GPU NUCLEAR

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July 19, 2000
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U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Dear Sir:

Subject: Oyster Creek Nuclear Generating Station
Docket No. 50-219
Emergency Plan Implementing Procedure Revisions

In accordance with 10 CFR 50, Appendix E, Section V, enclosed is the newly revised Index for the Oyster Creek Emergency Plan Implementing Procedures and the below listed procedure.

Procedure Number	Title	Revision
6630-ADM-4010.03	Emergency Dose Calculation Manual	11

If further information is required, please contact Mr. George Busch, Manager Nuclear Safety and Licensing at 609-971-4643.

Very truly yours,

Sander Levin
Acting Site Director

MBR\GWB:gl

Enclosures

cc: Administrator, Region I
NRC Sr. Project Manager
NRC Resident Inspector

A045

EPIP SERIES - EMERGENCY PLAN IMPLEMENTING PROCEDURES

PROCEDURE NO.	TITLE	REV. NO.	DATE
6630-ADM-4010.03	Emergency Dose Calculation Manual (EDCM)	11	07/23/00
EPIP-OC-.01	Classification of Emergency Conditions	7	04/08/00
EPIP-OC-.02	Direction of Emergency Response/Emergency Control Center	24	11/11/99
EPIP-OC-.03	Emergency Notification	24	01/22/00
EPIP-OC-.06	Additional Assistance and Notification	21	09/03/99
EPIP-OC-.10	Emergency Radiological Surveys Onsite	9	01/06/00
EPIP-OC-.11	Emergency Radiological Surveys Offsite	14	01/06/00
EPIP-OC-.12	Personnel Accountability	7	02/21/99
EPIP-OC-.13	Site Evacuation and Personnel Mustering at Remote Assembly Areas	6	11/10/97
EPIP-OC-.25	Emergency Operations Facility (EOF)	21	07/01/99
EPIP-OC-.26	The Technical Support Center	20	11/14/99
EPIP-OC-.27	The Operations Support Center	8	11/11/99
EPIP-OC-.31	Environmental Assessment Command Center	10	03/08/98
EPIP-OC-.33	Core Damage Estimation	4	12/03/99
EPIP-OC-.35	Radiological Controls Emergency Actions	13	07/11/99
EPIP-OC-.40	Site Security Emergency Actions	9	10/04/99
EPIP-OC-.41	Emergency Duty Roster Activation	4	06/21/97
EPIP-OC-.44	Thyroid Blocking	0	03/11/99
EPIP-OC-.45	Classified Emergency Termination/Recovery	0	02/21/99
OEP-ADM-1311.03	Emergency Preparedness Section Administration	3	08/28/99
OEP-ADM-1319.01	Oyster Creek Emergency Preparedness Program	6	05/15/99
OEP-ADM-1319.02	Emergency Response Facilities & Equipment Maintenance	6	09/03/99
OEP-ADM-1319.04	Prompt Notification System	1	05/02/97
OEP-ADM-1319.05	Oyster Creek Emergency Preparedness Program	0	02/20/99

GPU NUCLEAR	OYSTER CREEK RADIOLOGICAL CONTROLS POLICY AND PROCEDURE MANUAL	Number 6630-ADM-4010.03
Title: Oyster Creek Emergency Dose Calculation Manual		Revision No. 11
Applicability/Scope: All GPUN Employees		Responsible Office: Radiological Engr. 2820
This document is within QA plan scope X Yes ___No Safety Reviews Required X Yes ___No		Effective Date (07/13/00) 07/23/00

Prior Revision 10 incorporated the following Temporary Changes: N/A

This Revision 11 incorporates the following Temporary Changes: N/A

List of Pages (All pages rev'd to Rev. 11)

1.0 to 91.0

NON-CONTROLLED
This Document Will Not
Be Kept Up To Date
DCC Oyster Creek

This Procedure Replace 9300-ADM-4010.03

	Signature	Concurring Organization Element	Date
Originator	G. SEALS	Radiological Engineer	7/11/00
Concurred By	FOR P. HAYS	Emergency Prep. - Manager, OC	7/11/00
	[illegible]	Environmental Controls	7/11/00
Approved By	[illegible]	Manager, Radiological Engineering	7/12/00

Oyster Creek Emergency Dose Calculation Manual (EDCM)

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1.0 PURPOSE

The purpose of this manual is to provide a document that describes the assumptions and methodology used in the current Oyster Creek Radiological Assessment Computer Program (RACP). This includes calculating projected offsite doses from releases of radioactive material to the environment in accident conditions upon implementation of the Emergency Plan. As such, this document describes methods of projecting offsