FOR A VOLUME AVERAGED THERMAL (L'00021260
1622. 4T 0.876 EV) FLUX ARE AS FOLLOWS.',/, ' N-GAMMA - SIGNG * THERM'00021270
1623. 5 + RING * RES.',/, ' FISSION - SIGF * THERM + RIF * RES + SIGF'00021280
1624. 6F * FAST.',10X,'THERM = 1/V CORRECTION FOR THERMAL SPECTRUM AND T'00021290

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1626. 7MPERATURE.,/,,' N-2N - SIGN2N * FAST.,36X,'RES = RATIO 00021300
 1627. 80F RESCANCE FLUX PER LETHARGY UNIT TO THERMAL FLUX.)) 00021310
 1628. 9008 FORMAT(' N-ALPHA - SIGNA * THERM + RINA * RES + SIGNAF * FAST00021320
 1629. 1.,7X,'FAST = 1.45 * RATIO OF FAST (GT 1.0 MEV) TO THERMAL FLUX '00021330
 1630. 2/' N-PROTON - SIGNP * THERM + RINP * RES + SIGNPF * FAST.)) 00021340
 1631. 9009 FORMAT(1H0,59X,'REFERENCES',/,,' HALF LIVES, DECAY SCHEMES, AND 00021350
 1632. 1THERMAL POWER',/,,' C M LEDERER, J M HOLLANDER, AND I PERLMAN ''TAB00021360
 1633. 2LE OF ISOTOPES - SIXTH EDITION'' JOHN WILEY AND SONS, INC (1967)''00021370
 1634. 3/,,' B S DZHELEPOV AND L K PEKER ''DECAY SCHEMES OF RADIOACTIVE NUC00021380
 1635. 4LEI'' PERGAMON PRESS (1961)''/,,' D T GOLDMAN AND JAMES R ROSSER ''00021390
 1636. 5'CHART OF THE NUCLIDES'' NINTH EDITION GENERAL ELECTRIC CO (JULY 00021400
 1637. 61966)''/,,' E D ARNOLD ''PROGRAM SPECTRA'' APPENDIX A OF ORNL-3576 00021410
 1638. 7(APRIL 1964)'' 00021420
 1639. 9010 FORMAT(' CROSS SECTIONS AND FLUX SPECTRA',/,,' B E PRINCE ''NEUT00021430
 1640. 1IRON REACTION RATES IN THE MSRE SPECTRUM'' ORNL-4119, PP 79-83 (JUL00021440
 1641. 2Y 1967)''/,,' B E PRINCE ''NEUTRON ENERGY SPECTRA IN MSRE AND MSBR''00021450
 1642. 3' ORNL-4191, PP 50-58 (DEC 1967)''/,,' M D GOLDBERG ET AL ''NEUTRON00021460
 1643. 4 CROSS SECTIONS'' BNL-325, SECOND ED, SUPP NO 2 (MAY 1964 - AUG 1900021470
 1644. 556) ALSO EARLIER EDITIONS',/,,' H T KERR, UNPUBLISHED ERC COMPILATIO0021480
 1645. 6ON (FEB 1968)''/,,' M K DRAKE ''A COMPILATION OF RESONANCE INTEGRAL00021490
 1646. 7S'' NUCLEONICS, VOL 24, NO 8, PP 108-111 (AUG 1966)''/,,' BNWL STAF00021500
 1647. 8F ''INVESTIGATION OF N-2N CROSS SECTIONS'' BNWC-98, PP 44-98 (JUNE00021510
 1648. 9 1965)'' 00021520
 1649. 9011 FORMAT(18A4,I3) 00021530
 1650. 9012 FORMAT(1H1,20X,18A4) 00021540
 1651. 9013 FORMAT(' H ALTER AND C E WEBER ''PRODUCTION OF H AND HE IN METALS 00021550
 1652. 1DURING REACTOR IRRADIATION'' J NUCL MATLS, VOL 16, PP 68-73 (1965)00021560
 1653. 2',/,,' L L BENNETT ''RECOMMENDED FISSION PRODUCT CHAINS FOR USE IN 00021570
 1654. 3REACTOR EVALUATION STUDIES'' ORNL-TM-1658 (SEPT 1966)'' 00021580
 1655. 9014 FORMAT(' FISSION PRODUCT YIELDS',/,,' M E MEEK AND B F RIDER, ''00021590
 1656. 1SUMMARY OF FISSION PRODUCT YIELDS FOR U-235, U-238, PU-239, AND PU00021600
 1657. 2-241 AT THERMAL, FISSION SPECTRUM AND/' 14 MEV NEUTRON ENERGI00021610
 1658. 3ES'' APED-5398-A(REV.), (OCT. 1968)''/' S KATCOFF '' FISSION PRODUCT00021620
 1659. 4YIELDS FROM NEUTRON INDUCED FISSION'' NUCLEONICS, VOL 18, NO 11, 00021630
 1660. 5(NOV 1960)''/' N D DUDEY '' REVIEW OF LOW-MASS ATOM PRODUCTION IN F00021640
 1661. 6AST REACTORS'' ANL-7434, (APRIL 1968) '' 00021650
 1662. 9015 FORMAT(1H0,20X,'LIGHT ELEMENTS, MATERIALS OF CONSTRUCTION, AND ACT00021660
 1663. 1IVATION PRODUCTS ',/,,'O NUCL DLAM FB1 FP FP1 FT F00021670
 1664. 2A SIGTH FNG1 FNA FNP RITH FINA FINP SIGMEV FN2N100021680
 1665. 3 FFNA FFPN Q FG') 00021690
 1666. 9016 FORMAT(1H0,20X,'LIGHT ELEMENTS, MATERIALS OF CONSTRUCTION, AND ACT00021700
 1667. 1IVATION PRODUCTS ',/,,'O NUCL DLAM FB1 FP FP1 FT F00021710
 1668. 2A SIGNG FNG1 SIGN2N FN2N1. SIGNA SIGNP Q FG ABU00021720
 1669. 3NDANCE') 00021730
 1670. 9017 FORMAT(1H ,A2,I3,A1,1PE9.2,0P5F6.3,1PE9.2,0P3F6.3,1PE9.2,0P2F6.3, 00021740
 1671. 11PE9.2,0P4F6.3,0PF5.2) 00021750
 1672. 9018 FORMAT(1H0,10X,'THERM= 'F10.5,5X,'RES= 'F10.5,5X,'FAST= 'F10.5, 00021760
 1673. 1//,1X,'NEUTRON SOURCE= '5(110,5X),5X,'NLIBE= 'I3) 00021770
 1674. 9019 FORMAT(1H0,36X,'FISSION PRODUCTS',/,,'O NUCL DLAM FB1 FP 00021780
 1675. 1 FP1 FT SIGNG ',/,,' FNG1 Y23 Y25 Y02 Y00021790
 1676. 228 Y49 Q FG') 00021800
 1677. 9020 FORMAT(1H0,36X,'FISSION PRODUCTS',/,,'O NUCL DLAM FB1 FP 00021810
 1678. 1 FP1 FT SIGNG FNG1 Y25 Y28 Y49 Q FG') 00021820
 1679. 9021 FORMAT(1H ,A2,I3,A1,1PE9.2,0P4F6.3, 1PE9.2,0PF6.3,1P5E9.2, 00021830
 1680. 10P2F6.3) 00021840
 1681. 9022 FORMAT(1H ,A2,I3,A1,1PE9.2,0P4F6.3,1PE9.2,0PF6.3,1P3E9.2,0P2F6.3) 00021850
 1682. 9023 FORMAT(1H0,32X, 'ACTINIDES AND THEIR DAUGHTERS',// 00021860
 1683. 1' NUCL DLAM FB1 FP FP1 FT FA FSF E+6 SIGNG R00021870
 1684. 2ING FNG1 SIGF RIF SIGFF SIGN2N SIGN3N Q FG')00021880
 9024 FORMAT(1H0,32X, 'ACTINIDES AND THEIR DAUGHTERS',// 00021890

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1685.      1* NUCL   DLAM   FB1   FP   FP1  FT   FA   FSF E+6  SIGNG  F00021900
1686.      2NG21  SIGF   SIGN2N  SIGN3N  Q   FG*)  00021910
1687.      9025  FORMAT(1H ,A2,I3,A1,1PE9.2,0P5F6.3,6PF6.1,1P2E9.2,0PF6.3,1P5E9.2, 00021920
1688.      1      OPF6.3,F5.2) 00021930
1689.      9026  FORMAT(1H ,A2,I3,A1,1PE9.2,0P5F6.3,6PF9.1,1PE9.2,0PF6.3,1P3E9.2, 00021940
1690.      1      OPF7.3,F5.2) 00021950
1691.      9027  FORMAT('OSUM OF YIELDS OF ALL FISSION PRODUCTS =' ,15X,1P3E9.2) 00021960
1692.      9028  FORMAT(I5,2X,1PE10.3,3X,E10.3,5(2X,E10.3,3X,I5)/(30X,5(2X,E10.3, 00021970
1693.      1      3X,I5))) 00021980
1694.      9029  FORMAT('1NOH-ZERO MATRIX ELEMENTS AND THEIR LOCATIONS' / 00021990
1695.      1* I     DIS(I)      CAP(I)      A(I,J)      J      A(I,J) 00022000
1696.      2J     A(I,J)      J      A(I,J)      J      A(I,J)      J ' ) 00022010
1697.      9030  FORMAT(64HOSUM OF YIELDS OF ALL FISSION PRODUCTS 00022020
1698.      1      ,1P5F9.2) 00022030
1699.      9031  FORMAT(5I10) 00022040
1700.      9032  FORMAT(I6,F5.3,I1,5F3.3,E5.2,3F3.3,E5.2,2F3.3,E5.2,3F3.3,F4.3,F3.3 00022050
1701.      1,F6.4) 00022060
1702.      9033  FORMAT(1H ,A2,I3,A1,1PE9.2,0P5F6.3,1PE9.2,0PF6.3,1PE9.2,0PF6.3, 00022070
1703.      1      1P2E9.2,0P2F6.3,F7.3) 00022080
1704.      9034  FORMAT(I7,F9.3,I1,5F5.3,1PE9.2,0P2F5.3,F7.3,2E6.0) 00022090
1705.      9035  FORMAT(7X,F9.2,3F5.3,F9.2,2F5.3,F9.2,3F5.3, 5X,I1) 00022100
1706.      9036  FORMAT(2GA4) 00022110
1707.      9037  FORMAT(7X,2F9.2,F5.3,4F9.2,F4.3,F9.2,I1) 00022120
1708.      9038  FORMAT(7X,2F9.2,F5.3,5F9.2, 4X,I1) 00022130
1709.      9039  FORMAT('O WARNING, MOUT OF RANGE IN NUDATA, =' I5) 00022140
1710.      9040  FORMAT( 7X,F9.2,3F8.6,F4.2,2F3.1,F9.2,3F5.3,5X,I1) 00022150
1711.      9041  FORMAT('O NUM HAS EXCEEDED 2500, EQUAL TO '216) 00022160
1712.      END 00022170
1713.      SUBROUTINE COLLECT(TMB,CWASTE,ILITE,ITOT) 00022180
1714.      COMMON/EQ/XZFR0(800), XZH(800),XTEMP(800),XNEW(10,800), 00022190
1715.      1      B(800),D(800) 00022200
1716.      DIMENSION CWASTE(800) 00022210
1717.      IF(TMB.LT.1) RETURN 00022220
1718.      DO 10 I=1,ITOT 00022230
1719.      B(I)=CWASTE(I) 00022240
1720.      10  XTEMP(I)=0.0 00022250
1721.      CALL DECAY(1,TMB,ITOT) 00022260
1722.      CALL TERM(TMB,1,J,ITOT) 00022270
1723.      CALL EQUIL(1,ITOT) 00022280
1724.      DO 20 I=1,ITOT 00022290
1725.      20  CWASTE(I)=XNEW(1,I)/TMB 00022300
1726.      RETURN 00022310
1727.      END 00022320
1728.      SUBROUTINE STORAG(TMB,CWASTE,ILITE,ITOT) 00022330
1729.      COMMON/EQ/XZFR0(800), XZH(800),XTEMP(800),XNEW(10,800), 00022340
1730.      1      B(800),D(800) 00022350
1731.      DIMENSION CWASTE(ITOT) 00022360
1732.      IF(TMB.LT.1) RETURN 00022370
1733.      DELT=TMB 00022380
1734.      DO 10 I=1,ITOT 00022390
1735.      B(I)=0.0 00022400
1736.      10  XTEMP(I)=CWASTE(I) 00022410
1737.      CALL DECAY(1,DELT,ITOT) 00022420
1738.      CALL TERM(TMB,1,ILITE,ITOT) 00022430
1739.      CALL EQUIL(1,ITOT) 00022440
1740.      DO 20 I=1,ITOT 00022450
1741.      20  CWASTE(I)=XNEW(1,I) 00022460
1742.      RETURN 00022470
1743.      END 00022480
1744.      C      PROGRAM BLOCK DATA 00022490

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1745.		BLOCK DATA	00022500
1746.		INTEGER*2 ELE(99),STA(2)	00022510
1747.		COMMON/LABEL/ ELE,STA	00022520
1748.		DATA ELF/' H','HE','LI','BE',' B',' C',' N',' O',' F','NE','NA','M00022530	
1749.		1G','AL','SI',' P',' S','CL','AR',' K','CA','SC','TI',' V','CR','MN00022540	
1750.		2','FE','CO','NI','CU','ZN','GA','GE','AS','SE','BR','KR','RB','SR'00022550	
1751.		3,' Y','ZR','NB','MO','TC','RU','RH','PD','AG','CD','IN','SN','SB',00022560	
1752.		4'TE',' I','XF','CS','RA','LA','CE','PR','ND','PM','SM','EU','GD',00022570	
1753.		5TB','CY','HO','ER','TM','YB','LU','HF','TA',' W','RE','OS','IR','P00022580	
1754.		6T','AU','HG','TL','PB','BI','PO','AT','RN','FR','RA','AC','TH','PA00022590	
1755.		7,' U','NP','PU','AM','CM','BK','CF','ES'/	00022600
1756.		DATA STA/' ','M '/	00022610
1757.		END	00022620
1758.		SUBROUTINE HALF(A,I)	00022630
1759.	C	SUBROUTINE HALF CONVERTS HALF-LIFE TO DECAY CONSTANT (1/SEC)	00022640
1760.		DIMENSION C(9)	00022650
1761.		DATA C/6.9315E-01,1.1552E-02,1.9254E-04,8.0226E-06,2.1965E-08,0.0,00022660	
1762.	1	2.1965E-11,2.1965E-14,2.1965E-17/	00022670
1763.		IF(A.GT.0.0) GO TO 10	00022680
1764.		IF(I.EQ.6) GO TO 20	00022690
1765.		A=9.99	00022700
1766.		RETURN	00022710
1767.	10	A=C(I)/A	00022720
1768.		RETURN	00022730
1769.	20	A=0.0	00022740
1770.		RETURN	00022750
1771.		END	00022760
1772.		SUBROUTINE NOAH(NUCLI,NAME)	00022770
1773.	C	SUBROUTINE NOAH CONVERTS SIX DIGIT IDENTIFIER TO ALPHAMERIC SYMBOL	00022780
1774.		INTEGER*2 NAME(3)	00022790
1775.		INTEGER*2 ELE(99),STA(2)	00022800
1776.		COMMON/LABEL/ ELE,STA	00022810
1777.		IS=MOD(NUCLI,10)+1	00022820
1778.		NZ =NUCLI/10000	00022830
1779.		MW=NUCLI/10-NZ *1000	00022840
1780.		NAME(1)=ELE(NZ)	00022850
1781.		NAME(2)=MW	00022860
1782.		NAME(3)=STA(IS)	00022870
1783.		RETURN	00022880
1784.		END	00022890

APPENDIX D

COMPUTER PROGRAMS FOR DOSE PARAMETERS

The following computer programs provide the NRC staff method for calculating various parameters used in the Technical Specifications.

PARTS, a computer program to calculate technical specification dose parameters for the iodine and particulate portions of gaseous effluents; available from the Radiological Assessment Branch of the Nuclear Regulatory Commission, Washington, D.C. 20555.

RABFIN, a computer program to calculate technical specification dose parameters for the noble gas portion of gaseous effluents; available from the Radiological Assessment Branch of the Nuclear Regulatory Commission, Washington, D.C. 20555.

LADTAP, a computer program to calculate the doses from radioactive effluents released to the hydrosphere; the program and a modification to calculate the technical specification dose parameters for radionuclides in liquid effluents is available from the Radiological Assessment Branch of the Nuclear Regulatory Commission, Washington, D.C. 20555.

The remainder of this Appendix contains the PARTS program listing, and modifying the routines to the LADTAP Code.

LADTAP MODIFICATIONS

An option has been added to the staff's code LADTAP to tabulate the $A_{i\tau}$ factors of Section 4.3.1 of this manual. Listed below are the routines which have been modified, the changes are indicated by the 'CHANGE 1' notation in columns 73-80.

To execute this option the standard LADTAP input is prepared with the following departures:

1. The 50 mile population (card 3 of the LADTAP input deck) should be set negative.
2. The release of all nuclides should be set to one Ci/yr.

Only the input data defining the ALARA determination of LADTAP is necessary. Following the input data deck structure of Enclosure 1 to the LADTAP program, data beyond card number 7 need not be prepared for the option.

PARTS INPUT DECK TABLE

Card No.	Format	Variable	Columns	Description
1	20 A4	Name	1-80	Plant Title Card, Name, Docket No. and Plant Type
2	F 5.2	H	1-5	Humidity absolute (default value = 8.0 gr/m ³)
	F 5.2	YL	6-10	Yield of leafy vegetables for human consumption (default value = 2.0 Kg/m ²)
	F 5.2	YV	11-15	Yield of produce other than leafy vegetables (default value = 2.0 Kg/m ²)
	F 5.2	YP	16-20	Agricultural productivity of animal pasture feed (default value = 0.70 Kg/m ² wet weight)
	F 5.2	YC	21-25	Agricultural crop productivity of animal feed other than pasture grass (default value = 2.0 Kg/m ² wet weight)
	F 5.2	QC	26-30	Milk cow and beef cattle consumption rate for feed or forage (default value = 50 Kg/day wet weight)
	F 5.2	QG	31-35	Goat consumption rate for feed or forage (default value = 6 Kg/day wet weight)
	E 8.2	DOQ	41-48	Annual average relative deposition rate (D/Q), determined for a specific plant airborne release and site location (meters ⁻²) (Optional Use For Reference & Information Only)
3	I1	IAGE	1	Identification of Controlling Age Group (1 is Infant, 2 is Child, 3 is Teen and 4 is Adult)
	I1	IORG	2	Identification of Controlling Organ (1 is Thyroid, 2 is the critical organ)
	6A4	ZLOC	3-26	Receptor Location identification, Name, Compass Sector and Distance
	F 5.0	GF	27-31	Fraction of yr. humans are exposed to ground surface radiation (default value = 1.0)
	F 5.0	ZIN	32-36	Annual occupancy factor for the inhalation pathway (default value = 1.0)
	F 5.0	FV	37-41	Fraction of yr. leafy vegetables are grown (default value = 1.0)
	F 5.0	FP	42-46	Fraction of yr. cows are on pasture (default value = 1.0)
	F 5.0	FG	47-51	Fraction of produce from local garden (default value = 0.76)
	F 5.0	FPF	52-56	Fraction of daily intake of cows derived from pasture while on pasture (default value = 1.0)
	F 5.0	FGT	57-61	Fraction of yr. goats are on pasture (default value = 1.0)
	F 5.0	FPG	62-66	Fraction of daily intake of goat from pasture while on pasture (default value = 1.0)
	F 5.0	FB	67-71	Fraction of yr. beef cattle are on pasture (default value 1.0)
	F 5.0	FBF	72-76	Fraction of daily intake of beef cattle derived from pasture while on pasture (default value = 1.0)

1	BLCK DATA BLKDAT	BLKDAT	2
	COMMON/IELEM/IELEM(100)	BLKDAT	3
	INTEGER IELEM	BLKDAT	4
	COMMON/POPUL/PERA,PERT,PERC,US	BLKDAT	5
5	DATA IELEM/	BLKDAT	6
	1'H ','HE','LI','HE','B ','C ','N ','O ','F ','NE','NA','MG','AL',	BLKDAT	7
	2'SI','P ','S ','CL','AR','K ','CA','SC','TI','V ','CR','MN','FE',	BLKDAT	8
	3'CU','NI','CO','ZN','GA','GE','AS','SE','BR','KR','RR','SR','Y ','	BLKDAT	9
10	4'ZR','HB','MO','TC','RU','RH','PD','AG','CD','IN','SN','SB','TE',	BLKDAT	10
	5'I ','XE','CS','HA','LA','CE','PR','ND','PM','SM','EU','GD','TH',	BLKDAT	11
	6'DY','HI','ER','TM','YB','LU','HF','TA','W ','RE','OS','IR','PT',	BLKDAT	12
	7'AU','HG','IL','PB','BI','PU','AT','RN','FR','RA','AC','TH','PA',	BLKDAT	13
	8'U ','NP','PU','AM','CM','BK','CF','ES','FM',	BLKDAT	14
	DATA PERA/0.66/	BLKDAT	15
15	DATA PERT/0.14/	BLKDAT	16
	DATA PERC/0.20/	BLKDAT	17
	DATA US/2.6E+08/	BLKDAT	18
	END	BLKDAT	19

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1      PROGRAM LAUTAP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE10)
      DIMENSION Q(200),PL,CFS,NSUR,LT,RELU(200),LIST(200,4),LCT,LZ ,CON,KIT
      + ,PIP
      COMMON/PIPL/PEHA,PERT,PERC,US
5      DIMENSION FACCF(100),FACCI(100),FACCA(100),SACCF(100),SACCI(100),
      + SACCA(100)
      DIMENSION ITITLE(20)
      DATA FACCF/
10     +9.0E-01,1.0E+00,5.0E-01,2.0E+00,2.2E-01,4.6E+03,1.5F+05,9.2E-01,
      +1.0E+01,1.0E+00,1.0E+02,5.0E+01,1.0E+01,2.5E+00,1.0E+05,7.5E+02,
      +5.0E+01,1.0E+00,1.0E+03,4.0E+01,2.0E+00,1.0E+03,1.0E+01,2.0E+02,
      +4.0E+02,1.0E+02,5.0E+01,1.0E+02,5.0E+01,2.0E+03,3.3E+02,3.3E+03,
      +1.0E+02,1.7E+02,4.2E+02,1.0E+00,2.0E+03,3.0E+01,2.5E+01,3.3E+00,
      +3.0E+04,1.0E+01,1.5E+01,1.0E+01,1.0E+01,1.0E+01,2.3E+00,2.0E+02,
15     +1.0E+05,3.0E+03,1.0E+00,4.0E+02,1.5E+01,1.0E+00,2.0E+03,4.0E+00,
      +2.5E+01,1.0E+00,2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,
      +2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,3.5E+00,
      +3.0E+04,1.2E+03,1.2E+02,1.0E+01,1.0E+01,1.0E+02,3.3E+01,1.0E+03,
      +1.0E+04,1.0E+02,1.5E+01,5.0E+02,1.5E+01,1.0E+00,4.0E+02,5.0E+01,
20     +2.5E+01,3.0E+01,1.1E+01,2.0E+00,1.0E+01,3.5E+00,2.5E+01,2.5E+01,
      +2.5E+01,2.5E+01,1.0E+01,1.0E+01/
      DATA FACCI/
      +9.0E-01,1.0E+00,4.0E+01,1.0E+01,5.0E+01,9.1E+03,1.5E+05,9.2E-01,
      +1.0E+02,1.0E+00,2.0E+02,1.0E+02,6.3E+01,2.5E+01,2.0E+04,1.0E+02,
25     +1.0E+02,1.0E+00,8.3E+02,3.3E+02,1.0E+03,3.0E+03,3.0E+03,2.0E+03,
      +9.0E+04,3.2E+03,2.0E+02,1.0E+02,4.0E+02,1.0E+04,6.7E+02,3.3E+01,
      +4.0E+01,1.7E+02,3.3E+02,1.0E+00,1.0E+03,1.0E+02,1.0E+03,6.7E+00,
      +1.0E+02,1.0E+01,5.0E+00,3.0E+02,3.0E+02,3.0E+02,7.7E+02,2.0E+03,
      +1.0E+05,1.0E+03,1.0E+01,1.0E+05,5.0E+00,1.0E+00,1.0E+02,2.0E+02,
30     +1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,
      +1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,6.7E+00,
      +6.7E+02,1.0E+01,6.0E+01,3.0E+02,3.0E+02,3.0E+02,5.0E+01,1.0E+05,
      +1.5E+04,1.0E+02,2.4E+01,2.0E+04,5.0E+00,1.0E+00,1.0E+02,2.5E+02,
      +1.0E+03,5.0E+02,1.1E+02,6.0E+01,4.0E+02,1.0E+02,1.0E+03,1.0E+03,
35     +1.0E+03,1.0E+03,1.0E+02,1.0E+02/
      DATA FACCA/
      +9.0E-01,1.0E+00,3.0E+00,2.0E+01,2.2E+00,4.6E+03,1.3E+04,9.2E-01,
      +2.0E+00,1.0E+00,5.0E+02,1.0E+02,4.2E+02,1.3E+02,5.0E+05,1.0E+02,
40     +5.0E+01,1.0E+00,6.7E+02,1.3E+02,1.0E+04,5.0E+02,1.0E+02,4.0E+03,
      +1.0E+04,1.0E+03,2.0E+02,5.0E+01,2.0E+03,2.0E+04,1.7E+03,3.3E+01,
      +3.0E+03,1.0E+03,5.0E+01,1.0E+00,1.0E+03,5.0E+02,5.0E+03,1.0E+03,
      +8.0E+02,1.0E+03,4.0E+01,2.0E+03,2.0E+02,2.0E+02,2.0E+02,1.0E+03,
      +1.0E+05,1.0E+02,1.5E+03,1.0E+02,4.0E+01,1.0E+00,5.0E+02,5.0E+02,
45     +5.0E+03,4.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,
      +5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,1.0E+03,
      +8.0E+02,1.2E+03,2.4E+02,2.0E+02,2.0E+02,2.0E+02,2.0E+02,3.3E+01,1.0E+03,
      +1.0E+05,2.0E+02,2.4E+01,2.0E+03,4.0E+01,1.0E+00,8.0E+01,2.5E+03,
      +5.0E+03,1.5E+03,1.1E+03,5.0E+01,3.0E+02,3.5E+02,5.0E+03,5.0E+03,
50     +5.0E+03,5.0E+03,1.0E+03,1.0E+03/
      DATA SACCF/
      +9.0E-01,1.0E+00,5.0E-01,2.0E+02,2.2E-01,1.8E+03,6.0E+04,9.6E-01,
      +3.6E+00,1.0E+00,6.7E-02,7.7E-01,1.0E+01,1.0E+01,2.9E+04,1.7E+00,
      +1.3E-02,1.0E+00,1.1E+01,5.0E-01,2.0E+00,1.0E+03,1.0E+01,4.0E+02,
      +5.5E+02,3.0E+03,1.0E+02,1.0E+02,6.7E+02,2.0E+03,3.3E+02,3.3E+03,
55     +3.3E+02,4.0E+03,1.5E+02,1.0E+00,8.3E+00,2.0E+00,2.5E+01,2.0E+02,
      +3.0E+04,1.0E+01,1.0E+01,3.0E+00,1.0E+01,1.0E+01,3.3E+03,3.0E+03,
      +1.0E+05,3.0E+03,4.0E+01,1.0E+01,1.0E+01,1.0E+00,4.0E+01,1.0E+01,

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      ENL01      2
      LAUTAP    3
      LAUTAP    4
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      LAUTAP    6
      LAUTAP    7
      ENL01      8
      LAUTAP    9
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      LAUTAP   53
      LAUTAP   54
      LAUTAP   55
      LAUTAP   56
      LAUTAP   57

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D-4

D-5

	+2.5E+01,1.0E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,	LADTAP	58
	+2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.5E+01,2.0E+02,	LADTAP	59
60	+3.0E+04,3.0E+01,4.8E+00,1.0E+01,1.0E+01,1.0E+02,3.3E+01,1.7E+03,	LADTAP	60
	+1.0E+04,3.0E+02,1.5E+01,3.0E+02,1.0E+01,1.0E+01,1.0E+00,3.0E+01,5.0E+01,	LADTAP	61
	+2.5E+01,1.0E+04,1.0E+01,1.0E+01,1.0E+01,3.0E+00,2.5E+01,2.5E+01,	LADTAP	62
	+2.5E+01,2.5E+01,1.0E+01,1.0E+01/	LADTAP	63
	DATA SACC1/	LADTAP	64
65	+9.3E-01,1.0E+00,5.0E-01,2.0E+02,4.4E-01,1.4E+03,1.7E+04,9.0E-01,	LADTAP	65
	+3.6E+00,1.0E+00,1.9E-01,7.7E-01,6.0E+01,3.3E+01,3.0E+04,4.4E-01,	LADTAP	66
	+1.9E-02,1.0E+00,6.6E+00,1.3E+01,1.0E+04,1.0E+04,5.0E+01,2.0E+03,	LADTAP	67
	+4.0E+02,2.0E+04,1.0E+03,2.5E+02,1.7E+03,5.0E+04,6.7E+02,1.7E+04,	LADTAP	68
	+3.3E+02,1.0E+03,3.1E+00,1.0E+00,1.7E+01,2.0E+01,1.0E+03,8.0E+01,	LADTAP	69
70	+1.0E+02,1.0E+01,5.0E+01,1.0E+03,2.0E+03,2.0E+03,3.3E+03,2.5E+05,	LADTAP	70
	+1.0E+05,1.0E+03,5.0E+00,1.0E+05,5.0E+01,1.0E+00,2.5E+01,1.0E+02,	LADTAP	71
	+1.0E+03,4.0E+02,1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,	LADTAP	72
	+1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,1.0E+03,2.0E+01,	LADTAP	73
	+1.7E+04,3.0E+01,6.0E+01,2.0E+03,2.0E+03,2.0E+03,3.3E+01,3.3E+04,	LADTAP	74
75	+1.5E+04,1.0E+03,2.4E+01,5.0E+03,5.0E+01,1.0E+00,2.0E+01,1.0E+02,	LADTAP	75
	+1.0E+03,2.0E+03,1.0E+01,1.0E+01,1.0E+01,2.0E+02,1.0E+03,1.0E+03,	LADTAP	76
	+1.0E+03,1.0E+03,1.0E+01,1.0E+01/	LADTAP	77
	DATA SACCA/	LADTAP	78
	+9.3E-01,1.0E+00,3.0E+00,1.0E+03,2.2E+00,1.8E+03,1.0E+04,9.6E-01,	LADTAP	79
80	+1.4E+00,1.0E+00,9.5E-01,7.7E-01,5.0E+02,6.7E+01,3.0E+03,4.4E-01,	LADTAP	80
	+7.6E-02,1.0E+00,2.6E+01,5.0E+00,1.0E+05,2.0E+03,1.0E+02,2.0E+03,	LADTAP	81
	+5.5E+03,7.3E+02,1.0E+03,2.5E+02,1.0E+03,1.0E+03,1.7E+03,4.3E+02,	LADTAP	82
	+1.7E+03,1.0E+03,1.5E+00,1.0E+00,1.7E+01,1.0E+01,5.0E+03,1.0E+03,	LADTAP	83
	+5.0E+02,1.0E+01,4.0E+03,2.0E+03,2.0E+03,2.0E+03,2.0E+02,1.0E+03,	LADTAP	84
85	+1.0E+05,1.0E+02,1.5E+03,1.0E+03,1.0E+03,1.0E+00,5.0E+01,5.0E+02,	LADTAP	85
	+5.0E+03,6.0E+02,5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,	LADTAP	86
	+5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,5.0E+03,2.0E+03,	LADTAP	87
	+1.0E+03,3.0E+01,2.4E+02,2.0E+03,2.0E+03,2.0E+03,3.3E+01,1.0E+03,	LADTAP	88
	+1.0E+05,5.0E+03,2.4E+01,2.0E+03,4.0E+03,1.0E+00,2.0E+01,1.0E+02,	LADTAP	89
90	+5.0E+03,3.0E+03,6.0E+00,6.7E+01,6.0E+00,1.0E+03,5.0E+03,5.0E+03,	LADTAP	90
	+5.0E+03,5.0E+03,6.0E+01,6.0E+01/	LADTAP	91
	10 FORMAT(2X,19A4,A2)	BNL01	4
	20 FORMAT(4F10,0)	LADTAP	95
	24 FORMAT(110,2F10,2,I10)	LADTAP	96
95	25 FORMAT(1H0,2X,'DISCHARGE=',1PE8,2,' CFS',10X,'SOURCE TERM MULTIPLI	LADTAP	97
	+FR=',1E8,2)	LADTAP	98
	26 FORMAT(1H0,2X,'FRESHWATER SITE')	LADTAP	99
	27 FORMAT(1H0,2X,'SALTWATER SITE')	LADTAP	100
	30 FORMAT(1H0,' 50-MILE POPULATION=',1PE8,2,5X,'FRACTION --- ADULT='	LADTAP	101
100	+',0PF4.2,/,49X,'TEENAGER=',F4,2,/,49X,'CHILD=',F4,2)	LADTAP	102
	28 FORMAT(1H1)	LADTAP	103
	PL=15,0	LADTAP	104
	IPRNT=1	LADTAP	105
	JSB=1	LADTAP	106
105	22 READ(5,10)ITITLE	LADTAP	107
	IF(EOF(5).NE.0)GOTO500	LADTAP	108
	PRINT 28	LADTAP	109
	READ 24,L1,CFS,UML,LCT	LADTAP	110
	IF(UML.E4,0.) UML=1.	LADTAP	111
110	READ 20,PUP,TR	LADTAP	112
	IF(TR.GT,0.) READ 20,PERA,PRT,PERC	LADTAP	113
	PRINT 10,ITITLE	LADTAP	114
	PRINT 25,CFS,UML	LADTAP	115
	IF(POP.GT,0) PRINT 30,PUP,PERA,PRT,PERC	LADTAP	116

115	IF(LT.EQ.0) PRINT 26	LADTAP	117
	IF(LT.GT.0) PRINT 27	LADTAP	118
	IF(JSB.EQ.1) CALL REDDF(IPRNT)	LADTAP	119
	JSH=JSH+2	LADTAP	120
	CALL PLUP(DOSE,4)	LADTAP	121
120	CALL SOURCE(UML)	LADTAP	122
	IF(LT.EQ.0) CALL ALARA(FACCF,FACCI,FACCA)	LADTAP	123
	IF(LT.GT.0) CALL ALARA(SACCF,SACCI,SACCA)	LADTAP	124
	IF(LT.EQ.0) CALL WHY(FACCF,1,1)	LADTAP	125
	IF(LT.EQ.0) CALL WHY(FACCF,1,2)	LADTAP	126
125	IF(LT.EQ.0) CALL WHY(FACCI,2,1)	LADTAP	127
	IF(LT.EQ.0) CALL WHY(FACCI,2,2)	LADTAP	128
	IF(LT.GT.0) CALL WHY(SACCF,1,1)	LADTAP	129
	IF(LT.GT.0) CALL WHY(SACCF,1,2)	LADTAP	130
	IF(LT.GT.0) CALL WHY(SACCI,2,1)	LADTAP	131
130	IF(LT.GT.0) CALL WHY(SACCI,2,2)	LADTAP	132
	CALL WATER	LADTAP	133
	CALL ACTIVE	LADTAP	134
	CALL FLUID	LADTAP	135
	IF(LT.EQ.0) CALL WHU(FACCF,FACCI,FACCA)	LADTAP	136
135	IF(LT.GT.0) CALL WHU(SACCF,SACCI,SACCA)	LADTAP	137
	CALL PLUP(DOSE,3)	LADTAP	138
	GO TO 22	LADTAP	139
500	STOP	LADTAP	140
	END	LADTAP	141

1	SUBROUTINE REDDF(IPRNT)	REDDF	2
	COMMON/SURCE/IZ(300),IMASS(300),META(300),NLIBA,NLIBT,NLIBC,NLIBI	REDDF	5
	COMMON/ELEMFN/ELEEM(100)	REDDF	6
	COMMON D(200),PL,CFS,NSUR,LT,RECO(200),LIST(200,4),LCT,LZ ,CON,KIT	REDDF	7
5	+ ,PIJP	REDDF	8
	COMMON/DFLIB/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	REDDF	9
	+EFF(300,8)	REDDF	10
	DIMENSION LS(20)	BNL01	5
	10 FORMAT(1H1)	REDDF	12
10	11 FORMAT(/,/,)	REDDF	13
	12 FORMAT(2X,19A4,A2)	BNL01	6
	13 FORMAT(' CHILD DOSE FACTORS')	REDDF	15
	14 FORMAT(' ADULT DOSE FACTORS')	REDDF	16
	15 FORMAT(' TEENAGER DOSE FACTORS')	REDDF	17
15	16 FORMAT(1X,2I3,A1,5E8,0)	REDDF	18
	17 FORMAT(10E8,0)	REDDF	19
	18 FORMAT(' ADULT HEADING GOES HERE')	REDDF	20
	19 FORMAT(14,A2,14,A1,1P12E9,2,/,56X,1P7E9,2,/,10X,1P8E10,2)	REDDF	21
	20 FORMAT(' TEENAGER HEADING GOES HERE')	REDDF	22
20	21 FORMAT(14,A2,14,A1,1P7E9,2,/,11X,1P7E9,2)	REDDF	23
	22 FORMAT(' INFANT DOSE FACTORS')	REDDF	24
	23 FORMAT(' DOSE FACTOR LIBRARY CONTAINS',14,' ENTRIES')	REDDF	25
	24 FORMAT(1X,9E8,2)	REDDF	26
25	C** READ ADULT DOSE FACTOR LIBRARY	REDDF	27
	READ (10,12)LS	REDDF	28
	K=0	REDDF	29
	39 K=K+1	REDDF	30
	READ(10,16)IZ(K),IMASS(K),META(K),TAU(K),EXG(K,2),EXS(K,2),EXG(K,1	REDDF	31
),EXS(K,1)	REDDF	32
30	TAU(K)=1AU(K)+3600.	REDDF	33
	IF (IZ(K))45,45,40	REDDF	34
	40 READ(10,17)(DFL(K,J),J=1,7)	REDDF	35
	READ(10,17)(DFA(K,J),J=1,7)	REDDF	36
	READ(10,24)(EFF(K,J),J=1,8)	REDDF	37
35	GOTO 39	REDDF	38
	45 NLIBA=K-1	REDDF	39
	K=K-1	REDDF	40
	C** READ TEENAGER DOSE FACTOR LIBRARY	REDDF	41
	READ(10,12)LS	REDDF	42
40	49 K=K+1	REDDF	43
	READ(10,16)IZ(K),IMASS(K),META(K)	REDDF	44
	IF (IZ(K))55,55,50	REDDF	45
	50 READ(10,17)(DFL(K,J),J=1,7)	REDDF	46
	READ(10,17)(DFA(K,J),J=1,7)	REDDF	47
45	GOTO 49	REDDF	48
	55 NLIBT=K-1	REDDF	49
	K=K-1	REDDF	50
	C** READ CHILD DOSE FACTOR LIBRARY	REDDF	51
	READ(10,12)LS	REDDF	52
50	59 K=K+1	REDDF	53
	READ(10,16)IZ(K),IMASS(K),META(K)	REDDF	54
	IF (IZ(K))65,65,60	REDDF	55
	60 READ(10,17)(DFL(K,J),J=1,7)	REDDF	56
	READ(10,17)(DFA(K,J),J=1,7)	REDDF	57
55	GOTO 59	REDDF	58
	65 NLIBC=K-1	REDDF	59
	K=K-1	REDDF	60

	READ(10,12)LS	REDDF	61
60	66 K=K+1	REDDF	62
	READ(10,16)IZ(K),IMASS(K),META(K)	REDDF	63
	IF(IZ(K)64,68,67	REDDF	64
	67 READ(10,17)(DFL(K,J),J=1,7)	REDDF	65
	READ(10,17)(DFA(K,J),J=1,7)	REDDF	66
	GO TO 66	REDDF	67
65	68 NLIBI=K-1	REDDF	68
	IF(IPRNT.GT.0)GOTO 1000	REDDF	69
	C** PRINT OUT ADULT DOSE FACTORS	REDDF	70
	PRINT 10	REDDF	71
	PRINT 11	REDDF	72
70	PRINT 14	REDDF	73
	PRINT 18	REDDF	74
	DO 70 K=1,NLIBA	REDDF	75
	KK=IZ(K)	REDDF	76
75	70 PRINT 19, IZ(K),IELEM(KK),IMASS(K),META(K),TAU(K),(EXG(K,J),J=1,2)	REDDF	77
	1,(EXS(K,J),J=1,2),(DFL(K,J),J=1,7),(DFA(K,J),J=1,7),(EFF(K,J),J=1,	REDDF	78
	28)	REDDF	79
	K1=NLIBA+1	REDDF	80
	C** PRINT OUT TEENAGER DOSE FACTORS	REDDF	81
	PRINT 10	REDDF	82
80	PRINT 11	REDDF	83
	PRINT 15	REDDF	84
	PRINT 20	REDDF	85
	DO 80 K=K1,NLIBT	REDDF	86
	KK=IZ(K)	REDDF	87
85	80 PRINT 21,IZ(K),IELEM(KK),IMASS(K),META(K),(DFL(K,J),J=1,7),(DFA(K,	REDDF	88
	1J),J=1,7)	REDDF	89
	K1=NLIBT+1	REDDF	90
	C** PRINT OUT CHILD DOSE FACTORS	REDDF	91
	PRINT 10	REDDF	92
90	PRINT 11	REDDF	93
	PRINT 13	REDDF	94
	PRINT 20	REDDF	95
	DO 90 K=K1,NLIHC	REDDF	96
	KK=IZ(K)	REDDF	97
95	90 PRINT 21,IZ(K),IELEM(KK),IMASS(K),META(K),(DFL(K,J),J=1,7),(DFA(K,	REDDF	98
	1J),J=1,7)	REDDF	99
	K1=NLIHC+1	REDDF	100
	C** PRINT OUT INFANT DOSE FACTORS	REDDF	101
	PRINT 10	REDDF	102
100	PRINT 11	REDDF	103
	PRINT 22	REDDF	104
	PRINT 20	REDDF	105
	DO 100 K=K1,NLIBI	REDDF	106
	KK=IZ(K)	REDDF	107
105	100 PRINT 21,IZ(K),IELEM(KK),IMASS(K),META(K),(DFL(K,J),J=1,7),(DFA(K,	REDDF	108
	CJ),J=1,7)	REDDF	109
	PRINT 23,NLIHC	REDDF	110
	1000 RETURN	REDDF	111
	END	REDDF	112

1	SUBROUTINE SOURCE(OML)	SOURCE	2
	COMMON N(200),PL,CFS,NSUR,LT,RECO(200),LIST(200,4),LCT,L7,CON,KIT	SOURCE	5
	+ ,POP	SOURCE	6
5	COMMON/IFLIB/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	SOURCE	7
	+EFF(300,8)	SOURCE	8
	COMMON/SOURCE/IZ(300),IMASS(300),META(300),NLIBA,NLIBT,NLIBC,NLIBI	SOURCE	9
	COMMON/ELEMENT/ELEM(100)	SOURCE	10
	DIMENSION IM(5),NUM(12),ISUR(20)	BNL01	7
	DATA NUM/1,10,11,12,13,14,15,16,17,18,19,IM/	SOURCE	12
10	11 FORMAT(8F10.0)	SOURCE	13
	12 FORMAT(2X,19A0,A2)	BNL01	8
	13 FORMAT(' GRIEF ',A2,5A1,1PE10.2)	SOURCE	15
	21 FORMAT(2X,A2,5A1,1X,F10.0)	SOURCE	16
	22 FORMAT(1H,14,A2,14,A1,1X,1P12F9.2)	SOURCE	17
15	23 FORMAT(1H0,'TOTAL NUMBER IN SOURCE TERM IS ',14,5X,'TOTAL RELEASE	SOURCE	18
	+IS ',1PE10.4)	SOURCE	19
	30 FORMAT(1H,'NUCLIDE CURIE/YEAR BONE LIVER TOTAL BODY THYR	SOURCE	20
	+IID KIDNEY LUNG GI=LLI SKIN TOTAL BODY RECON')	SOURCE	21
	31 FORMAT(1H0,21X,' _____ INGESTION DOSE FACTORS _____	SOURCE	22
20	+ _____ SHORELINE _____')	SOURCE	23
	35 FORMAT(1H,45X,'(MREM/PCI INTAKE)',22X,'(MREM/HR)/(PCI/M**2)')	SOURCE	24
	32 FORMAT(1H1,30X,'* * * TEENAGER DOSE FACTORS * * *')	SOURCE	25
	33 FORMAT(1H0,30X,'* * * CHILD DOSE FACTORS * * *')	SOURCE	26
	34 FORMAT(1H0,30X,'* * * INFANT DOSE FACTORS * * *')	SOURCE	27
25	36 FORMAT(1H0,30X,'* * * ADULT DOSE FACTORS * * *')	SOURCE	28
	READ 12,ISUR	SOURCE	29
	PRINT 12,ISUR	SOURCE	30
	I=0	SOURCE	31
	NT=0.	SOURCE	32
30	75 I=I+1	SOURCE	33
	READ 21,IA,IM,QQ	SOURCE	34
	IF(QQ)101,101,76	SOURCE	35
	76 K=-1	SOURCE	36
	MASS=0	SOURCE	37
35	MET=NUM(1)	SOURCE	38
	DO 90 JJ=1,5	SOURCE	39
	J=A-.JJ	SOURCE	40
	IF(IM(J).EQ.NUM(1))GOTO 90	SOURCE	41
	IF(IM(J).NE.NUM(12))GOTO 78	SOURCE	42
40	MET=NUM(12)	SOURCE	43
	GOTO 90	SOURCE	44
	78 K=K+1	SOURCE	45
	DO 80 L=2,11	SOURCE	46
	80 IF(NUM(L).EQ.IM(J))GOTO 85	SOURCE	47
45	PRINT 13,IA,IM,QQ	SOURCE	48
	I=I-1	SOURCE	49
	GOTO 75	SOURCE	50
	85 MASS=MASS+(L-2)*10.**K	SOURCE	51
	90 CONTINUE	SOURCE	52
50	C** FIND Z OF NUCLIDE	SOURCE	53
	DO 91 IK=1,100	SOURCE	54
	91 IF(ELEM(IK).EQ.IA)GOTO 92	SOURCE	55
	PRINT 13,IA,IM,QQ	SOURCE	56
	I=I-1	SOURCE	57
55	GOTO 75	SOURCE	58
	C** FINE NUCLIDE IN ADULT LIBRARY	SOURCE	59
	92 DO 95 LL=1,NLIBA	SOURCE	60

	IF (IZ(LL),NE,IK)GOTO 95	SOURCE	61
	IF (IMASS(LL),NE,MASS)GOTO 95	SOURCE	62
60	IF (META(LL),NE,MET)GOTO 95	SOURCE	63
	GOTO 96	SOURCE	64
	95 CONTINUE	SOURCE	65
	I=I-1	SOURCE	66
	PRINT 13,IA,IM,00	SOURCE	67
65	GOTO 75	SOURCE	68
	96 LIST(I,1)=LL	SOURCE	69
	C** FIND NUCLIDE IN TEENAGER LIBRARY	SOURCE	70
	K1=NLIRA+1	SOURCE	71
	DO 97 LL=K1,NLIBT	SOURCE	72
70	IF (IZ(LL),NE,IK)GOTO 97	SOURCE	73
	IF (IMASS(LL),NE,MASS)GOTO 97	SOURCE	74
	IF (META(LL),NE,MET)GOTO 97	SOURCE	75
	GOTO 98	SOURCE	76
	97 CONTINUE	SOURCE	77
75	LIST(I,2)=LIST(I,1)	SOURCE	78
	GOTO 99	SOURCE	79
	98 LIST(I,2)=LL	SOURCE	80
	DPL(LL,5)=DPL(LIST(I,1),5)	SOURCE	81
	DFA(LL,5)=DFA(LIST(I,1),5)	SOURCE	82
80	C** FIND NUCLIDE IN CHILD DOSE FACTOR LIBRARY	SOURCE	83
	99 K1=NLIRI+1	SOURCE	84
	DO 106 LL=K1,NLIRC	SOURCE	85
	IF (IZ(LL),NE,IK)GOTO 106	SOURCE	86
85	IF (IMASS(LL),NE,MASS)GOTO 106	SOURCE	87
	IF (META(LL),NE,MET)GOTO 106	SOURCE	88
	GOTO 107	SOURCE	89
	106 CONTINUE	SOURCE	90
	LIST(I,3)=LIST(I,2)	SOURCE	91
	GOTO 108	SOURCE	92
90	107 LIST(I,3)=LL	SOURCE	93
	DPL(LL,5)=DPL(LIST(I,1),5)	SOURCE	94
	DFA(LL,5)=DFA(LIST(I,1),5)	SOURCE	95
	108 CONTINUE	SOURCE	96
	C** FIND NUCLIDE IN INFANT DOSE FACTOR LIBRARY	SOURCE	97
95	K1=NLIRC+1	SOURCE	98
	DO 110 LL=K1,NLIRI	SOURCE	99
	IF (IZ(LL),NE,IK)GO TO 110	SOURCE	100
	IF (IMASS(LL),NE,MASS)GO TO 110	SOURCE	101
100	IF (META(LL),NE,MET)GO TO 110	SOURCE	102
	GO TO 115	SOURCE	103
	110 CONTINUE	SOURCE	104
	LIST(I,4)=LIST(I,3)	SOURCE	105
	GO TO 120	SOURCE	106
105	115 LIST(I,4)=LL	SOURCE	107
	DPL(LL,5)=DPL(LIST(I,1),5)	SOURCE	108
	DFA(LL,5)=DFA(LIST(I,1),5)	SOURCE	109
	120 CONTINUE	SOURCE	110
	QT=QT+QQ	SOURCE	111
	Q(I)=HQ*UML	SOURCE	112
110	GOTO 75	SOURCE	113
	101 NSOR=1-1	SOURCE	114
	C** PRINT OUT SOURCE TERM	SOURCE	115
	C**CALCULATES ANY RECONCENTRATION OF RADIONUCLIDES	SOURCE	116
	CALL RECON	SOURCE	117

115	PRINT 36	SOURCE	118
	PRINT 31	SOURCE	119
	PRINT 35	SOURCE	120
	PRINT 30	SOURCE	121
	DO 105 I=1,NSUR	SOURCE	122
120	LL=LIST(I,1)	SOURCE	123
	IK=IZ(LL)	SOURCE	124
105	PRINT 22,IK,IELEM(IK),IMASS(LL),META(LL),Q(I),(DFL(LL,J),J=1,7),	SOURCE	125
	+FXG(LL,1),FXG(LL,2),RECU(I)	SOURCE	126
	DO 210 J1=2,4	SOURCE	127
125	IF(J1,EQ.4) PRINT 34	SOURCE	128
	IF(J1,EQ.3) PRINT 33	SOURCE	129
	IF(J1,EQ.2) PRINT 32	SOURCE	130
	PRINT 31	SOURCE	131
	PRINT 35	SOURCE	132
130	PRINT 30	SOURCE	133
	DO 200 I=1,NSUR	SOURCE	134
	LL=LIST(I,1)	SOURCE	135
	IK=IZ(LL)	SOURCE	136
	LA=LIST(I,JT)	SOURCE	137
135	IF(LA,EQ.LL) GO TO 200	SOURCE	138
	PRINT 22,IK,IELEM(IK),IMASS(LL),META(LL),Q(I),(DFL(LA,J),J=1,7)	SOURCE	139
200	CONTINUE	SOURCE	140
210	CONTINUE	SOURCE	141
	QT=QT+UHL	SOURCE	142
140	PRINT 23,NSUR,QT	SOURCE	143
	RETURN	SOURCE	144
	END	SOURCE	145

1	SUBROUTINE RECON	RECON	2
	COMMON Q(200),PL,CFS,NSUR,LT,RECU(200),LIST(200,4),LCT,LZ ,CIN,KIT	RECON	3
	+ ,PIP	RECON	4
	COMMON/DPLIB/DPL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	RECON	5
5	+FFF(300,R)	RECON	6
	COMMON/SURCE/IZ(300),IMASS(300),META(300),NLIBA,NLITB,NLIBC,NLIBI	RECON	7
	PEAL MAKE	RECON	8
	10 FORMAT(110,5F10.2)	RECON	9
	15 FORMAT(1H0,'NU RECONCENTRATION OF NUCLIDES ')	RECON	10
10	16 FORMAT(1H0,'RECONCENTRATION== MAKE-UP=',1PE8.2,5X,'CYCLE TIME=',	RECON	11
	+E8.2,' HR',5X,'VOL OF POND=',E8.2,' FT**3',/,20X,'TURNOVER RATE=',	RECON	12
	+E8.2,' /HR',5X,'COOLANT FLOW=',E8.2,' CFS')	RECON	13
	17 FORMAT(1H0,'RECONCENTRATION== CYCLE TIME=',F10.2,' HR',5X,'RECYC	RECON	14
	+LE FRACTION=',F10.2)	RECON	15
15	READ(5,10)M,MAKE,CT,VOL,TR,RF	RECON	16
	IF(M.EQ.0)WRITE(6,15)	RECON	17
	IF(M.EQ.1)WRITE(6,16)MAKE,CT,VOL,TR,CFS	RECON	18
	IF(M.EQ.2)WRITE(6,17)CT,RF	RECON	19
	IF(M.EQ.0)GO TO 100	RECON	20
20	IF(M=1)20,20,30	RECON	21
	20 DO 50 J=1,NSUR	RECON	22
	MU=LIST(J,1)	RECON	23
	ARGU=TAU(MU)*CT	RECON	24
	IF(ARGU.GT.100.)ARGU=100.	RECON	25
25	50 RECU(J)=1./(1.-((CFS-MAKE)*EXP(-ARGU))/(CFS+VOL*TR/3600.))	RECON	26
	RETURN	RECON	27
	30 TUTC=PL*365.25*24./CT	RECON	28
	N=1+INT(TUTC)	RECON	29
30	DO 60 J=1,NSUR	RECON	30
	MU=LIST(J,1)	RECON	31
	ARGU=TAU(MU)*CT	RECON	32
	IF(ARGU.GT.100.)ARGU=100.	RECON	33
	STFW=RF*EXP(-ARGU)	RECON	34
	TEST=TUTC*ALOG(STFW)	RECON	35
35	IF(TEST.LT.-11.51)GO TO 40	RECON	36
	STFW=STFW**N	RECON	37
	GO TO 60	RECON	38
	40 STFW=1.0E-05	RECON	39
	60 RECU(J)=(1.-STFW)/(1.-(RF*EXP(-ARGU)))	RECON	40
40	RETURN	RECON	41
	100 DO 70 J=1,NSUR	RECON	42
	70 RECU(J)=1.	RECON	43
	RETURN	RECON	44
	END	RECON	45

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1      SUBROUTINE ALARA (ACCF,ACCI,ACCA)                ALARA      2
      COMMON Q(200),PL,CFS,NSUR,LT,RECQ(200),LIST(200,4),LCT,LZ ,CON,KIT ALARA      3
      + ,PUP                                           ALARA      4
      DIMENSION ACCF(100),ACCI(100),ACCA(100)         ALARA      5
5      DIMENSION LUCA (3)                             ALARA      6
      C                                               ALARA      7
      C                                               ALARA      8
      C PRINTS HEADINGS FOR THE APPENDIX I INDIVIDUAL ALARA      9
      C DOSE TABLES AND THE SELECTED LOCATION DOSE   ALARA     10
      C TABLES-ALSO CALLS SUBROUTINE OUT WITH        ALARA     11
      C THE CORRECT USAGE PARAMETERS FOR A           ALARA     12
      C PARTICULAR AGE GROUP                         ALARA     13
      C                                               ALARA     14
      C                                               ALARA     15
15     10 FORMAT(1H1,35X,'* * * AS LOW AS REASONABLY ACHIEVABLE *' ALARA     16
      C * * *')                                       ALARA     17
      20 FORMAT(1H ,55X,'MREM PER YEAR')             ALARA     18
      25 FORMAT(1H1)                                  ALARA     19
      40 FORMAT(1H0,'PATHWAY          SKIN          BONE          LI          ALARA     20
      1VER          TOTAL BODY          THYROID          KIDNEY          LUNG          ALARA     21
      2          GI-LLI')                             ALARA     22
      50 FORMAT(1H0,17X,'-----DOSE'              ALARA     23
      + '(MREM PER YEAR INTAKE)-----')            ALARA     24
      60 FORMAT(1H0,20X,'A D U L T  D O S E S  ')    ALARA     25
25     70 FORMAT(1H0,20X,'C H I L D  D O S E S  ')    ALARA     26
      80 FORMAT(1H0,20X,'T E E N A G E R  D O S E S  ') ALARA     27
      90 FORMAT(1H0,20X,'I N F A N T  D O S E S  ')  ALARA     28
      160 FORMAT(1H0,'LOCATION IS ',3A4)              ALARA     29
      C                                               ALARA     30
30     100 FORMAT(1I10,7E10.0)                      ALARA     31
      110 FORMAT(7E10.0)                             ALARA     32
      130 FORMAT(1H1,35X,'* * * SELECTED LOCATION * * *') ALARA     33
      140 FORMAT(1I10,3E10.0,3A4)                   ALARA     34
      CON=1.0                                         ALARA     35
35     KK=0                                           ALARA     36
      150 CONTINUE                                   ALARA     37
      DATA TDF, TDC, TDA, TDW, TDS, TDSW, TDB/0.0,0.0,0.0,510.,0.0,0.0,0.0/ ALARA     38
      DATA CHF, CHC, CHA, CHW, CHS, CHSW, CHB/6.9,0.0,0.0,510.,14.,0.0,0.0/ ALARA     39
      IF(LT.GT.0) CHC=1.7                             ALARA     40
40     DATA TAF, TAC, TAA, TAW, TAS, TASW, TAB/16.,0.0,0.0,510.,67.,0.0,0.0/ ALARA     41
      IF(LT.GT.0) TAC=3.8                             ALARA     42
      DATA FIUS, CRUS, ALUS, WUSE, SHU, SWU, BUSE/21.,0.,0.,730.,12.,0.,0./ ALARA     43
      C                                               ALARA     44
      C                                               ALARA     45
45     IF(LT.GT.0) CRUS=5.0                           ALARA     46
      IF(KK.EQ.0) READ 100,N,SWF,DILU,SHD,DWD,T,LU   ALARA     47
      IF(KK.GT.0) READ 140,N,DILU,T,SWF,(LUCA(J),J=1,3) ALARA     48
      IF (N.EQ.0)GO TO 120                            ALARA     49
      READ 110,FIUS,CRUS,ALUS,WUSE,SHU,SWU,BUSE      ALARA     50
      READ 110,TAF,TAC,TAA,TAW,TAS,TASW,TAB         ALARA     51
50     READ 110,CHF,CHC,CHA ,CHW,CHS,CHSW,CHB       ALARA     52
      READ 110,TDF,TDC,TDA,TDW,TDS,TDSW,TDB         ALARA     53
      120 CONTINUE                                   ALARA     54
      IF(DILU.EQ.0.)GO TO 200                         ALARA     55
      IF(KK.GT.0) PRINT 130                           ALARA     56
55     IF(KK.EQ.0)PRINT 10                            ALARA     57
      IF(KK.GT.1)SHD=DILU                             ALARA     58
      SWD=SHD                                         ALARA     59

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	HDIL=DILU	ALARA	59
	IF(KK.GT.1)DWD=DILU	ALARA	60
60	IF(KK.GT.1) PRINT 160,LUCA	ALARA	61
	IF(KK.GT.1) TD=T	ALARA	62
	C	ALARA	63
	PRINT 60	ALARA	64
	PRINT 50	ALARA	65
65	PRINT 40	ALARA	66
	CALL OUT(1,ACCF,ACCI,ACCA,T,FIUS,CRUS,ALUS,WUSE,SMU,SWU,RUSE,DILU,	ALARA	67
	+DWD,SHD,SWD,BDIL,SWF,KK,N,TD)	ALARA	68
	IF(KK.GT.0.AND.LCT.GT.0)PRINT 130	ALARA	69
	IF(KK.GT.1) PRINT 160,LUCA	ALARA	70
70	IF(KK.EQ.0.AND.LCT.GT.0)PRINT 10	ALARA	71
	PRINT 80	ALARA	72
	PRINT 50	ALARA	73
	PRINT 40	ALARA	74
	CALL OUT(2,ACCF,ACCI,ACCA,T,TAF,TAC,TAA,TAN,TAS,TASW,TAB,DILU,DWD,	ALARA	75
75	+SHD,SWD,BDIL,SWF,KK,N,TD)	ALARA	76
	IF(KK.GT.0.AND.LCT.GT.0)PRINT 130	ALARA	77
	IF(KK.GT.1) PRINT 160,LUCA	ALARA	78
	IF(KK.EQ.0.AND.LCT.GT.0)PRINT 10	ALARA	79
	PRINT 70	ALARA	80
80	PRINT 50	ALARA	81
	PRINT 40	ALARA	82
	CALL OUT(3,ACCF,ACCI,ACCA,T,CHF,CHC,CHA,CHW,CHS,CHSW,CHB,DILU,DWD,	ALARA	83
	+SHD,SWD,BDIL,SWF,KK,N,TD)	ALARA	84
	IF(TDW.EQ.0..OR.LT.GT.0) GO TO 145	ALARA	85
85	IF(KK.GT.0.AND.LCT.GT.0)PRINT 130	ALARA	86
	IF(KK.GT.1) PRINT 160,LUCA	ALARA	87
	IF(KK.EQ.0.AND.LCT.GT.0)PRINT 10	ALARA	88
	PRINT 90	ALARA	89
	PRINT 50	ALARA	90
90	PRINT 40	ALARA	91
	CALL OUT(4,ACCF,ACCI,ACCA,T,TDF,TDC,TDA,TDW,TDS,TDSW,TDB,DILU,DWD),	ALARA	92
	+SHD,SWD,BDIL,SWF,KK,N,TD)	ALARA	93
145	KK=KK+2	ALARA	94
	GO TO 150	ALARA	95
95	200 CONTINUE	ALARA	96
	RETURN	ALARA	97
	END	ALARA	98

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1      SUBROUTINE OUT(KOP,ACCF,ACCI,ACCA,T,FIUS,CRUS,ALUS,WUSE,SHU,SWU,BU OUT      2
+SE,DILU,DWD,SHD,SWD,HUIL,SWF,KK,N,TU) OUT      3
COMMON Q(200),PL,CFS,NSUP,LT,RELO(200),LIST(200,4),LCT,LZ ,CON,KIT OUT      4
+ ,POP OUT      5
5      DIMENSI(ON W(3),X(3),Y(3),Z(3),H(3),FDUSE(8),CDUSE(8),ADUSE(8),SDUS OUT      6
1E(8),SWD(8),BDUSE(8),TDUSE(8),A(3),H(3),C(3),WDUSE(A) OUT      7
DIMENST(ON ACCF(100),ACCI(100),ACCA(100),DUSE(200,8) OUT      8
C      OUT      9
C      OUT     10
C      CONTROLS THE CALLING OF THE CALCULATIONAL SUBROUTINES WITH THE OUT     11
C      APPROPRIATE USAGE PARAMETERS FOR THE PARTICULAR AGE GROUP OUT     12
C      OUT     13
C      OUT     14
C      DATA Y/'TOTA','L  ',' '  '/' OUT     15
DATA X/'INVE','RTEH','RATE'/' OUT     16
DATA Z/'ALGA','E  ',' '  '/' OUT     17
DATA C/'HOAT','ING  ',' '  '/' OUT     18
DATA H/'GRIN','KING',' '  '/' OUT     19
DATA W/'FISH',' '  ',' '  '/' OUT     20
20      DATA A/'SHOW','ELIN','E  '/' OUT     21
DATA B/'SWIM','MING',' '  '/' OUT     22
10      FORMAT(1H ,3A4,15X,1P7E15.2) BNL01      4
20      FORMAT(1H ,3A4,1P8E15.2) OUT     24
T2=T+24. OUT     25
25      T3=TD+12. OUT     26
LZ=0 OUT     27
KIT=0 OUT     28
CALL AQUA(W,DILU,FIUS,T2,FDUSE,KOP,ACCF) OUT     29
PRINT 10,W,(FDUSE(J),J=2,8) OUT     30
30      CALL AQUA(X,DILU,CRUS,T2,CDUSE,KOP,ACCI) OUT     31
IF(CRUS.GT.0.) PRINT 10,X,(CDUSE(J),J=2,8) OUT     32
CALL AQUA(Z,DILU,ALUS,T2,ADUSE,KOP,ACCA) OUT     33
IF(ALUS.GT.0.) PRINT 10,Z,(ADUSE(J),J=2,8) OUT     34
CALL DRIFK(DWD,T3,WUSE,WDUSE,KOP) OUT     35
35      IF(LT.EQ.0) PRINT 10,H,(WDUSE(J),J=2,8) OUT     36
CALL SHIPE(A,SWF,SHD,T,SHU,SDUSE) OUT     37
PRINT 20,A,SDUSE OUT     38
GEOM=1. OUT     39
CALL SWIM(H,SWD,T,SWU,GEOM,SWDD) OUT     40
40      IF(SWU.GT.0.) PRINT 20,B,SWDU OUT     41
GEOM=2. OUT     42
CALL SWIM(C,HUIL,T,BUSE,GEOM,HOUSE) OUT     43
IF(BUSE.GT.0.) PRINT 20,C,HOUSE OUT     44
DO 40 J=1,M OUT     45
45      40 TDUSE(J)=FDUSE(J)+CDUSE(J)+ADUSE(J)+SDUSE(J)+WDUSE(J)+SWDD(J)+BDUS OUT     46
1E(J) OUT     47
PRINT 20,Y,TDUSE OUT     48
60      FORMAT(1H0,12X,'USAGE (KG/YR,HR/YR) DILUTION TIME(HR OUT     49
+)',10X,'SHOREWIDTH FACTOR=',F3.1) OUT     50
50      70      FORMAT(1H ,3A4,7X,+B.1,10X,F10.1,3X,F10.2) OUT     51
PRINT 60,SWF OUT     52
PRINT 70,W,FIUS, DILU,T2 OUT     53
IF(CRUS.GT.0.) PRINT 70,X,CRUS,DILU,T2 OUT     54
IF(ALUS.GT.0.) PRINT 70,Z,ALUS,DILU,T2 OUT     55
55      IF(WUSE.GT.0..AND.LT.EQ.0) PRINT 70,H,WUSE,DWD,T3 OUT     56
IF(SHU.GT.0.) PRINT 70,A,SHU,SHD,T OUT     57
IF(SWU.GT.0.) PRINT 70,B,SWU,SWD,T OUT     58

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60      IF(BUSE.GT.0.0) PRINT 70,C,BUSE,BDIL,T  
        KIT#10  
      80 CONTINUE  
        IF(LCT.GT.0)CALL PERODS(W,TDOSE,DOSE)  
        RETURN  
        END
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      OUT      59  
      OUT      60  
      OUT      61  
      OUT      62  
      OUT      63  
      OUT      64
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	CALL SHORE(TYPE,CSWF,DILU,T,2922.,EXT)	WHU	59
	CALL SWIM(TYPE,DILU,T,2922.,1.,EXI)	WHU	60
60	TEXT=EXT(2)+EXI(2)	WHU	61
	TOT=TEXT+TDUSE(1)	WHU	62
	PRINT 20,A,TDUSE(1),TEXT,TOT	WHU	63
	CALL EAT(H,RAC,RACMAS,RACUSE,DILU,T,TDUSE,ACCI)	WHU	64
	CALL SHORE(TYPE,CSWF,DILU,T,2191.,EXT)	WHU	65
65	TOT=EXT(2)+TDUSE(1)	WHU	66
	PRINT 20,B,TDUSE(1),EXT(2),TOT	WHU	67
	CALL EAT(C,HERMIN,HERMAS,HERUSE,DILU,T,TDUSE,ACCF)	WHU	68
	CALL SHORE(TYPE,CSWF,DILU,T,2922.,EXT)	WHU	69
	CALL SWIM(TYPE,DILU,T,2920.,2.,EXI)	WHU	70
70	TEXT=EXT(2)+EXI(2)	WHU	71
	TOT=TEXT+TDUSE(1)	WHU	72
	PRINT 20,C,TDUSE(1),TEXT,TOT	WHU	73
	CALL EAT(D,DUCK,DUCKMAS,DUCKUSE,DILU,T,TDUSE,ACCA)	WHU	74
	CALL SHORE(TYPE,CSWF,DILU,T,4383.,EXT)	WHU	75
75	TEXT=EXT(2)+EXI(2)*3./2.	WHU	76
	TOT=TEXT+TDUSE(1)	WHU	77
	PRINT 20,D,TDUSE(1),TEXT,TOT	WHU	78
	KIT=70	WHU	79
	IF(LCT.GT.0) CALL PERDUS(A,TDUSE,DOUSE)	WHU	80
80	GO TO 80	WHU	81
	100 CONTINUE	WHU	82
	RETURN	WHU	83
	END	WHU	84

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1      SUBROUTINE WHY(ACC,I,N)                                WHY      2
      COMMON/POPUL/PERA,PERT,PERC,IIS                      WHY      3
      COMMON D(200),PL,CFS,NSUR,LT,PECO(200),LIST(200,4),LCT,LZ ,CON,KIT WHY      4
      + ,POP                                                WHY      5
5      DIMENSION ACC(100),X(3),W(3),CATH(20),DILU(20),T(20),TDOSE(8),DOSE WHY      6
      +(200,8),A(3),B(3),C(3),TYPE(3),CONC(200)           WHY      7
      DIMENSION D(3),PD(7)                                  WHY      8
      C                                                      WHY      9
      C                                                      WHY     10
10     C      CONTROLS THE CALCULATION OF THE SPORT        WHY     11
      C      AND COMMERCIAL FISH AND INVERTEBRATE         WHY     12
      C      POPULATION DOSES=ACTUAL CALCULATIONS        WHY     13
      C      DONE BY SUBROUTINES PAFD AND CENT            WHY     14
      C                                                    WHY     15
15     C
      DATA X/'INVE','R' , , ' /                          WHY     17
      DATA W/'FISH','I' , , ' /                          WHY     18
      DATA A/'ADUL','T' , , ' /                          WHY     19
      DATA B/'TEEN','AGER','I' , , ' /                  WHY     20
20     DATA C/'CHIL','D' , , ' /                          WHY     21
      DATA D/'TUTA','L' , , ' /                          WHY     22
15     FORMAT(1H ,6A4,1P8E10.2)                             WHY     23
20     FFORMAT(1H0,'PATHWAY      AGE GROUP      USAGE      RONE      LIVER  WHY     24
      + TOTAL BODY THYROID      KIDNEY      LUNG      GI-LLI')    WHY     25
25     FFORMAT(1H0,34X,'-----DOSE (MAN-REM)-----'  WHY     26
      +-----')                                          WHY     27
60     FFORMAT(1H0,' DILUTION  CATCH  TIME(HR)-INCLUDES FOOD PROCESSING  WHY     28
      + TIME OF ',1PE8.2,' HR',5X,'POPULATION=',E8.2)  WHY     29
61     FFORMAT(1H ,53X,'MAN-REM')                          WHY     30
30     64 FFORMAT(1H1,35X,'* * * INVERTERRATE CONSUMPTION POPULATION DOSES  WHY     31
      + * * *')                                          WHY     32
65     FFORMAT(1H1,35X,'* * * FISH CONSUMPTION POPULATION DOSES * *  WHY     33
      +*')                                          WHY     34
66     FFORMAT(1H0,' _____SPORTFISH HARVEST_____')  WHY     35
67     FFORMAT(1H0,' _____COMMERCIAL HARVEST_____')  WHY     36
68     FFORMAT(1H0,' _____NEPA DOSES_____')          WHY     37
69     FFORMAT(1H0,'NOTE--TOTAL NEPA DOSE MUST INCLUDE SPORT CATCH, DOSES  WHY     38
      +HELLO ARE FOR COMMERCIAL CATCH ONLY')          WHY     39
70     FFORMAT(1E10.2)                                     WHY     40
40     71 FFORMAT(1H ,1P8E10.2)                             WHY     41
75     FFORMAT(1H0,'AVERAGE INDIVIDUAL CONSUMPTION (KG/YR)  ADULT=',  WHY     42
      +1PE8.2,5X,'TEEN=',E8.2,5X,'CHILD=',E8.2)      WHY     43
      P(AMT,AU,TU,CU)=AMT/(AU*PERA+TU*PERT+CU*PERC)      WHY     44
      AUSE(PEN,AU)=PEU*PERA*AU                            WHY     45
45     TUSE(PEN,TU)=PEU*PERT*TU                            WHY     46
      CUSE(PEN,CU)=PEU*PERC*CU                            WHY     47
      CU=1000.                                             WHY     48
      LH=0                                                 WHY     49
      IF(N.EQ.1) NN=1                                       WHY     50
50     IF(N.EQ.2) NN=2                                       WHY     51
      IF(I.EQ.1.AND.LT.EQ.0) HARV=44.0E+06                WHY     52
      IF(I.EQ.2.AND.LT.EQ.0) HARV=2.30E+06                WHY     53
      IF(I.EQ.1.AND.LT.GT.0) HARV=6.58E+08                WHY     54
      IF(I.EQ.2.AND.LT.GT.0) HARV=4.10E+08                WHY     55
55     IF(N.EQ.1) FPT=168.                                    WHY     56
      IF(N.EQ.2) FPT=240.,                                  WHY     57
      J=1                                                  WHY     58

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	80	HEAD 70,CATH(J),DILU(J),T(J)	WHY	59
		T(J)=T(J)+FPT	WHY	60
60		J=J+1	WHY	61
		M=J-1	WHY	62
		IF(DILU(M).EQ.0.) GO TO 85	WHY	63
		GO TO 80	WHY	64
	85	M=M-1	WHY	65
65		IF(M.EQ.0) GO TO 100	WHY	66
		IF(I.EQ.1)PRINT 65	WHY	67
		IF(I.EQ.2)PRINT 64	WHY	68
		PRINT 61	WHY	69
		IF(N.EQ.1)PRINT 66	WHY	70
70		IF(N.EQ.2)PRINT 67	WHY	71
		PRINT 30	WHY	72
		PRINT 20	WHY	73
		GO TO (21,22),I	WHY	74
		GO TO 100	WHY	75
75		21 AU=6.9	WHY	76
		TU=5.2	WHY	77
		DO 17 J=1,3	WHY	78
	17	TYPE(J)=M(J)	WHY	79
		CU=2.2	WHY	80
80		GO TO 86	WHY	81
	22	AU=1.	WHY	82
		TU=0.75	WHY	83
		CU=0.33	WHY	84
		DO 16 J=1,3	WHY	85
85		16 TYPE(J)=X(J)	WHY	86
		GO TO 86	WHY	87
	86	AMT=0.	WHY	88
		IF(N.EQ.1) NL=1	WHY	89
		IF(N.EQ.2) NL=2	WHY	90
90		DO 87 IN=1,M	WHY	91
	87	AMT=AMT+CATH(IN)	WHY	92
		IF(N.EQ.1)PE(U=P(AMT,AU,TU,CU)	WHY	93
		IF(N.EQ.2)PE(U=POP	WHY	94
	88	LZ=0	WHY	95
95		KIT=0	WHY	96
		USE=AU*SE(PEO,AU)	WHY	97
		CALL CENT(T,CATH,DILU,M,CONC,AMT,MAXV,NL)	WHY	98
		CALL PAFD(TYPE,ACC,CONC,1,USE,TDUSE,NN,LM)	WHY	99
		PRINT 15,TYPE,A,USE,(TDUSE(JK),JK=1,7)	WHY	100
100		DO 89 J=1,7	WHY	101
	89	PD(J)=TDUSE(J)	WHY	102
		SUM=USE	WHY	103
		USE=TUSE(PEO,TU)	WHY	104
		CALL PAFD(TYPE,ACC,CONC,2,USE,TDUSE,NN,LM)	WHY	105
105		PRINT 15,TYPE,B,USE,(TDUSE(JK),JK=1,7)	WHY	106
		DO 91 J=1,7	WHY	107
	91	PD(J)=PD(J)+TDUSE(J)	WHY	108
		SUM=SUM+USE	WHY	109
		USE=CUSE(PEO,CU)	WHY	110
110		CALL PAFD(TYPE,ACC,CONC,3,USE,TDUSE,NN,LM)	WHY	111
		PRINT 15,TYPE,C,USE,(TDUSE(JK),JK=1,7)	WHY	112
		DO 92 J=1,7	WHY	113
	92	PD(J)=PD(J)+TDUSE(J)	WHY	114
		SUM=SUM+USE	WHY	115

115	PRINT 15,TYPE,D,SUM,(PD(J),J=1,7)	WHY	116
	IF(LD.GT.0)GO TO 100	WHY	117
	PRINT 60,FPT,PEU	WHY	118
	DO 90 J=1,M	WHY	119
120	90 PRINT 71,DILO(J),CATH(J),T(J)	WHY	120
120	PRINT 75,AU,TU,CU	WHY	121
	KIT=30	WHY	122
	IF(LCT.GT.0)CALL PERDOS(W,TOOSE,DOSE)	WHY	123
	IF(N.EQ.1)GO TO 100	WHY	124
	LM=10	WHY	125
125	NL=1	WHY	126
	PRINT 68	WHY	127
	PRINT 69	WHY	128
	PRINT 30	WHY	129
	PRINT 20	WHY	130
130	PEQ=P(AMT,AU,TU,CU)	WHY	131
	GO TO 88	WHY	132
100	CONTINUE	WHY	133
	RETURN	WHY	134
	END	WHY	135

CARD NR. SEVERITY DETAILS DIAGNOSIS OF PROBLEM

73	I	AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
74	I	THERE IS NO PATH TO THIS STATEMENT.

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1      SUBROUTINE WATER                                WATER      2
      COMMON N(200),PL,CFS,NSUR,LT,REGO(200),LIST(200,4),LCT,LZ ,CON,KIT WATER      3
      + ,POP                                           WATER      4
      COMMON/POPUL/PERA,PERT,PERC,US                 WATER      5
5      COMMON/SOURCE/IZ(300),IMASS(300),META(300),NLIBA,NLIBT,NLIBC,NLIBI WATER      6
      DIMENSION TDOSE(8),A(3),H(3),C(3),D(3),TRI(3)   WATER      7
      DIMENSION TYPE(3)                               WATER      8
      DIMENSION PD(8),CUM(8),E(3)                     WATER      9
      DATA TH/'WATE', 'R', ' ', ' ', ' ', ' ', ' ', ' ' WATER     10
10     DATA D/'TOTA', 'L', ' ', ' ', ' ', ' ', ' ', ' ' WATER     11
      DATA E/'CUMU', 'L TO', 'TAL', ' ', ' ', ' ', ' ', ' ' WATER     12
      DATA A/'ADUL', 'T', ' ', ' ', ' ', ' ', ' ', ' ' WATER     13
      DATA B/'TEFN', 'AGER', ' ', ' ', ' ', ' ', ' ', ' ' WATER     14
      DATA C/'CHIL', 'D', ' ', ' ', ' ', ' ', ' ', ' ' WATER     15
15     DATA TYPE/'DRIN', 'KING', ' ', ' ', ' ', ' ', ' ', ' ' WATER     16
      10 FORMAT(1H, '6A4,1P8E10.2)                     WATER     17
      20 FORMAT(1H0, 'PATHWAY      AGE GROUP      USAGE      BONE      LIVER      WATER     18
      + TOTAL BODY THYROID      KIDNEY      LUNG      GI=LLI') WATER     19
      30 FORMAT(1H1,35X, '* * * POPULATION WATER CONSUMPTION DOSES * * WATER     20
      + *') WATER     21
      35 FORMAT(1H0,34X, '-----DOSE (MAN-REM)-----' WATER     22
      +-----') WATER     23
      50 FORMAT(1H0, '-----' WATER     24
      +-----') WATER     25
25     55 FORMAT(1H0, 'POPULATION=',1P8,2,5X, 'DILUTION=',E8,2,5X, 'TRANSIT TI
      +ME=',E8,2, ' HR (INCLUDING 24 HR FOR TREATMENT FACILITY)') WATER     26
      60 FORMAT(8E10,0) WATER     28
      65 FORMAT(1H0, '-----HYDROSPHERE TRITIUM DOSE-----') WATER     29
      66 FORMAT(1H0, '-----CUMULATIVE TOTAL-----') WATER     30
30     80 FORMAT(1H0, 'AVERAGE INDIVIDUAL CONSUMPTION (L/YR)      ADULT=',
      +1P8,2,5X, 'TEFN=',E8,2,5X, 'CHILU=',E8,2) WATER     31
      DATA AH/370, / WATER     33
      DATA TH/260, / WATER     34
      DATA CU/260, / WATER     35
35     AUSE(P,AU)=P*PERA*AU WATER     36
      TUSE(P,TU)=P*PERT*TU WATER     37
      CUSE(P,CU)=P*PERC*CU WATER     38
      CON=1000. WATER     39
      DU 56 JF=1,8 WATER     40
40     56 CUM(JM)=0.0 WATER     41
      EUS=0.0 WATER     42
      PRINT 30 WATER     43
      40 READ 60,P,DILU,T,GAL,GUS WATER     44
      PRINT 50 WATER     45
45     IF(P.EQ.0..AND.GUS.GT.0.) P=GAL/GUS WATER     46
      IF(DILU.EQ.0)GO TO 100 WATER     47
      PRINT 35 WATER     48
      PRINT 20 WATER     49
      DO 41 JM=2,8 WATER     50
50     41 PD(JM)=0.0 WATER     51
      T=T+24. WATER     52
      USE=AUSE(P,AU) WATER     53
      KIT=0 WATER     54
      LZ=0 WATER     55
55     CALL DRINK(DILU,T,USE,TDOSE,1) WATER     56
      PRINT 10,TYPE,A,USE,(TDOSE(JK),JK=2,8) WATER     57
      DO 42 JM=2,8 WATER     58

```

1	SUBROUTINE ACTIVE	ACTIVE	2
	COMMON N(200),PL,CFS,NSUR,LT,RFCO(200),LIST(200,4),LCT,LZ ,CON,KIT	ACTIVE	3
	+ ,POP	ACTIVE	4
	DIMENSION S(3),SW(3),D(3),A(3),B(3),C(3),TDOSE(8)	ACTIVE	5
5	DIMENSION LUCA(3)	ACTIVE	6
	DATA S/'SHR', 'ELIN', 'E ' /	ACTIVE	7
	DATA S/'SWIM', 'MING', ' ' /	ACTIVE	8
	DATA D/'HUA', 'ING', ' ' /	ACTIVE	9
	DATA A/'TOTA', 'L PO', 'PUL ' /	ACTIVE	10
10	80 FORMAT(1H, 'LOCATION= ', 3A4)	ACTIVE	11
	15 FORMAT(1H, 'DILUTION= ', E8.2, 10X, 'TRANSIT TIME= ', E8.2, ' HR', 10X, 'SW	ACTIVE	12
	+F= ', F3.1)	ACTIVE	13
	10 FORMAT(1H, '6A4, 1P7E15.2)	BNLO1	10
15	16 FORMAT(1H1, 35X, '* * * RECREATION POPULATION DOSES * * *	ACTIVE	15
	+*')	ACTIVE	16
	20 FORMAT(1H0, 'PATHWAY AGE GROUP USAGE SKIN	ACTIVE	17
	+ TOTAL BODY (HYDRO)'	ACTIVE	18
	30 FORMAT(1H1, '* * * POPULATION DOSES * * *')	ACTIVE	19
	40 FORMAT(1H, '48X, '-----DOSE(MAN=HEM)-----')	ACTIVE	20
20	50 FORMAT(1H0, '-----')	ACTIVE	21
	+-----')	ACTIVE	22
	60 FORMAT(1H0, 'DILUTION= ', E8.2, 10X, 'TRANSIT TIME= ', E8.2, ' HR')	ACTIVE	23
	70 FORMAT(4E10.0, 3A4)	ACTIVE	24
	75 FORMAT(3E10.0, 3A4)	ACTIVE	25
25	PRINT 16	ACTIVE	26
	CON=1000.	ACTIVE	27
	JL=10	ACTIVE	28
100	READ 70, SHU, DILU, T, SWF, (LUCA(J), J=1, 3)	ACTIVE	29
	PRINT 50	ACTIVE	30
30	IF (DILU.EQ.0.)GO TO 110	ACTIVE	31
	LZ=0	ACTIVE	32
	PRINT 40	ACTIVE	33
	KIT=0.	ACTIVE	34
	PRINT 20	ACTIVE	35
35	CALL SHORE(S, SWF, DILU, T, SHU, TDOSE)	ACTIVE	36
	PRINT 10, S, A, SHU, (TDOSE(J), J=1, 3)	ACTIVE	37
	PRINT 80, LUCA	ACTIVE	38
	PRINT 15, DILU, T, SWF	ACTIVE	39
	KIT=40	ACTIVE	40
40	IF (JL.LT.0)GO TO 100	ACTIVE	41
	IF (LCT.GT.0)CALL PERDUS(W, TDOSE, DOSE)	ACTIVE	42
	JL=-10	ACTIVE	43
	GO TO 100	ACTIVE	44
45	110 READ 75, SWU, DILU, T, (LUCA(J), J=1, 3)	ACTIVE	45
	PRINT 50	ACTIVE	46
	IF (DILU.EQ.0.)GO TO 120	ACTIVE	47
	LZ=0	ACTIVE	48
	KIT=0.	ACTIVE	49
	PRINT 40	ACTIVE	50
50	PRINT 20	ACTIVE	51
	GEOM=1.	ACTIVE	52
	CALL SWIM(SW, DILU, T, SWU, GEOM, TDOSE)	ACTIVE	53
	PRINT 10, SW, A, SWU, (TDOSE(J), J=1, 3)	ACTIVE	54
	PRINT 80, LUCA	ACTIVE	55
55	PRINT 60, DILU, T	ACTIVE	56
	KIT=40	ACTIVE	57
	IF (JL.GT.0)GO TO 110	ACTIVE	58

	42	PD(JM)=PD(JM)+TDUSE(JM)	WATER	59
		DU 57 JM=2,8	WATER	60
60	57	CUM(JM)=CUM(JM)+TDUSE(JM)	WATER	61
		TUS=USE	WATER	62
		USE=TUSE(P,TU)	WATER	63
		CALL DRINK(DILU,T,USE,TDUSE,2)	WATER	64
		PRINT 10,TYPE,R,USE,(TDUSE(JK),JK=2,8)	WATER	65
65		DU 43 JM=2,8	WATER	66
	43	PD(JM)=PD(JM)+TDUSE(JM)	WATER	67
		DU 58 JM=2,8	WATER	68
	58	CUM(JM)=CUM(JM)+TDUSE(JM)	WATER	69
		TUS=TUS+USE	WATER	70
70		USE=CUSE(P,CU)	WATER	71
		CALL DRINK(DILU,T,USE,TDUSE,3)	WATER	72
		PRINT 10,TYPE,C,USE,(TDUSE(JK),JK=2,8)	WATER	73
		DU 44 JM=2,8	WATER	74
	44	PD(JM)=PD(JM)+TDUSE(JM)	WATER	75
75		DU 59 JM=2,8	WATER	76
	59	CUM(JM)=CUM(JM)+TDUSE(JM)	WATER	77
		TUS=TUS+USE	WATER	78
		EUS=FUS+TUS	WATER	79
		PRINT 10,TYPE,D,TUS,(PD(JM),JM=2,8)	WATER	80
80		KIT=20	WATER	81
		PRINT 55,P,DILU,T	WATER	82
		PRINT 80,AU,TU,CU	WATER	83
		IF(LCT.GT.0) CALL PERDUS(TYPE,TDUSE,DUSE)	WATER	84
		GU TO 40	WATER	85
85	100	CONTINUE	WATER	86
		IF(PD(2).GT.0.0) PRINT 66	WATER	87
		IF(PD(7).GT.0.0) PRINT 20	WATER	88
		IF(PD(2).GT.0.0) PRINT 10,TYPE,E,EUS,(CUM(JM),JM=2,8)	WATER	89
		PRINT 65	WATER	90
90		PRINT 20	WATER	91
		USE=2.2	WATER	92
		DU 70 I=1,NSOR	WATER	93
		M=LIST(I,1)	WATER	94
		IF(M.EQ.1) CALL TRIUM(Q(M),POP,H3B,H3T)	WATER	95
95		IF(M.EQ.1)PRINT 10,TRI,D,USE,H3B,H3T,H3B,H3B,H3B,H3B,H3B,H3B	WATER	96
	70	CONTINUE	WATER	97
		RETURN	WATER	98
		END	WATER	99

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        IF(LCT.GT.0)CALL PERDUS(W,TDUSE,DUSE)
        JL=10
60      GO TO 110
        120 READ 75,HUSE,DILU,T,(LUCA(J),J=1,3)
        PRINT 50
        IF(DILU.EQ.0.)GO TO 130
        LZ=0
65      KIT=0.
        GEUM=2.0
        PRINT 40
        PRINT 20
        CALL SWIM(D,DILU,T,BUSE,GEUM,TDUSE)
70      PRINT 10,D,A,BUSE,(TDUSE(J),J=1,3)
        PRINT 80,LUCA
        PRINT 60,DILU,T
        C
        C
75      GO TO 120
        130 CONTINUE
        RETURN
        END

```

ACTIVE	59
ACTIVE	60
ACTIVE	61
ACTIVE	62
ACTIVE	63
ACTIVE	64
ACTIVE	65
ACTIVE	66
ACTIVE	67
ACTIVE	68
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ACTIVE	73
ACTIVE	74
ACTIVE	75
ACTIVE	76
ACTIVE	77
ACTIVE	78
ACTIVE	79

1	SUBROUTINE AQUA (CRITH,DILU,USE,T,TDUSE,JJ,ACC)	AQUA	2
	COMMON/DFLIB/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	AQUA	3
	+EFF(300,8)	AQUA	4
5	COMMON Q(200),PL,CFS,NSUR,LT,RECU(200),LIST(200,4),LCT,LZ,CON,KIT	AQUA	5
	+ ,PIP	AQUA	6
	COMMON/SORCE/IZ(300),IMASS(300),META(300),NLIBA,NLIBT,NLIBC,NLIBI	AQUA	7
	DIMENSION ACC(100),TDUSE(8),DOSE(200,8),CRITH(3)	AQUA	8
	DO 8 J=1,8	AQUA	9
8	TDUSE(J)=0.0	AQUA	10
10	IF(USE.EQ.0.)GO TO 50	AQUA	11
	DO 10 I=1,NSUR	AQUA	12
	DOSE(I,1)=0.	CHANGE 1	1
	LL=LIST(I,JJ)	AQUA	13
15	LM=LIST(I,1)	AQUA	14
	MU=IZ(LM)	AQUA	15
	ARGU=TAU(LM)*T	AQUA	16
	IF(ARGU.GT.20.)GO TO 20	AQUA	17
	FACT=1119.*Q(I)*RECU(I)/CFS/DILU*EXP(-ARGU)*USE*ACC(MU)/CON	AQUA	18
	GO TO 30	AQUA	19
20	FACT=0.0	AQUA	20
30	DO 40 J=2,8	AQUA	21
	L=J-1	AQUA	22
	DOSE(I,J)=DFL(LL,L)*FACT	AQUA	23
40	TDUSE(J)=TDUSE(J)+DOSE(I,J)	AQUA	24
25	10 CONTINUE	AQUA	25
	IF(LCT.GT.0) CALL PERDUS(CRITH,TDUSE,DOSE)	AQUA	26
50	CONTINUE	AQUA	27
	RETURN	AQUA	28
	END	AQUA	29

1	SUBROUTINE DRINK(DWD,T,USE,TDUSE,JJ)	DRINK	2
	COMMON G(200),PL,CFS,NSUR,LT,RECU(200),LIST(200,4),LCT,LZ ,CON,KIT	DRINK	3
	+ ,PIP	DRINK	4
	COMMON/SORCE/IZ(300),INASS(300),META(300),NL1UA,NL1BT,NL1BC,NL1BI	DRINK	5
5	COMMON/DFLTH/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	DRINK	6
	+EFF(300,8)	DRINK	7
	COMMON/TRANS/DILW	CHANGE1	2
	DIMENSION TDUSE(8),DOSE(200,8),TYPE(3)	DRINK	8
	DATA TYPE/'DRIN','KING',' '	DRINK	9
10	DILW = DWD	CHANGE1	3
	DO 8 J=1,8	DRINK	10
	8 TDUSE(J)=0.0	DRINK	11
	IF(USE.EQ.0.)GO TO 50	DRINK	12
	IF(LT.GT.0) GO TO 50	DRINK	13
15	DO 10 I=1,NSUR	DRINK	14
	DOSE(I,1)=0.	CHANGE1	4
	LL=LIST(I,JJ)	DRINK	15
	LM=LIST(I,1)	DRINK	16
	MU=IZ(LM)	DRINK	17
20	ARGU=TAU(LM)*T	DRINK	18
	IF(ARGU.GT.20.) GO TO 20	DRINK	19
	FACT=1119.*U(I)*RECU(I)/CFS/DWD*EXP(-ARGU)*USE/CON	DRINK	20
	GO TO 30	DRINK	21
25	20 FACT=0.0	DRINK	22
	30 DO 40 J=2,8	DRINK	23
	L=J-1	DRINK	24
	DOSE(I,J)=DFL(LL,L)*FACT	DRINK	25
	40 TDUSE(J)=TDUSE(J)+DOSE(I,J)	DRINK	26
	10 CONTINUE	DRINK	27
30	IF (LCT.GT.0) CALL PERUS(TYPE,TDUSE,DOSE)	DRINK	28
	IF(CON.GT.10.)CALL PLUP(DUSE,7)	DRINK	29
	50 CONTINUE	DRINK	30
	RETURN	DRINK	31
	END	DRINK	32

1	SUBROUTINE SHORE (TYPE, SWF, DILU, T, USE, TDOUSE)	SHORE	2
	(DIMENSION Q(200), PL, CFS, NSUR, LT, RFCU(200), LIST(200,4), LCT, LZ, CON, KIT	SHORE	3
	+ , POP	SHORE	4
	COMMON/DFLH/DFL(300,7), DFA(300,7), EXG(300,2), TAU(300), EXS(300,2),	SHORE	5
5	+EFF(300,8)	SHORE	6
	COMMON/SURCE/IZ(300), IMASS(300), META(300), NLIBA, NLIBT, NLIBC, NLIBI	SHORE	7
	DIMENSION TYPE(3), TDOUSE(8), DOSE(200,8)	SHORE	8
	DO 8 J=1,8	SHORE	9
8	TDOUSE(J)=0.0	SHORE	10
10	IF (USE.EQ.0.) GO TO 50	SHORE	11
	DO 10 I=1, NSUR	SHORE	12
	LM=LIST(I,1)	SHORE	13
	MU=IZ(LM)	SHORE	14
	ARGU=TAU(LM)*PL*8760.	SHORE	15
15	IF (ARGU.GT.100.) ARGU=100	SHORE	16
	TP=TAU(LM)*T	SHORE	17
	IF (TP.GT.100) TP=100	SHORE	18
	FACT=1/10000.*(0.693/TAU(LM)/24.)*Q(I)*RFCU(I)/CFS/DILU*EXP(-TP)*SWF	SHORE	19
	C*(1.-EXP(-ARGU))*USE/CON	SHORE	20
20	DO 20 J=1,8	CHANGE1	5
	IF (J.GT.2) GOTO 15	CHANGE1	6
	DOSE(I,J)=FACT*EXG(LM,J)	SHORE	22
	TDOUSE(J)=TDOUSE(J)+DOSE(I,J)	CHANGE1	7
	GOTO 20	CHANGE1	8
25	15 DOSE(I,J)=DOSE(I,2)	CHANGE1	9
	20 CONTINUE	CHANGE1	10
	10 CONTINUE	SHORE	24
	IF (USE.GT.1000..AND.CON.LT.10.) GO TO 50	SHORE	25
30	IF (LCT.GT.0) CALL PERDUS(TYPE, TDOUSE, DOSE)	SHORE	26
	50 CONTINUE	SHORE	27
	DO 40 J=3,8,1	SHORE	28
40	TDOUSE(J)=TDOUSE(2)	SHORE	29
	IF (CON.GT.10..AND.USE.GT.0.) CALL PLOP(DOUSE,5)	SHORE	30
	RETURN	SHORE	31
35	END	SHORE	32

1	SUBROUTINE SWIM(TYPE,DILU,T,USE,GEOM,TDOUSE)	SWIM	2
	COMMON(200),PL,CFS,NSUR,LT,RECU(200),LIST(200,4),LCT,LZ,CON,KIT	SWIM	3
	+ ,PLUP	SWIM	4
	COMMON/DFLIB/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	SWIM	5
5	+FFF(300,8)	SWIM	6
	COMMON/SORCE/IZ(300),IMASS(300),META(300),NLIBA,NLITB,NLIBC,NLIBI	SWIM	7
	DIMENSION TDOUSE(8),DOSE(200,8)	SWIM	8
	DO 8 J=1,8	SWIM	9
	8 TDOUSE(J)=0.0	SWIM	10
10	IF(USE.EQ.0.)GO TO 50	SWIM	11
	IF(DILU.EQ.0.)GO TO 50	SWIM	12
	DO 10 I=1,NSUR	SWIM	13
	LM=LIST(I,1)	SWIM	14
	M0=IZ(LM)	SWIM	15
15	ARGU=TAU(LM)*T	SWIM	16
	IF(ARGU.GT.20.)GO TO 20	SWIM	17
	FACT=1119.*4(I)*RECU(I)/CFS/DILU*EXP(-ARGU)/GEOM*USE/CON	SWIM	18
	GO TO 30	SWIM	19
	20 FACT=0.0	SWIM	20
20	30 DOSE(I,1)=EXS(LM,1)*FACT	SWIM	21
	DOSE(I,2)=EXS(LM,2)*FACT	SWIM	22
	DO 15 J=3,8	CHANGE1	11
	15 DOSE(I,J)=DOSE(I,2)	CHANGE1	12
	TDOSE(1)=TDOSE(1)+DOSE(I,1)	SWIM	23
25	10 TDOSE(2)=TDOSE(2)+DOSE(I,2)	SWIM	24
	IF(INT(GEOM).EQ.2) GO TO 50	SWIM	25
	IF(USE.GT.1000..AND.CON.LT.10.) GO TO 50	SWIM	26
	IF(LCT.GT.0) CALL PERDUS(TYPE,TDOUSE,DOSE)	SWIM	27
	IF(CON.GT.10.)CALL PLUP(DOUSE,5)	SWIM	28
30	50 CONTINUE	SWIM	29
	DO 40 J=3,8,1	SWIM	30
	40 TDOSE(J)=TDOSE(2)	SWIM	31
	RETURN	SWIM	32
	END	SWIM	33

1	SUBROUTINE CRITTR(CRITR,DILU,T,TDUSE,ACC)	CRITTR	2
	COMMON N(200),PL,CFS,NSUR,LT,PFCD(200),LIST(200,4),LCT,LZ ,LON,KIT	CRITTR	3
	+ ,POP	CRITTR	4
	COMMON/SUR(E/IZ(300),IMASS(300),META(300),NLIBA,NLIBT,NLIBC,NLIBI	CRITTR	5
5	COMMON/DFLIB/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	CRITTR	6
	+FFF(300,8)	CRITTR	7
	DIMENSION TDUSE(8),ACC(100),CRITR(3),DOSE(200,8)	CRITTR	8
	DO 8 J=1,8	CRITTR	9
	8 TDUSE(J)=0.0	CRITTR	10
10	DO 10 I=1,NSUR	CRITTR	11
	LM=LIST(I,1)	CRITTR	12
	MD=IZ(LM)	CRITTR	13
	ARGU=TAU(LM)*T	CRITTR	14
	IF (ARGU.GT.40.)GO TO 9	CRITTR	15
15	FACT=21.*N(I)*RECU(I)/CFS/DILU*EXP(-ARGU)*EFF(LM,2)	CRITTR	16
	GO TO 11	CRITTR	17
	9 FACT=0.0	CRITTR	18
	11 DOSE(I,1)=FACT*ACC(MD)	CRITTR	19
	10 TDUSE(I)=TDUSE(I)+DOSE(I,1)	CRITTR	20
20	IF (LCT.GT.0) CALL PERDOS(CRITR,TDUSE,DOSE)	CRITTR	21
	RETURN	CRITTR	22
	END	CRITTR	23

1	SUBROUTINE EAT(BIOT,RAD,MASS,CONS,DILU,T,TDUSE,ACC)	EAT	2
	COMMON Q(200),PL,CFS,NSUR,LT,RECO(200),LIST(200,4),LCT,LZ,CON,KIT	EAT	3
	+ ,POP	EAT	4
	COMMON/DFLIB/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	EAT	5
5	+FFF(300,8)	EAT	6
	COMMON/SORCE/IZ(300),IMASS(300),META(300),NLIBA,NLBT,NLBC,NLBI	EAT	7
	REAL MASS	EAT	8
	DIMENSION BIOT(4),STAN(9),ACC(100),TDUSE(8),DUSE(200,8)	EAT	9
	DATA STAN/0.,1.4,2.,3.,5.,7.,10.,20.,30./	EAT	10
10	TDUSE(1)=0.0	EAT	11
	TDUSE(2)=0.0	EAT	12
	DO 10 J=2,8	EAT	13
	IF(RAD.LE.1.4)GO TO 50	EAT	14
	JUT=J-1	EAT	15
15	PT=(STAN(JUT)+STAN(J))/2.	EAT	16
	JEB=J+1	EAT	17
	TP=(STAN(J)+STAN(JEB))/2.	EAT	18
	IF(RAD.GE.PT.AND.RAD.LT.TP)GO TO 50	EAT	19
10	CONTINUE	EAT	20
20	L=J-1	EAT	21
	DO 20 I=1,NSOR	EAT	22
	MO=LIST(I,1)	EAT	23
	MT=IZ(MO)	EAT	24
	ARGU=TAU(MO)*T	EAT	25
25	IF(ARGU.GT.40.)GO TO 9	EAT	26
	IF(EFF(MO,8).EQ.0.)GO TO 9	EAT	27
	FACT=2.HAE+07*Q(I)*RECO(I)/CFS/DILU*EXP(-ARGU)*CONS/MASS/EFF(MO,8)	EAT	28
	+*DFL(MO,5)*FFF(MO,L)	EAT	29
	GO TO B	EAT	30
30	9 FACT=0.0	EAT	31
	8 CONTINUE	EAT	32
	DOSE(I,1)=FACT*ACC(MT)	EAT	33
20	TDUSE(1)=TDUSE(1)+DOSE(I,1)	EAT	34
	IF(LCT.GT.0)CALL PERDOS(BIOT,TDUSE,DOSE)	EAT	35
35	100 CONTINUE	EAT	36
	RETURN	EAT	37
	END	EAT	38

1	SUBROUTINE PAFD(TYPE,ACC,CONC,JJ,USE,TDUSE,NN,LM)	PAFD	2
	COMMON/SOURCE/IZ(300),IMASS(300),META(300),NLIBA,NLINT,NLIHC,NLIHT	PAFD	3
	COMMON Q(200),PL,CFS,NSUR,LT,RECU(200),LIST(200,4),LCT,LZ,CON,KIT	PAFD	4
	+ ,PIP	PAFD	5
5	COMMON/DFLTH/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	PAFD	6
	+EFF(300,8)	PAFD	7
	DIMENSION TYPE(3),ACC(100),CONC(200)	PAFD	8
	DIMENSION DOSE(200,8),TDUSE(8)	PAFD	9
	DO 50 KJ=1,NSUR	PAFD	10
10	ML=LIST(KJ,1)	PAFD	11
	LL=LIST(KJ,JJ)	PAFD	12
	MU=IZ(ML)	PAFD	13
	FACT=CONC(KJ)*ACC(MU)/CON*1100.	PAFD	14
	DO 60 J=1,7	PAFD	15
15	IF(KJ.EQ.1)TDUSE(J)=0.	PAFD	16
	DOSE(KJ,J)=FACT*DFL(LL,J)*USE	PAFD	17
60	TDUSE(J)=TDUSE(J)+DOSE(KJ,J)	PAFD	18
50	CONTINUE	PAFD	19
	IF(LM.EQ.0.AND.NN.EQ.1)CALL PLOP(DOSE,6)	PAFD	20
20	IF(LM.EQ.0.AND.NN.EQ.2)CALL PLOP(DOSE,6)	PAFD	21
	IF(LCT.GT.0)CALL PERDUS(TYPE,TDUSE,DOSE)	PAFD	22
	RETURN	PAFD	23
	END	PAFD	24

1	SUBROUTINE CEN(T,CATH,DILU,J,CONC,AMT,HARV,N)	CENT	2
	COMMON Q(200),PL,CFS,NSUR,LT,RECO(200),LIST(200,4),LCT,LZ ,CON,KIT	CENT	3
	+ ,POP	CENT	4
	COMMON/SORCE/IZ(300),IMASS(300),META(300),NLIBA,NLJBT,NLIBC,NLIHI	CENT	5
5	COMMON/DFLIH/DFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	CENT	6
	+EFF(300,8)	CENT	7
	DIMENSION CATH(20),DILU(20),T(20),CONC(200)	CENT	8
	DO 20 K=1,J	CENT	9
	DO 40 KK=1,NSUR	CENT	10
10	IF(K.EQ.1)CONC(KK)=0.0	CENT	11
	LM=LIST(KK,1)	CENT	12
	MU=IZ(LM)	CENT	13
	ARGU=TAU(LM)*T(K)	CENT	14
	IF(ARGU.GT.20.)GO TO 40	CENT	15
15	IF(N.EQ.2) CONC(KK)=CONC(KK)+CATH(K)*Q(KK)*RECO(KK)/CFS/DILU(K)*	CENT	16
	+EXP(-ARGU)/HARV	CENT	17
	IF(N.EQ.1)CONC(KK)=CONC(KK)+CATH(K)*Q(KK)*RECO(KK)/CFS/DILU(K)*EXP	CENT	18
	+(-ARGU)/AMT	CENT	19
40	CONTINUE	CENT	20
20	CONTINUE	CENT	21
	RETURN	CENT	22
	END	CENT	23

1	SUBROUTINE TRTIUM(CIYR,P,H3B,H3T)	TRTIUM	2
	COMMON Q(200),PL,CFS,NSUR,LT,RFCO(200),LIST(200,4),LCT,LZ ,CON,KIT	TRTIUM	3
	+ ,PIJP	TRTIUM	4
	COMMON/POPUL/PERA,PERT,PERC,US	TRTIUM	5
5	COMMON/DFLIB/UFL(300,7),DFA(300,7),EXG(300,2),TAU(300),EXS(300,2),	TRTIUM	6
	+FFF(300,8)	TRTIUM	7
	DATA HYDRU/2.7E+19/	TRTIUM	8
	DATA CONSUM/800./	TRTIUM	9
	ARGU=TAU(1)*PL*8760.	TRTIUM	10
10	IF(ARGU.GT.40.)ARGU=40.	TRTIUM	11
	H3CON=CIYR*1.0E+12*(1.-EXP(-ARGU))/(TAU(1)*8760.*HYDRU)	TRTIUM	12
	H3B=H3CON*CONSUM*DFL(1,3)/CON*US	TRTIUM	13
	H3T=H3CON*CONSUM*DFL(1,4)/CON*US	TRTIUM	14
	RETURN	TRTIUM	15
15	END	TRTIUM	16

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1      SUBROUTINE FLOOD
      CUMIN D(200),PL,CFS,NSUR,LI,RECIN(200),LIST(200,4),LCT,LZ ,CON,KIT
      + ,POP
      COMMON/POPUL/PERA,PERT,PFRC,US
5      PEAL IRRIG
      DIMENSION TYPE(3),A(3),B(3),C(3),TDOSE(8)
      DIMENSION D(3),VEG(3),LV(3),MLK(3),MET(3),AALD(7),AAND(7),TALD(7),
      +TAND(7),CALD(7),CAND(7)
10     DIMENSION DILU(20),T(20),PROD(20),CONC(200)
      DIMENSION GUND(7),BAD(7)
      DATA D/'TOTA','L ','/'
      DATA TYPE/'IRRI','FOO','D '/'
      DATA VEG/'VEGE','TATI','ON '/'
      DATA LV/'LEAF','Y VE','GE '/'
15     DATA MLK/'MILK',' ','/'
      DATA MET/'MEAT',' ','/'
      DATA A/'ADUL','T ','/'
      DATA B/'TEEN','AGER','/'
      DATA C/'CHIL','D ','/'
20     10 FORMAT(1H1,35X,'* * * IRRIGATED FOOD PATHWAY * * *')
      40 FORMAT(1H0,22X,'BONE LIVER TOTAL BODY THYROID
      L KIDNEY LUNG GI=LLI')
      41 FORMAT(1H0,19X,'-----INDIVIDUAL
      + DOSES(MREM PER YEAR INTAKE)-----')
25     42 FORMAT(1H0,16X,'-----POPULATION DOSES(MAN-REM)-----
      +-----')
      43 FORMAT(1H0,15X,'NOTE= INDIVIDUAL DOSES CALCULATED WITH DILUTION=',
      +1PE8.2,' AND TRANSIT TIME=',F8.2,' HRS. ')
30     50 FORMAT(2I10,6E10.0)
      60 FORMAT(1H ,3A4,1P7E15.2)
      80 FORMAT(8E10.2)
      84 FORMAT(17X,1P5E10.2)
      85 FORMAT(1H0,'INDEX FOR FOOD PATHWAY DOES NOT EXIST')
      90 FORMAT(1H0,'$ $ $ ALARA DOSES $ $ $')
35     91 FORMAT(1H0,'* * * NEPA DOSES * * *')
      96 FORMAT(1H0,3A4,5X,'IRRIGATION RATE=',1PE8.2,' L/M**2/MON',5X,'YIEL
      +D=',1PE8.2,' KG/M**2',5X,'GROWING PERIOD=',E8.2,' DAYS',/,17X,
      + 'TOTAL SO MILE GROW=',E8.2,' KG/YR',5X,'TOTAL CROP IRRIGATION=',E8
      +.2,/,17X,' DILUTION HARVEST TRANSIT TIME')
40     97 FORMAT(1H0,'INDIVIDUAL CONSUMPTION RATES ADULT=',1PE8.2,' KG',
      +5X,'TEEN=',E8.2,5X,'CHILD=',E8.2,5X,'FOOD PROCESS TIME=',E8.2,' HR
      +')
      98 FORMAT(1H , 'POPULATION CONSUMPTION RATES ADULT=',1PE8.2,' KG',
      +5X,'TEEN=',E8.2,5X,'CHILD=',E8.2,5X,'FOOD PROCESS TIME=',E8.2,' HR
      +')
45     100 READ 50,N,KZ,IRRIG,YIELD,GROW,TFMG
      TTIG=0.0
      IF(N.EQ.0) GO TO 200
      IF(KZ.GT.0)READ 80,ACUN,TCUN,CCUN,AC,TC,CC,HOLD,MLD1
50     J=1
      104 READ 80,DILU(J),PROD(J),T(J)
      M=J+1
      IF(DILU(J).EQ.0.) GO TO 105
      J=J+1
      GO TO 104
55     105 CONTINUE
      JM=T(1)
      FLOOD
  
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        DL=DILU(1)
        DO 107 J=1,M
60      IF(DILU(J).LT.DL) DL=DILU(J)
        107 IF(DILU(J).LT.DL) TM=T(J)
           PRINT 10
           DO 106 J=1,M
65      TTIG=TTIG+PRND(J)
           IF(K7.(GT.0))GO TO 160
           GO TO (120,130,140,150),N
           PRINT 85
           RETURN
        120 AC=190.
           TC=240.
           CC=200.
           ACIN=520.
           TCIN=630.
           CCIN=520.
75      HLD1=1440.
           HOLD=340.
           GO TO 160
        130 AC=30.
           TC=20.
           CC=10.
           ACIN=64.
           TCIN=42.
           CCIN=26.
80      HOLD=50.
           HLD1=24.
           GO TO 160
        140 AC=110.
           TC=200.
           CC=170.
           ACIN=310.
           TCIN=400.
           CCIN=330.
           HOLD=96.
           HLD1=48.
90      GO TO 160
        150 AC=95.
           TC=59.
           CC=37.
           ACIN=110.
           TCIN=65.
           CCIN=41.
           HOLD=480.
           HLD1=480.
95      GO TO 160
        160 CONTINUE
105      IF(N.EQ.1) PRINT 60,VEG
           IF(N.EQ.2) PRINT 60,LV
           IF(N.EQ.3) PRINT 60,MLK
           IF(N.EQ.4) PRINT 60,MET
           IF(N.GT.4) PRINT 85
110      P=TFMG/(AC*PERA+TC*PERT+CC*PERC)
           TP=TTIG/(AC*PERA+TC*PERT+CC*PERC)
           IF(P.GT.PUP)P=PUP
           KIT=0
           LZ=0
    
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        FLOOD 59
        FLOOD 60
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        FLOOD 114
        FLOOD 115
    
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115	CALL CENT(T,PRID,DILU,M,CONC,AMT,TFMG,2)	FLOOD	116
	CALL FLOD(TYPE,CONC,HOLD,HLD1,ACUN,IRRIG,YIELD,GROW,TFMG,TTIG,TP	FLOOD	117
	+,AC,TDUSE,AALD,AAND,N,1,P,TH,DL)	FLOOD	118
	PRINT 41	FLOOD	119
	PRINT 40	FLOOD	120
120	PRINT 60,A,(TDUSE(J),J=1,7)	FLOOD	121
	CALL FLOD(TYPE,CONC,HOLD,HLD1,TCUN,IRRIG,YIELD,GROW,TFMG,TTIG,TP	FLOOD	122
	+,TC,TDUSE,TALD,TAND,N,2,P,TH,DL)	FLOOD	123
	PRINT 60,H,(TDUSE(J),J=1,7)	FLOOD	124
	CALL FLOD(TYPE,CONC,HOLD,HLD1,CCUN,IRRIG,YIELD,GROW,TFMG,TTIG,TP	FLOOD	125
125	+,CC,TDUSE,CALD,CAND,N,3,P,TH,DL)	FLOOD	126
	PRINT 60,L,(TDUSE(J),J=1,7)	FLOOD	127
	PRINT 43,DL,TH	FLOOD	128
	PRINT 42	FLOOD	129
	PRINT 91	FLOOD	130
130	PRINT 40	FLOOD	131
	PRINT 60,A,(AAND(JM),JM=1,7)	FLOOD	132
	PRINT 60,H,(TAND(JM),JM=1,7)	FLOOD	133
	PRINT 60,C,(CAND(JM),JM=1,7)	FLOOD	134
	DO 165 JM=1,7	FLOOD	135
135	165 GUUD(JM)=AAND(JM)+TAND(JM)+CAND(JM)	FLOOD	136
	PRINT 60,U,(GUUD(JM),JM=1,7)	FLOOD	137
	PRINT 90	FLOOD	138
	PRINT 40	FLOOD	139
	PRINT 60,A,(AALD(JM),JM=1,7)	FLOOD	140
140	PRINT 60,B,(TALD(JM),JM=1,7)	FLOOD	141
	PRINT 60,C,(CALD(JM),JM=1,7)	FLOOD	142
	DO 166 JM=1,7	FLOOD	143
	166 BAD(JM)=AALD(JM)+TALD(JM)+CALD(JM)	FLOOD	144
	PRINT 60,D,(BAD(JM),JM=1,7)	FLOOD	145
145	PRINT 96,TYPE,IRRIG,YIELD,GROW,TFMG,TTIG	FLOOD	146
	DO 170 J=1,M	FLOOD	147
	170 PRINT 84,DILU(J),PRID(J),T(J)	FLOOD	148
	PRINT 97,ACUN,TCUN,CCUN,HLD1	FLOOD	149
	PRINT 98,AC,TC,CC,HOLD	FLOOD	150
150	KIT=30	FLOOD	151
	IF(LCT.GT.0) CALL PERDUS(TYPE,TDUSE,DUSE)	FLOOD	152
	GO TO 100	FLOOD	153
	200 CONTINUE	FLOOD	154
	RETURN	FLOOD	155
155	END	FLOOD	156

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CARD NR.	SEVERITY	DETAILS	DIAGNOSIS OF PROBLEM
67	I		THERE IS NO PATH TO THIS STATEMENT.

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1      SUBROUTINE F100(TYPE, CONC, HOLD, HLD1, CUNSUM, IRRIG, YFLD, GRDW,      F100      2
+TIMG, TTIG, TP, C, THISE, ALD, AND, N, JJ, P, TM, DL)      F100      3
  COMMON N(200), PL, CFS, NSUR, LT, RFCN(200), LIST(200,4), LCT, LZ, CUN, KIT      F100      4
+ , PIP      F100      5
5      COMMON/PIPPUL/PEHA, PERT, PERC, IIS      F100      6
  COMMON/DFLIR/DFL(300,7), DFA(300,7), EXG(300,2), TAU(300), EXS(300,2),      F100      7
+EFF(300,8)      F100      8
  COMMON/SURCE/IZ(300), IMASS(300), META(300), NLIHA, NLIHT, NLIHC, NLIHI      F100      9
  REAL IRRIG      F100     10
10     DIMENSION ALD(7), AND(7), TYPE(3), THISE(8), DUSE(200,8), POHL(200,8)      F100     11
  DIMENSION CUNL(200)      F100     12
  DIMENSION SUIL(100), ZMET(100), ZMLK(100)      F100     13
  DATA Q1, Q2, Q3, Q4/50., 60., 50., 50./      F100     14
  DATA FRAC/0.25/      F100     15
15     DATA ZMET/
+2.1E-02, 2.0E-02, 1.0E-02, 1.0E-03, 8.0E-04, 5.1E-02, 7.7E-02, 1.6E-02,      F100     17
+1.5E-01, 2.0E-02, 3.0E-02, 5.0E-03, 1.5E-03, 4.0E-05, 4.6E-02, 1.0E-01,      F100     18
+8.0E-02, 2.0E-02, 1.2E-02, 4.0E-03, 1.6E-02, 5.1E-02, 2.3E-03, 2.4E-03,      F100     19
+8.0E-04, 4.0E-02, 1.3E-02, 5.3E-03, 8.0E-03, 8.0E-03, 5.0E-02, 1.3E-00, 2.0E-01,      F100     20
+2.0E-03, 1.5E-02, 2.6E-02, 2.0E-02, 3.1E-02, 6.0E-04, 4.6E-03, 3.4E-02,      F100     21
+2.8E-01, 8.0E-03, 4.0E-01, 4.0E-01, 1.5E-03, 4.0E-03, 1.7E-02, 5.3E-04,      F100     22
+8.0E-03, 8.0E-02, 4.0E-03, 7.7E-02, 2.9E-03, 2.0E-02, 4.0E-03, 3.2E-03,      F100     23
+2.0E-04, 1.2E-03, 4.7E-03, 3.3E-03, 4.8E-03, 5.1E-03, 4.8E-03, 3.6E-03,      F100     24
+4.4E-03, 5.3E-03, 4.4E-03, 4.0E-03, 4.4E-03, 4.0E-03, 4.4E-03, 4.0E-01,      F100     25
25     +1.6E-00, 1.3E-03, 8.0E-03, 4.0E-01, 1.5E-03, 4.0E-03, 8.0E-03, 2.6E-01,      F100     26
+4.0E-02, 2.9E-04, 1.3E-02, 1.2E-02, 8.0E-00, 2.0E-02, 2.0E-02, 3.4E-02,      F100     27
+6.0E-02, 2.0E-04, 8.0E-02, 3.4E-04, 2.0E-04, 1.4E-05, 2.0E-04, 2.0E-04,      F100     28
+2.0E-04, 2.0E-04, 2.0E-04, 2.0E-04/      F100     29
  DATA SUIL/      F100     30
30     14.8      , 5.0E-02, 8.3E-04, 4.2E-04, 1.2E-01, 5.5      , 7.5      , 1.6      ,
26.5E-04, 1.4E-01, 5.2E-02, 1.3E-01, 1.8E-04, 1.5E-04, 1.1E+00, 5.9E-01,      F100     32
35.0E+00, 6.0E-01, 3.7E-01, 3.6E-02, 1.1E-03, 5.4E-05, 1.3E-03, 2.5E-04,      F100     33
42.9E-02, 6.6E-04, 9.4E-03, 1.9E-02, 1.2E-01, 4.0E-01, 2.5E-04, 1.0E-01,      F100     34
51.0E-02, 1.3E-00, 7.6E-01, 3.0E-00, 1.3E-01, 1.7E-02, 2.6E-03, 1.7E-04,      F100     35
69.4E-03, 1.2E-01, 2.5E-01, 5.0E-02, 1.3E+01, 5.0E+00, 1.5E-01, 3.0E-01,      F100     36
72.5E-01, 2.5E-03, 1.1E-02, 1.3E-00, 2.0E-02, 1.0E+01, 1.0E-02, 5.0E-03,      F100     37
82.5E-03, 2.5E-03, 2.5E-03, 2.4E-03, 2.5E-03, 2.5E-03, 2.5E-03, 2.5E-03,      F100     38
92.6E-03, 2.5E-03, 2.6E-03, 2.5E-03, 2.6E-03, 2.5E-03, 2.6E-03, 1.7E-04,      F100     39
A6.3E-03, 1.8E-02, 2.5E-01, 5.0E-02, 1.3E+01, 5.0E-01, 2.5E-03, 3.8E-01,      F100     40
B2.9E-01, 6.8E-02, 1.5E-01, 1.5E-01, 2.5E-01, 3.5E-00, 1.0E-02, 3.1E-04,      F100     41
C2.5E-03, 4.2E-03, 2.5E-03, 2.5E-03, 2.5E-03, 2.5E-04, 2.5E-04, 2.5E-03,      F100     42
D2.5E-03, 2.5E-03, 2.5E-03, 2.5E-03/      F100     43
  DATA ZMLK/      F100     44
45     +1.3E-02, 2.0E-02, 4.0E-02, 1.0E-04, 2.7E-03, 1.2E-02, 2.2E-02, 2.0E-02,      F100     45
+1.4E-02, 2.0E-02, 4.0E-02, 1.0E-02, 5.0E-04, 1.0E-04, 2.5E-02, 1.4E-02,      F100     46
+5.0E-02, 2.0E-02, 1.0E-02, 8.0E-03, 5.0E-06, 5.0E-06, 1.0E-03, 2.2E-03,      F100     47
+2.5E-04, 1.2E-03, 1.0E-03, 6.7E-03, 1.4E-02, 3.9E-02, 5.0E-05, 5.1E-04,      F100     48
+6.0E-03, 4.5E-02, 5.0E-02, 2.0E-02, 3.0E-02, 8.0E-04, 1.0E-05, 5.0E-06,      F100     49
+2.5E-03, 7.5E-03, 2.5E-02, 1.0E-06, 1.0E-02, 1.0E-02, 5.0E-02, 1.2E-04,      F100     50
+1.0E-04, 2.5E-03, 1.5E-03, 1.0E-03, 6.0E-03, 2.0E-02, 1.2E-02, 4.0E-04,      F100     51
+5.0E-06, 6.0E-04, 5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06,      F100     52
+5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06,      F100     53
+2.5E-02, 5.0E-04, 2.5E-02, 5.0E-03, 5.0E-03, 5.0E-03, 5.0E-03, 3.8E-02,      F100     54
+2.2E-02, 6.2E-04, 5.0E-04, 3.0E-04, 5.0E-02, 2.0E-02, 5.0E-02, 8.0E-03,      F100     55
+5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06, 2.0E-06, 5.0E-06, 5.0E-06,      F100     56
+5.0E-06, 5.0E-06, 5.0E-06, 5.0E-06/      F100     57
  IF (JJ.EQ.1) TERM=PEHA      F100     58

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	IF (JJ.EQ.3) TERM=PERC	FOOD	59
	IF (JJ.EQ.2) TERM=PERT	FOOD	60
60	DO 8 J=1,8	FOOD	61
	8 TDOSE(J)=0.0	FOOD	62
	IF (N.EQ.0) GO TO 50	FOOD	63
	TRANS=1.	FOOD	64
	DO 10 I=1,NSOR	FOOD	65
65	ML=LIST(1,1)	FOOD	66
	MT=1Z(MI)	FOOD	67
	LL=LIST(1, JJ)	FOOD	68
	CNC1=0.0	FOOD	69
	ARGU=TAU(MI)*TM	FOOD	70
70	IF (ARGU.GT.20.) GO TO 25	FOOD	71
	CNC1=C(J)*PECO(I)/CFS/DL*EXP(-ARGU)*1100.	FOOD	72
25	CONTINUE	FOOD	73
	IF (JJ.EQ.1) CNC(I)=CNC(I)*1100.	FOOD	74
	DECAY=0.693/14.+24.*TAU(MU)	FOOD	75
75	ARGU=DF(AY*GRUW	FOOD	76
	IF (ARGU.GT.20.) ARGU=20.	FOOD	77
	LEAF=FRAC*TRANS/YIELD*(1.-EXP(-ARGU))/(DECAY*30.)	FOOD	78
	ARG1=TAU(MI)*PL*H766.	FOOD	79
	IF (ARG1.GT.20.) ARG1=20.	FOOD	80
80	ROOT=SUJL(MT)*(1.-EXP(-ARG1))/(TAU(MU)*240.*730.)	FOOD	81
	PCUN=CUNC(I)*IRRIG*(LEAF+ROOT)	FOOD	82
	PCN1=CNC1*IRRIG*(LEAF+ROOT)	FOOD	83
	IF (MI.EQ.1) PCUN=CUNC(I)	FOOD	84
	IF (MI.EQ.1) PCN1=CNC1	FOOD	85
85	ARGU=TAU(MU)*HOLD	FOOD	86
	ARG1=TAU(MU)*HLD1	FOOD	87
	IF (ARGU.GT.60.) ARGU=60.	FOOD	88
	IF (ARG1.GT.60.) ARG1=60.	FOOD	89
	IF (N.GT.2) GO TO 30	FOOD	90
90	FCN1=PCN1*EXP(-ARG1)	FOOD	91
	FCUN=PCN1*EXP(-ARGU)	FOOD	92
	GO TO 40	FOOD	93
30	IF (N.EQ.3) FCUN=(U1*PCUN+Q2*CUNC(I))*ZMLK(MT)*EXP(-ARGU)	FOOD	94
	IF (N.EQ.3) FCN1=(Q1*PCN1+Q2*CNC1)*ZMLK(MT)*EXP(-ARG1)	FOOD	95
95	IF (N.EQ.4) FCUN=(U3*PCUN+Q4*CUNC(I))*ZMET(MT)*EXP(-ARGU)	FOOD	96
	IF (N.EQ.4) FCN1=(N3*PCN1+Q4*CNC1)*ZMET(MT)*EXP(-ARG1)	FOOD	97
	IF (N.EQ.3.AND.MU.EQ.1) FCUN=(0.0028*CUNC(I)/0.28)*(38.+60.)	FOOD	98
	IF (N.EQ.3.AND.MU.EQ.1) FCN1=(0.0028*CNC1/0.28)*(38.+60.)	FOOD	99
	IF (N.EQ.4.AND.MU.EQ.1) FCUN=(0.0041*CUNC(I)/0.52)*(28.+50.)	FOOD	100
100	IF (N.EQ.4.AND.MU.EQ.1) FCN1=(0.0041*CNC1/0.52)*(28.+50.)	FOOD	101
	GO TO 40	FOOD	102
	C	FOOD	103
40	DO 60 J=1,7	FOOD	104
	IF (I.EQ.1) ALD(J)=0.	FOOD	105
105	IF (I.EQ.1) AND(J)=0.	FOOD	106
	DOSE(I, J)=DFL(LL, J)*FCN1*CONSUM	FOOD	107
	FACT=TERM*PAC	FOOD	108
	FCT1=TERM*TP*G	FOOD	109
	PDUL(1, J)=DFL(LL, J)*FCUN*FACT/1000.	FOOD	110
110	PUL1=DFL(LL, J)*FCUN*FCT1*TFMG/TTIG/1000.	FOOD	111
	ALD(J)=ALD(J)+PDUL(1, J)	FOOD	112
	AND(J)=AND(J)+PUL1	FOOD	113
60	TDOSE(J)=TDOSE(J)+DOSE(I, J)	FOOD	114
10	CONTINUE	FOOD	115

115

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CALL PL(IP(PDIL,6)
IF(LCT.GT.0)CALL PERDUS(TYPE,TDUSE,DISE)
50 CONTINUE
RETURN
END
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FOOD 116
FOOD 117
FOOD 118
FOOD 119
FOOD 120
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1      SUBROUTINE PERDUS(SPECIE,TDISE,DIUSE)
COMMON D(200),PL,CFS,NSUR,LT,RECO(200),LIST(200,4),LCT,LZ ,CUN,KIT
+ ,PIP
COMMON/ELEMN/IELEM(100)
5      COMMON/SURCF/LZ(300),IMASS(300),META(300),NLIBA,NLIBT,NLIBC,NLIBI
DIMENSION SPECIE(3),TDISE(8),DIUSE(200,8),PATH(8,3),SFT(12),A1(7,8,
+20),A2(7,8,20),A3(7,8,20),ISIT(7,8,20),IMET(7,8,20),NAUS(7,8)
DIMENSION B1(7,8,20),B2(7,8,20),B3(7,8,20)
COMMON/TRANS/DILK
10     DIMENSION DUS(8,100,8)
C
DATA SET/1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H0,1H ,1HX/
10     FORMAT(1H0,'PATHWAY          SKIN          BONE          LI
+VER          TOTAL BODY          THYROID          KIDNEY          LUNG
+          GI=LLI')
15     FORMAT(1H0,'PATHWAY          BODY')
DATA BLAK/' /
110    FORMAT(1H0,'AGE GROUP          TOTAL BODY          THYROID')
115    FORMAT(1H0,'AGE GROUP          SKIN          TOTAL BODY')
20     FORMAT(1H0,'* * * ISOTOPE CONTRIBUTION * * *')
130    FORMAT(1H0,'AGE GROUP          BONE          LIVER          TOTAL
+BODY          THYROID          KIDNEY          LUNG          GI=LLI')
IF(LZ.GT.0) GO TO 50
D0 65 J=1,7
D0 66 K=1,8
06     NAUS(J,K)=1
65     CONTINUE
D0 70 J=1,7
D0 80 K=1,8
30     D0 90 I=1,20
A1(J,K,I)=BLAK
A2(J,K,I)=BLAK
A3(J,K,I)=BLAK
ISIT(J,K,I)=BLAK
35     B1(J,K,I)=BLAK
B2(J,K,I)=BLAK
B3(J,K,I)=BLAK
IMET(J,K,I)=BLAK
90     CONTINUE
40     CONTINUE
70     CONTINUE
50     IF(KIT.EQ.40) GO TO 300
IF(KIT.EQ.30)GO TO 300
IF(KIT.EQ.10)GO TO 200
45     IF(KIT.EQ.50)GO TO 300
IF(KIT.EQ.20) GO TO 300
IF(KIT.EQ.70) GO TO 200
LZ=LZ+1
PATH(LZ,1)=SPECIE(1)
50     PATH(LZ,2)=SPECIE(2)
PATH(LZ,3)=SPECIE(3)
D0 20 J=1,NSUR
D0=LIST(J,1)
D1=IZ(D0)
55     JDDU = IMASS(D0)/10
IFEN = (IMASS(D0)-IHUN*100)/10
JDDIT = IMASS(D0)-JDDU*100-IFEN*10

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PERDUS 2
PERDUS 3
PERDUS 4
PERDUS 5
PERDUS 9
PERDUS 10
PERDUS 11
PERDUS 12
CHANGE1 13
CHANGE1 14
PERDUS 15
BNL01 11
PERDUS 15
PERDUS 16
PERDUS 17
PERDUS 18
PERDUS 19
PERDUS 20
PERDUS 21
PERDUS 22
PERDUS 23
PERDUS 24
PERDUS 25
PERDUS 26
PERDUS 27
PERDUS 28
PERDUS 29
PERDUS 30
PERDUS 31
PERDUS 32
PERDUS 33
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PERDUS 36
PERDUS 37
PERDUS 38
PERDUS 39
PERDUS 40
PERDUS 41
PERDUS 42
PERDUS 43
PERDUS 44
PERDUS 45
PERDUS 46
PERDUS 47
PERDUS 48
PERDUS 49
PERDUS 50
PERDUS 51
PERDUS 52
PERDUS 53
PERDUS 54
PERDUS 55
PERDUS 56
CHANGE1 15
CHANGE1 16
CHANGE1 17

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	IF (IHUN,GT,0,AND,IIFN,EQ,0) IIFN = 10	CHANGE1	18
	IF (IHUN,EQ,0,AND,IIFN,EQ,0) IIFN = 11	CHANGE1	19
60	IF (IHUN,EQ,0) IHUN = 11	CHANGE1	20
	IF (IUNIT,EQ,0) IUNIT = 10	CHANGE1	21
	C1=SET(IHUN)	CHANGE1	22
	C2=SET(IIFN)	CHANGE1	23
	C3=SET(IUNIT)	CHANGE1	24
65	DO 30 JJ=1,8	PERDOS	57
	DOS(LZ,J,JJ)=101.94*CFS*DOSE(J,JJ)	CHANGE1	25
	L=NADS(LZ,JJ)	CHANGE1	26
	IF(L,GT,20)GOTO 30	CHANGE1	27
	IF(TDOSE(JJ),LT,1.E-10)GOTO 30	CHANGE1	28
70	PER=DOSE(J,JJ)/TDOSE(JJ)*100.	PERDOS	60
	IF(PER,LT,1.)GOTO 30	CHANGE1	29
	IIFN=INT(PER/10.)	PERDOS	62
	IUNIT=INT(PER)-IIFN*10	PERDOS	63
	IF(IIFN,EQ,0)IIFN=11	PERDOS	64
75	IF(IUNIT,EQ,0)IUNIT=10	PERDOS	65
	A1(LZ,JJ,L)=SET(IIFN)	PERDOS	66
	A2(LZ,JJ,L)=SET(IUNIT)	PERDOS	67
	A3(LZ,JJ,L)=SET(12)	PERDOS	68
	ISOT(LZ,JJ,L)=IELEM(MT)	PERDOS	69
80	H1(LZ,JJ,L)=C1	CHANGE1	30
	H2(LZ,JJ,L)=C2	CHANGE1	31
	H3(LZ,JJ,L)=C3	CHANGE1	32
	IMET(LZ,JJ,L)=META(MO)	CHANGE1	33
	NADS(LZ,JJ)=NADS(LZ,JJ)+1	PERDOS	81
85	C	CHANGE1	34
	30 CONTINUE	PERDOS	83
	20 CONTINUE	PERDOS	84
	RETURN	PERDOS	85
	C * INDIVIDUAL PERCENTAGE	PERDOS	86
90	200 CONTINUE	PERDOS	87
	210 FORMAT(1H0,3A4,8(4X,A2,1X,4A1,1X,3A1))	PERDOS	88
	220 FORMAT(1H ,12X,8(4X,A2,1X,4A1,1X,3A1))	PERDOS	89
	PRINT 120	PERDOS	90
	IF(KIT,EQ,10) PRINT 10	PERDOS	91
95	IF(KIT,EQ,70) PRINT 15	PERDOS	92
	DO 240 K=1,LZ	PERDOS	93
	LOW=NADS(K,1)	PERDOS	94
	DO 250 JS=1,8	PERDOS	95
	IF(NADS(K,JS),GT,LOW)LOW=NADS(K,JS)	PERDOS	96
100	250 CONTINUE	PERDOS	97
	IF(LOW,GT,20)LOW=20	CHANGE1	35
	PRINT 210,(PATH(K,KL),KL=1,3),(ISOT(K,J,1),B1(K,J,1),B2(K,J,1),B3(K,J,1),IMET(K,J,1),A1(K,J,1),A2(K,J,1),A3(K,J,1),J=1,8)	PERDOS	98
	+K,J,1),IMET(K,J,1),A1(K,J,1),A2(K,J,1),A3(K,J,1),J=1,8)	PERDOS	99
	DO 260 KJ=2,LOW	PERDOS	100
105	PRINT 220,(ISOT(K,J,KJ),B1(K,J,KJ),B2(K,J,KJ),B3(K,J,KJ),IMET(K,J,KJ),A1(K,J,KJ),A2(K,J,KJ),A3(K,J,KJ),J=1,8)	PERDOS	101
	+KJ),A1(K,J,KJ),A2(K,J,KJ),A3(K,J,KJ),J=1,8)	PERDOS	102
	260 CONTINUE	PERDOS	103
	240 CONTINUE	PERDOS	104
	IF(POP,GE,0.)RETURN	CHANGE1	36
110	PRINT 599	CHANGE1	37
	599 FORMAT(1H1,32X,'TABLE 4.11=2'/24X,'LIQUID EFFLUENT DOSE PARAMETERS	CHANGE1	38
	+1//37X,'A(I),MBREM/HR PER UCI/ML'/16X,'RADIUNUCLIDE',6X,'TOTAL BODY	CHANGE1	39
	+1,5X,'CRITICAL ORGAN'/)	CHANGE1	40
	DO 503 J=1,NSUB	CHANGE1	41

115	MD=LIST(J,1)	CHANGE1	42
	MT=I2(MD)	CHANGE1	43
	DUS1 = DUS(1,J,4) + DUS(2,J,4)	CHANGE1	44
	CDUS = 0.	CHANGE1	45
	DO 510 JJ=2,M	CHANGE1	46
120	DUS2 = DUS(1,J,JJ) + DUS(2,J,JJ)	CHANGE1	47
	IF(DUS2.GT.CDUS) CDUS = DUS2	CHANGE1	48
510	CONTINUE	CHANGE1	49
	PRINT 505,JELEM(MT),JMASS(MD),META(MD),DUS1,CDUS	CHANGE1	50
505	FORMAT(1H ,1HX,A2,14,A1,9X,1PER.2,9X,F8.2)	CHANGE1	51
125	503 CONTINUE	CHANGE1	52
	PRINT 506	CHANGE1	53
506	FORMAT(//////////)	CHANGE1	54
	PRINT 507,(PATH(2,KL), KL=1,3),DILW	CHANGE1	55
507	FORMAT(2X,3A4,' DILUTION IN ADDITION TO THAT FOR FISH=',F5.1)	CHANGE1	56
130	STOP	CHANGE1	57
	C * * IRRIGATED FIELDS AND PUD.	PERDUS	100
320	FORMAT(1H ,12X,2(4X,A2,1X,4A1,1X,3A1))	PERDUS	107
300	CONTINUE	PERDUS	108
510	FORMAT(1H ,12X,7(4X,A2,1X,4A1,1X,3A1))	PERDUS	109
135	580 FORMAT(1H0,'ADULT')	PERDUS	110
590	FORMAT(1H0,'TEENAGER')	PERDUS	111
595	FORMAT(1H0,'CHILD')	PERDUS	112
	PRINT 120	PERDUS	113
	IF(KIT.EQ,20) PRINT 130	PERDUS	114
140	IF(KIT.EQ,50) PRINT 110	PERDUS	115
	IF(KIT.EQ,30)PRINT 130	PERDUS	116
	IF(KIT.EQ,40) PRINT 115	PERDUS	117
	DO 340 K=1,LZ	PERDUS	118
	IF(K.EQ,1)PRINT 380	PERDUS	119
145	IF(K.EQ,2)PRINT 390	PERDUS	120
	IF(K.EQ,3) PRINT 395	PERDUS	121
	LW=NADS(K,1)	PERDUS	122
	DO 350 JS=1,7	PERDUS	123
	IF(NADS(K,JS).GT.LW)LW=NADS(K,JS)	PERDUS	124
150	350 CONTINUE	PERDUS	125
	IF(LW.GT,20)LW=20	CHANGE1	58
	DO 360 KJ=1,LW	PERDUS	126
	IF(KIT.EQ,30) PRINT 310,(ISOT(K,J,KJ),B1(K,J,KJ),B2(K,J,KJ),B3(K,J	PERDUS	127
	+ ,KJ),IMET(K,J,KJ),A1(K,J,KJ),A2(K,J,KJ),A3(K,J,KJ),J=1,7)	PERDUS	128
155	IF(KIT.EQ,20) PRINT 310,(ISOT(K,J,KJ),B1(K,J,KJ),B2(K,J,KJ),B3(K,J	PERDUS	129
	+ ,KJ),IMET(K,J,KJ),A1(K,J,KJ),A2(K,J,KJ),A3(K,J,KJ),J=2,8)	PERDUS	130
	IF(KIT.EQ,50)PRINT 320,(ISOT(K,J,KJ),B1(K,J,KJ),B2(K,J,KJ),B3(K,J	PERDUS	131
	+ ,KJ),IMET(K,J,KJ),A1(K,J,KJ),A2(K,J,KJ),A3(K,J,KJ),J=3,4)	PERDUS	132
	IF(KIT.EQ,40) PRINT 320,(ISOT(K,J,KJ),B1(K,J,KJ),B2(K,J,KJ),B3(K,J	PERDUS	133
160	+ ,KJ),IMET(K,J,KJ),A1(K,J,KJ),A2(K,J,KJ),A3(K,J,KJ),J=1,2)	PERDUS	134
360	CONTINUE	PERDUS	135
340	CONTINUE	PERDUS	136
	RETURN	PERDUS	137
	END	PERDUS	138

1	SUBROUTINE PLOP(DOSE,N)	PLOP	2
	INTEGER IELEM	PLOP	3
	LOGICAL META	PLOP	4
	COMMON/SOURCE/IZ(300),IMASS(300),META(300),NLIHA,NLIHT,NLIHC,NLIHT	PLOP	5
5	COMMON/ELEMENT/ELEM(100)	PLOP	6
	COMMON Q(200),PL,CFS,NSUR,LY,RECO(200),LIST(200,4),LCT,LZ ,CON,KIT	PLOP	7
	+ ,POP	PLOP	8
	DIMENSION DOSE(200,8),CUBEAD(200,8)	PLOP	9
10	10 FORMAT(1H1,20X,'* * * COST-BENEFIT ANALYSIS * * *')	PLOP	10
10	11 FORMAT(1H0,' NUCLIDE RELEASE MAN-REM DOSE ')	PLOP	11
	+ '____MAN-REM PER CURIE____')	PLOP	12
	12 FORMAT(1H ,13X,'1 CI/YR I TOTAL BODY I THYROID I TOTAL BOD	BNL01	12
	+Y I THYROID I')	BNL01	13
	13 FORMAT(1H ,14,A2,14,A1,' I ',1PE8.2,' I ',E8.2,' I ',E8.2,	BNL01	14
15	+ ' I ',E8.2,' I ',E8.2,' I')	BNL01	15
	14 FORMAT(1H0,' TOTAL',20X,1PER,2,5X,E8.2)	PLOP	17
	IF(N,EQ,6,OR,N,EQ,7)GO TO 15	PLOP	18
	IF(N,EQ,5)GO TO 20	PLOP	19
	IF(N,EQ,3) GO TO 100	PLOP	20
20	IF(N,EQ,4) GO TO 50	PLOP	21
	15 DO 30 J=1,NSUR	PLOP	22
	CUBEAD(J,1)=CUBEAD(J,1)+DOSE(J,N=3)	PLOP	23
	CUBEAD(J,2)=CUBEAD(J,2)+DOSE(J,N=2)	PLOP	24
	30 CONTINUE	PLOP	25
25	RETURN	PLOP	26
	20 DO 40 J=1,NSUR	PLOP	27
	CUBEAD(J,1)=CUBEAD(J,1)+DOSE(J,2)	PLOP	28
	CUBEAD(J,2)=CUBEAD(J,2)+DOSE(J,2)	PLOP	29
	40 CONTINUE	PLOP	30
30	RETURN	PLOP	31
	50 DO 60 J=1,200	PLOP	32
	CUBEAD(J,1)=0.	PLOP	33
	CUBEAD(J,2)=0.	PLOP	34
	60 CONTINUE	PLOP	35
35	TUR=0.0	PLOP	36
	TOT=0.0	PLOP	37
	RETURN	PLOP	38
	100 PRINT 10	PLOP	39
	PRINT 11	PLOP	40
40	PRINT 12	PLOP	41
	DO 110 J=1,NSUR	PLOP	42
	LL=LIST(J,1)	PLOP	43
	IK=IZ(LL)	PLOP	44
	CIR=CUBEAD(J,1)/Q(J)	PLOP	45
45	CIT=CUBEAD(J,2)/Q(J)	PLOP	46
	PRINT 13,IK,IELEM(IK),IMASS(LL),META(LL),Q(J),CUBEAD(J,1),CUBEAD(J	PLOP	47
	+,2),CIR,CIT	PLOP	48
	TUR=TUR+CUBEAD(J,1)	PLOP	49
	TOT=TOT+CUBEAD(J,2)	PLOP	50
50	110 CONTINUE	PLOP	51
	PRINT 14,TOT,TOT	PLOP	52
	RETURN	PLOP	53
	END	PLOP	54

PROGRAM WILL BE ENTERED AT LADTAP (340)

SCM LENGTH 156366 LCM LENGTH 0

BLOCK	ADDRESS	LENGTH
/ELEMEN/	100	144
/PIPOL/	244	4
HLKDAT	250	0
LADTAP	250	1623
/SOURCE/	2073	1610
/DFLIR/	3703	17644
REDF	23547	1306
SOURCE	25055	724
RECIN	26001	244
ALARA	26245	1000
OUT	27245	3714
WMO	33161	626
WHY	34007	4516
WATER	40525	637
ACTIVE	41364	513
AQUA	42077	3242
/TRANS/	45341	1
DRINK	45342	3252
SHORE	50614	3311
SWIM	54125	3266
CRITTR	57413	3213
EAT	62626	3264
PAFU	66112	3240
CENT	71352	121
TRIUM	71473	40
FLUID	71533	1743
FOOD	73476	7410
PERDUS	103106	40467
PLIP	143575	3333
/FCL.C./	147130	23
/NR.ID./	147153	134
OUNTRY#	147307	1
COMID#	147310	44
FIF	147354	20
FECMSK#	147374	41
FLTIN#	147435	154
FLTOUT#	147611	314
FMTAP#	150125	372
FORSYS#	150517	556
FIRUTL#	151275	16
GETFIT#	151313	43
INCOM#	151356	257
INPC#	151635	173
KNOER#	152030	467
KWAKER#	152517	454
OUTC#	153173	171
OUTCOM#	153364	203
GUTJER#	153567	14
ALUG	153603	77
EXP	153702	100
SYSID#	154002	1
SYS#1ST	154003	62

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S C U P E 2 L O A D M A P

LOADER VFRSION 1.0 10/18/78 15.17.49 PAGE 2

XTUI■	154065	10
//	154075	2271

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LAD TEST DECK FOR LIQUID EFFLUENT T/S IN FRESH WATER

DISCHARGE=2.00E+01 CFS

SOURCE TERM MULTIPLIER=1.00E+00

FRESHWATER SITE
TECH SPEC NUCLIDES

NO RECONCENTRATION OF NUCLIDES

* * * ADULT DOSE FACTORS * * *

NUCLIDE	CURIE/YEAR	INGESTION DOSE FACTORS (MREM/PCI INTAKE)							SHORELINE (MREM/HR)/(PCI/1**2)			RFCON
		BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LI	SKIN	TOTAL BODY		
1H	3	1.00E+00	0.	1.34E-07	1.34E-07	1.34E-07	1.34E-07	1.34E-07	1.34E-07	0.	0.	1.00E+00
15F	32	1.00E+00	1.93E-04	1.21E-05	7.47E-06	0.	0.	0.	2.17E-05	0.	0.	1.00E+00
24CR	51	1.00E+00	0.	0.	2.66E-09	1.59E-09	5.87E-10	3.53E-09	6.69E-07	2.00E-10	2.20E-10	1.00E+00
251N	54	1.00E+00	0.	4.57E-06	4.73E-07	0.	1.36E-06	0.	1.40E-05	6.80E-09	5.80E-09	1.00E+00
26F	55	1.00E+00	6.20E-06	2.79E-05	7.33E-06	0.	0.	3.23E-05	1.09E-05	0.	0.	1.00E+00
26FE	59	1.00E+00	4.34E-06	1.03E-05	3.92E-06	0.	0.	2.86E-06	3.40E-05	9.40E-09	8.00E-09	1.00E+00
270	58	1.00E+00	0.	7.46E-07	1.67E-06	0.	0.	0.	1.51E-05	8.20E-09	7.00E-09	1.00E+00
270	60	1.00E+00	0.	2.15E-06	4.72E-06	0.	0.	0.	4.02E-05	2.00E-08	1.70E-08	1.00E+00
30ZN	65	1.00E+00	4.85E-06	1.54E-05	6.97E-06	0.	1.03E-05	0.	9.70E-06	4.60E-09	4.00E-09	1.00E+00
30ZN	69M	1.00E+00	1.70E-07	4.09E-07	3.73E-08	0.	2.48E-07	0.	2.49E-05	3.40E-09	2.90E-09	1.00E+00
37KH	86	1.00E+00	0.	2.11E-05	9.84E-06	0.	0.	?	4.16E-06	7.20E-10	6.30E-10	1.00E+00
38SR	89	1.00E+00	3.09E-04	0.	8.85E-06	0.	0.	0.	4.94E-05	6.50E-13	5.80E-13	1.00E+00
38SR	90	1.00E+00	7.61E-03	0.	1.86E-03	0.	0.	0.	1.02E-04	0.	0.	1.00E+00
39Y	90	1.00E+00	9.63E-04	0.	2.58E-10	0.	0.	0.	1.02E-04	2.60E-12	2.20E-12	1.00E+00
39Y	91	1.00E+00	1.41E-07	0.	3.78E-09	0.	0.	0.	7.76E-05	2.70E-11	2.40E-11	1.00E+00
40ZR	95	1.00E+00	3.04E-08	9.76E-09	6.01E-09	0.	1.54E-08	0.	3.03E-05	5.80E-09	5.00E-09	1.00E+00
40ZR	97	1.00E+00	1.68E-09	3.39E-10	1.56E-10	0.	5.12E-10	0.	1.05E-04	6.40E-09	5.50E-09	1.00E+00
41NH	95	1.00E+00	6.23E-09	3.46E-09	1.36E-09	0.	3.43E-09	0.	2.10E-05	6.00E-09	5.10E-09	1.00E+00
42MO	90	1.00E+00	0.	4.31E-06	8.20E-07	0.	9.77E-06	0.	9.99E-06	2.20E-09	1.90E-09	1.00E+00
44MI	103	1.00E+00	1.85E-07	0.	7.98E-08	0.	7.07E-07	0.	2.16E-05	4.20E-09	3.60E-09	1.00E+00
44MI	106	1.00E+00	2.75E-06	0.	3.48E-07	0.	5.32E-06	0.	1.78E-04	1.80E-09	1.50E-09	1.00E+00
47AG	110M	1.00E+00	1.60E-07	1.48E-07	8.80E-08	0.	2.91E-07	0.	6.04E-05	2.10E-08	1.80E-08	1.00E+00
48FD	113M	1.00E+00	0.	3.19E-06	1.02E-07	0.	3.50E-06	0.	2.56E-05	2.60E-12	2.30E-12	1.00E+00
50SN	123	1.00E+00	3.11E-05	5.16E-07	7.60E-07	4.38E-07	0.	0.	6.33E-05	6.46E-08	0.	1.00E+00
50SN	126	1.00E+00	8.46E-05	1.08E-06	2.41E-06	4.92E-07	0.	0.	2.43E-05	1.00E-08	9.00E-09	1.00E+00
51SR	124	1.00E+00	2.81E-06	5.30E-08	1.11E-06	6.79E-09	0.	2.18E-06	7.95E-05	1.50E-08	1.40E-08	1.00E+00
51SR	125	1.00E+00	2.23E-06	2.40E-08	4.48E-07	1.98E-09	0.	2.33E-04	1.97E-05	3.50E-09	3.10E-09	1.00E+00
52TF	125M	1.00E+00	2.68E-06	9.73E-07	3.59E-07	8.07E-07	1.09E-05	0.	1.07E-05	4.80E-11	3.50E-11	1.00E+00
52TF	127M	1.00E+00	6.78E-06	2.37E-06	8.26E-07	1.73E-06	2.75E-05	0.	2.27E-05	1.30E-12	1.10E-12	1.00E+00
52TF	129M	1.00E+00	1.15E-05	4.30E-06	1.82E-06	3.95E-06	4.80E-05	0.	5.79E-05	9.00E-10	7.70E-10	1.00E+00
52TF	131M	1.00E+00	1.74E-06	8.47E-07	7.06E-07	1.34E-06	8.58E-06	0.	8.40E-05	9.90E-09	8.40E-09	1.00E+00
52TF	132	1.00E+00	2.53E-05	1.64E-06	1.53E-06	1.80E-06	1.58E-05	0.	7.71E-05	2.00E-09	1.70E-09	1.00E+00
53I	131	1.00E+00	4.16E-06	5.96E-06	3.41E-06	1.95E-03	1.02E-05	0.	1.57E-06	3.40E-09	2.80E-09	1.00E+00
53T	133	1.00E+00	1.43E-06	2.48E-06	7.57E-07	4.77E-04	4.33E-06	0.	2.18E-06	4.50E-09	3.70E-09	1.00E+00
55CS	134	1.00E+00	6.22E-05	1.46E-04	1.21E-04	0.	4.80E-05	1.59E-05	2.59E-06	1.40E-08	1.20E-08	1.00E+00
55CS	136	1.00E+00	6.51E-06	2.57E-05	1.85E-05	0.	1.43E-05	1.96E-06	2.92E-06	1.70E-08	1.50E-08	1.00E+00
55CS	137	1.00E+00	7.48E-05	1.09E-04	7.15E-05	0.	3.71E-05	1.23E-05	2.10E-06	4.90E-09	4.20E-09	1.00E+00
56HA	140	1.00E+00	2.03E-05	2.55E-08	1.34E-06	0.	8.68E-09	1.46E-08	4.18E-05	2.40E-09	2.10E-09	1.00E+00
57LA	140	1.00E+00	2.50E-09	1.26E-09	3.34E-10	0.	0.	0.	9.25E-05	1.70E-08	1.50E-08	1.00E+00
58CF	141	1.00E+00	9.37E-09	6.34E-09	7.18E-10	0.	2.94E-09	0.	2.42E-05	6.20E-10	5.50E-10	1.00E+00
58CF	143	1.00E+00	1.65E-09	1.22E-06	1.35E-10	0.	5.38E-10	0.	4.56E-05	2.50E-09	2.20E-09	1.00E+00
58CE	144	1.00E+00	4.89E-07	2.04E-07	2.62E-08	0.	1.21E-07	0.	1.65E-04	3.70E-10	3.20E-10	1.00E+00
59PR	143	1.00E+00	9.21E-09	3.70E-09	4.57E-10	0.	2.13E-09	0.	4.03E-05	0.	0.	1.00E+00
93NP	239	1.00E+00	1.20E-09	1.18E-10	6.46E-11	0.	3.65E-10	0.	2.40E-05	1.10E-09	9.50E-10	1.00E+00

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* * * TEENAGER DOSE FACTORS * * *

NUCLIDE	CURIE/YEAR	HUNE	INGESTION DOSE FACTORS (MREM/PCI INTAKE)						SHORELINE (MREM/HR)/(PCI/M**2)		REC'D
			LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	G.I-LI	SKIN	TOTAL BODY	
1H	3	1.00E+00	0.	1.06E-07	1.06E-07	1.06E-07	1.34E-07	1.06E-07	1.06E-07		
27Cl	54	1.00E+00	0.	9.92E-07	2.26E-06	0.	0.	0.	1.34E-05		
27Cl	60	1.00E+00	0.	2.76E-06	6.30E-06	0.	0.	0.	3.31E-05		
38SR	89	1.00E+00	4.60E-04	0.	1.32E-05	0.	0.	0.	4.99E-05		
38SR	90	1.00E+00	1.04E-02	0.	2.57E-03	0.	0.	0.	2.20E-04		
39Y	90	1.00E+00	3.30E-04	0.	8.87E-10	0.	0.	3.75E-05	1.09E-04		
39Y	91	1.00E+00	1.46E-07	0.	5.23E-09	0.	0.	0.	7.53E-05		
40ZR	95	1.00E+00	3.72E-08	1.24E-08	8.66E-09	0.	1.54E-08	0.	2.68E-05		
41NR	95	1.00E+00	7.24E-09	4.36E-09	2.46E-09	0.	3.43E-09	0.	1.78E-05		
44KH	103	1.00E+00	2.37E-07	0.	1.06E-07	0.	7.07E-07	0.	1.85E-05		
44KH	106	1.00E+00	4.00E-06	0.	5.03E-07	0.	5.32E-06	0.	1.81E-04		
50SN	123	1.00E+00	4.38E-05	7.22E-07	1.08E-06	5.78E-07	0.	0.	6.31E-05		
52F	125M	1.00E+00	3.83E-06	1.37E-06	5.08E-07	1.08E-06	1.09E-05	0.	1.07E-05		
52F	129M	1.00E+00	1.66E-05	6.15E-06	2.61E-06	5.30E-06	4.80E-05	0.	5.80E-05		
52TE	132	1.00E+00	3.55E-06	2.22E-06	2.10E-06	2.36E-06	1.58E-05	0.	8.00E-05		
53I	131	1.00E+00	5.57E-06	7.87E-06	4.69E-06	2.27E-03	1.02E-05	0.	1.49E-06		
53I	133	1.00E+00	2.03E-06	3.44E-06	1.06E-06	6.25E-04	4.33E-06	0.	2.50E-06		
55CS	134	1.00E+00	8.05E-05	1.94E-04	9.06E-05	0.	4.80E-05	2.35E-05	2.24E-06		
55CS	137	1.00E+00	1.07E-04	1.44E-04	5.05E-05	0.	3.71E-05	1.91E-05	1.92E-06		
56MA	140	1.00E+00	2.83E-05	3.48E-08	1.82E-06	0.	8.68E-09	2.33E-08	4.14E-06		
57LA	140	1.00E+00	3.48E-09	1.72E-09	4.55E-10	0.	-0.	0.	9.48E-05		
58CF	141	1.00E+00	1.26E-08	8.46E-09	4.70E-10	0.	2.94E-09	0.	2.29E-05		
58CE	144	1.00E+00	7.22E-07	2.96E-07	3.83E-08	0.	1.21E-07	0.	1.70E-04		

* * * CHILD DOSE FACTORS * * *

NUCLIDE	CURIE/YEAR	HUNE	INGESTION DOSE FACTORS (MREM/PCI INTAKE)						SHORELINE (MREM/HR)/(PCI/M**2)		REC'D
			LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	G.I-LI	SKIN	TOTAL BODY	
1H	3	1.00E+00	0.	2.03E-07	2.03E-07	2.03E-07	1.34E-07	2.03E-07	2.03E-07		
27Cl	54	1.00E+00	0.	1.85E-06	5.58E-06	0.	0.	0.	1.10E-05		
27Cl	60	1.00E+00	0.	5.17E-06	1.55E-05	0.	0.	0.	2.86E-05		
38SR	89	1.00E+00	1.38E-03	0.	3.95E-05	0.	0.	0.	5.15E-05		
38SR	90	1.00E+00	1.72E-02	0.	4.36E-03	0.	0.	0.	2.29E-04		
39Y	90	1.00E+00	4.21E-08	0.	1.13E-09	0.	0.	0.	1.20E-04		
39Y	91	1.00E+00	5.65E-07	0.	1.56E-08	0.	0.	0.	7.77E-05		
40ZR	95	1.00E+00	1.04E-07	2.42E-08	2.20E-08	0.	1.54E-08	0.	2.50E-05		
41NR	95	1.00E+00	1.45E-08	8.32E-09	6.11E-09	0.	3.43E-09	0.	1.44E-05		
44KH	103	1.00E+00	6.78E-07	0.	2.74E-07	0.	7.07E-07	0.	1.78E-05		
44KH	106	1.00E+00	1.19E-05	0.	1.48E-06	0.	5.32E-06	0.	1.85E-04		
50SN	123	1.00E+00	1.31E-04	1.64E-06	3.22E-06	1.73E-06	0.	0.	6.50E-05		
52F	125M	1.00E+00	1.14E-05	3.09E-06	1.52E-06	3.20E-06	1.09E-05	0.	1.10E-05		
52F	129M	1.00E+00	4.95E-05	1.38E-05	7.65E-06	1.58E-05	4.80E-05	0.	5.96E-05		
52TE	132	1.00E+00	1.02E-05	4.50E-06	5.42E-06	6.62E-06	1.58E-05	0.	7.89E-05		
53I	131	1.00E+00	1.63E-05	1.67E-05	1.26E-05	5.43E-03	1.02E-05	0.	1.43E-06		
53I	133	1.00E+00	5.98E-06	7.38E-06	2.90E-06	1.78E-03	4.33E-06	0.	2.99E-06		
55CS	134	1.00E+00	2.24E-04	3.77E-04	8.02E-05	0.	4.80E-05	4.19E-05	2.04E-06		
55CS	137	1.00E+00	3.12E-04	3.02E-04	4.50E-05	0.	3.71E-05	3.54E-05	1.84E-06		
56MA	140	1.00E+00	8.26E-05	7.25E-08	4.85E-06	0.	8.68E-09	4.32E-08	4.21E-06		
57LA	140	1.00E+00	1.01E-08	3.52E-09	1.19E-09	0.	-0.	0.	1.00E-04		
58CF	141	1.00E+00	3.76E-08	1.88E-08	2.80E-09	0.	2.94E-09	0.	2.36E-05		
58CE	144	1.00E+00	2.14E-06	6.70E-07	1.14E-07	0.	1.21E-07	0.	1.74E-04		

* * * INFANT DOSE FACTORS * * *

NUCLIDE	CURIE/YEAR	BONE	INGESTION DOSE FACTORS (MREM/PCI INTAKE)						SOURCE LINE (MREM/HR)/(PCI/M**2)		RECON
			LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY	
1F	3	1.00E+00	0.	3.07E-07	3.07E-07	3.07E-07	1.34E-07	3.07E-07	3.07E-07	3.07E-07	
27CO	58	1.00E+00	0.	3.78E-06	4.26E-06	0.	0.	0.	9.79E-06		
27CO	60	1.00E+00	0.	1.07E-05	2.56E-05	0.	0.	0.	2.64E-05		
36SR	89	1.00E+00	2.43E-03	0.	8.42E-05	0.	0.	0.	5.48E-05		
36SR	90	1.00E+00	2.51E-02	0.	6.40E-03	0.	0.	0.	2.43E-04		
39Y	90	1.00E+00	8.97E-08	0.	2.41E-09	0.	0.	0.	1.29E-04		
39Y	91	1.00E+00	1.25E-06	0.	3.33E-08	0.	0.	0.	8.27E-05		
40ZR	95	1.00E+00	2.11E-07	5.32E-08	3.78E-08	0.	1.54E-08	0.	2.36E-05		
41NR	95	1.00E+00	3.89E-08	1.75E-08	1.03E-08	0.	3.43E-09	0.	1.40E-05		
44RU	103	1.00E+00	1.41E-06	0.	4.85E-07	0.	7.07E-07	0.	1.76E-05		
44RU	106	1.00E+00	2.54E-05	0.	3.12E-06	0.	5.52E-06	0.	1.97E-04		
50SN	123	1.00E+00	2.79E-04	4.35E-06	6.86E-06	4.33E-06	0.	0.	6.91E-05		
52TF	125M	1.00E+00	2.43E-05	8.19E-06	3.24E-06	8.00E-06	1.09E-05	0.	1.17E-05		
52TF	129M	1.00E+00	1.05E-04	3.61E-05	1.60E-05	3.95E-05	4.80E-05	0.	6.33E-05		
52TF	132	1.00E+00	2.13E-05	1.05E-05	9.76E-06	1.55E-05	1.58E-05	0.	8.08E-05		
53I	131	1.00E+00	3.42E-05	4.07E-05	2.38E-05	1.31E-02	1.02E-05	0.	1.53E-06		
53I	133	1.00E+00	1.26E-05	1.84E-05	5.58E-06	4.35E-03	4.33E-06	0.	3.27E-06		
55CS	134	1.00E+00	4.58E-04	8.24E-04	6.97E-05	0.	4.80E-05	9.42E-05	1.96E-06		
55CS	137	1.00E+00	6.53E-04	7.31E-04	4.20E-05	0.	3.71E-05	8.81E-05	1.89E-06		
56BA	140	1.00E+00	1.74E-04	1.75E-07	8.99E-06	0.	8.68E-09	1.07E-07	4.43E-06		
57LA	140	1.00E+00	2.12E-08	8.37E-09	2.16E-09	0.	-0.	0.	1.04E-04		
59CE	141	1.00E+00	8.00E-08	4.91E-08	5.75E-09	0.	2.94E-09	0.	2.38E-05		
58CE	144	1.00E+00	4.49E-06	1.77E-06	2.42E-07	0.	1.21E-07	0.	1.85E-04		

TOTAL NUMBER IN SOURCE TERM IS 44 TOTAL RELEASE IS 4.4000E+01

* * * AS LOW AS REASONABLY ACHIEVABLE * * *

A D U L T D O S E S

DOSE (MREM PER YEAR INTAKE)

PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH		2.27E+04	2.12E+03	1.45E+03	4.26E+01	3.06E+02	7.50E+01	3.66E+03
DRINKING		3.46E+02	1.65E+01	8.73E+01	4.98E+01	1.02E+01	1.23E+01	6.99E+01
SHORELINE	8.01E+00	6.49E+00	6.49E+00	6.49E+00	6.49E+00	6.49E+00	6.49E+00	6.49E+00
TOTAL	8.01E+00	2.30E+04	2.14E+03	1.54E+03	1.39E+02	3.23E+02	9.38E+01	3.74E+03

PATHWAY	USAGE (KG/YR,HR/YR)	DILUTION	TIME (HR)	SHOREWIDTH FACTOR=1.0
FISH	21.0	1.0	24.00	
DRINKING	730.0	1.0	12.00	
SHORELINE	12.0	1.0	-0.00	

* * * ISOTOPE CONTRIBUTION * * *

PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH	P 32 95%	P 32 63%	P 32 57%	SN 126 5%	ZN 65 7%	FE 55 5%	P 32 66%	
	SR 90 1%	7N 65 1%	ZN 65 1%	SN 126 4%	TE 125M 1%	CS 134 49%	NB 95 19%	
	SN 126 1%	RB 86 2%	RB 86 1%	TE 127M 1%	TE 127M 4%	CS 136 5%	SN 123 6%	
		CS 134 16%	SR 90 4%	TE 129M 4%	TE 129M 7%	CS 137 38%	SN 126 2%	
		CS 136 2%	CS 134 19%	TF 132 1%	TE 132 1%			
		CS 137 12%	CS 136 2%	I 131 73%	CS 134 36%			
			CS 137 11%	I 133 8%	CS 136 10%			
					CS 137 28%			
	DRINKING	P 32 2%	P 32 2%	SR 90 87%	I 131 84%	7N 65 4%	FE 55 10%	P 32 1%
		SR 89 3%	MN 54 1%	CS 134 5%	I 133 14%	MU 99 3%	SB 125 77%	FE 59 1%
SR 90 89%		FE 55 6%	CS 137 3%		PU 106 2%	CS 134 5%	CU 60 2%	
		FE 59 2%			CU 113M 1%	CS 137 4%	SR 89 2%	
		ZN 65 3%			TE 125M 4%		SR 90 5%	
		RB 86 5%			TE 127M 11%		Y 90 5%	
		TE 129M 1%			TE 129M 19%		Y 91 4%	
		I 131 1%			TE 131M 2%		7K 95 1%	
		CS 134 36%			TE 132 5%		ZR 97 3%	
		CS 136 6%			I 131 3%		NB 95 1%	
SHORELINE		CS 137 27%			I 133 1%		RU 103 1%	
					CS 134 19%		RU 106 10%	
					CS 136 5%		AB 110M 3%	
					CS 137 14%		CU 113M 1%	
							SN 123 3%	
							SN 126 1%	
							SB 124 4%	
							SB 125 1%	
							TE 127M 1%	
							TE 129M 3%	
	MN 54 1%	MN 54 1%						
	CU 60 27%	CU 60 28%						
	AG 110M 4%	AG 110M 4%						
	SN 123 6%	SN 126 34%						
	SN 126 31%	SB 125 3%						
	SB 125 2%	CS 134 9%						
	CS 134 8%	CS 137 13%						
	CS 137 12%							

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TABLE 4.11-2
LIQUID EFFLUENT DOSE PARAMETERS

RADIOISOTOPE	A(1), MREM/HR PER UCI/ML TOTAL BODY	CRITICAL ORGAN
H 3	1.14E+01	1.14E+01
P 32	1.71E+06	4.41E+07
CR 51	1.46E+00	3.66E+02
MN 54	9.07E+02	1.45E+04
FE 55	2.36E+03	1.04E+04
FE 59	1.25E+03	1.08E+04
CU 58	3.36E+02	3.04E+03
CU 60	9.58E+02	8.16E+03
ZN 65	3.39E+04	7.49E+04
ZN 69M	5.55E+01	3.70E+04
RH 86	4.62E+04	9.91E+04
SR 89	1.36E+03	4.75E+04
SR 90	2.89E+05	1.18E+06
Y 90	3.08E-02	1.22E+04
Y 91	5.37E-01	1.10E+04
ZR 95	5.99E-01	2.75E+03
ZR 97	8.40E-03	5.65E+03
NH 95	9.59E+01	1.48E+06
MO 99	7.55E+01	9.19E+02
KU 103	8.47E+00	2.29E+03
RU 106	3.73E+01	1.91E+04
AG 110M	7.80E+00	5.35E+03
CD 113M	5.74E+01	1.44E+04
SN 123	5.50E+03	4.58E+05
SN 126	1.75E+04	6.15E+05
SB 124	9.45E+01	6.77E+03
SB 125	3.64E+01	2.00E+04
TE 125M	3.70E+02	1.12E+04
TE 127M	8.55E+02	2.85E+04
TE 129M	1.86E+03	5.91E+04
TE 131M	4.33E+02	5.15E+04
TE 132	1.30E+03	6.55E+04
I 131	3.84E+02	2.20E+05
I 133	5.45E+01	3.43E+04
CS 134	5.89E+05	7.21E+05
CS 136	8.55E+04	1.19E+05
CS 137	3.48E+05	5.31E+05
BA 140	1.21E+02	3.77E+03
LA 140	3.59E-02	9.93E+03
CE 141	6.08E-02	2.05E+03
CE 143	8.93E-03	3.02E+03
CE 144	2.24E+00	1.41E+04
PR 143	6.31E-02	5.56E+03
NP 239	5.79E-03	2.15E+03

DRINKING DILUTION IN ADDITION TO THAT FOR FISH = 1.0

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ADDENDUM

Setpoint Calculations

The radiological effluent Technical Specifications require alarm/trip setpoints for radiation monitors and flow measurement devices for each effluent line. Setpoint values are to be calculated to assure that alarm and trip actions occur prior to exceeding the limits of 10 CFR 20 at the release point to the unrestricted area. The calculated alarm and trip action setpoints to be specified in the ODCM for each radioactive liquid effluent line monitor and flow measurement device must satisfy the following equation:

$$\frac{cf}{F+f} \leq C$$

where:

C = the effluent concentration limit (Specification 3.11.1) implementing 10 CFR 20 for the site, in $\mu\text{Ci/ml}$

c = the setpoint, in $\mu\text{Ci/ml}$, of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint, which is proportional to the volumetric flow of the effluent line and inversely proportional to the volumetric flow of the dilution stream plus the effluent stream, represents a value which, if exceeded, would result in concentrations exceeding the limits of 10 CFR 20 in the unrestricted area

f = the flow setpoint as measured at the radiation monitor location, in volume per unit time, but in the same units as F, below

F = the dilution water flow setpoint as measured prior to the release point, in volume per unit time.

[Note that if no dilution is provided, $c \leq C$. Also, note that when (F) is large compared to (f), then $F+f = F$.]

The equation is satisfied when the following alarm/trip setpoints are provided for each effluent line in the ODCM:

$$f \leq \frac{CF}{c} \quad (\text{in ml/sec; for example}).$$

$$F \leq \frac{cf}{C} \quad (\text{in ml/sec; for example}).$$

$$c \leq \frac{CF}{F} \quad (\text{in } \mu\text{Ci/ml; for example}).$$

Some plants may be operated using a fixed value for one or more of these three variables, c, f or F.

Example 1

By using a constant capacity radwaste system discharge pump (on the undiluted stream) the value of (f) is fixed; therefore, the setpoints to be given in the ODCM are:

$$\begin{aligned}
 f &= \text{_____ ml/sec (fixed)} \\
 F &> \text{_____ ml/sec} = cf/C \\
 c &= \text{_____ } \times F \text{ } \mu\text{Ci/ml} \leq CF/f
 \end{aligned}$$

If $C = 3 \times 10^{-8} \mu\text{Ci/ml}$, $f = 4000 \text{ ml/sec}$ and $F > 4 \times 10^6 \text{ ml/sec}$, the radiation monitor setpoint is calculated as follows:

$$\begin{aligned}
 c &\leq CF/f \\
 &= \frac{(3 \times 10^{-8})F}{4000} = 7.5 \times 10^{-12} F \text{ } \mu\text{Ci/ml}.
 \end{aligned}$$

If F is measured at some value in excess of the limiting value (the limiting value is $4 \times 10^6 \text{ ml/sec}$ in this example), then c may be established proportionately. If $F = 8 \times 10^6 \text{ ml/sec}$, the alarm setpoint is:

$$\begin{aligned}
 c &= 7.5 \times 10^{-12} F (\mu\text{Ci/ml per ml/sec})(\text{ml/sec}) \\
 &= 7.5 \times 10^{-12} (8 \times 10^6) = 6 \times 10^{-5} \mu\text{Ci/ml}.
 \end{aligned}$$

In this case, the alarm setpoint for the radioactive liquid effluent line monitor can be established at $6 \times 10^{-5} \mu\text{Ci/ml}$, provided that an automatic isolation/control trip action occurs to satisfy the condition:

$$c/F < 7.5 \times 10^{-12} \mu\text{Ci/ml per ml/sec}.$$

Example 2

By using a constant capacity dilution pump (on the dilution stream prior to a mixing box), the value of (F) is fixed; therefore, the setpoints to be given in the ODCM are:

$$\begin{aligned}
 f &< \text{_____ ml/sec} = CF/c \\
 F &= \text{_____ ml/sec (fixed)} \\
 c &= \text{_____ } \times (1/f) \mu\text{Ci/ml} \leq CF/f
 \end{aligned}$$

If $C = 3 \times 10^{-8} \mu\text{Ci/ml}$, $F = 4 \times 10^6 \text{ ml/sec}$ and $f < 4000 \text{ ml/sec}$, the radiation monitor setpoint is calculated as follows:

$$\begin{aligned}
 c &\leq CF/f \\
 &= \frac{(3 \times 10^{-8}) \times 4 \times 10^6}{f} = 0.12(1/f) \mu\text{Ci/ml}.
 \end{aligned}$$

If f is measured at some value less than the limiting value (the limiting value is 4000 ml/sec in this example), then c may be established proportionately. If $f = 1000 \text{ ml/sec}$, the alarm setpoint is:

$$\begin{aligned}
 c &= 0.12(1/f)(\mu\text{Ci/sec})(\text{sec/ml}) \\
 &= \frac{0.12}{1000} = 1.2 \times 10^{-4} \mu\text{Ci/ml}.
 \end{aligned}$$

In this case, the alarm setpoint for the radioactive liquid effluent line monitor can be established at 1.2×10^{-4} $\mu\text{Ci/ml}$, provided that an automatic isolation/control trip action occurs to satisfy the condition:

$$cf > 0.12 \mu\text{Ci/sec.}$$

Value of c

A detailed description of the method to be used to obtain the value of (c) should be provided in the ODCM. Since (c) is dependent on the radionuclide distribution, yields, calibration and the monitor's parameters, each of these variables should be considered and the fixed or adjustable setpoint method of determination described in the ODCM for each effluent monitor. This may be accomplished by tabulation. Changes to the ODCM shall be provided in the SEMIANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT.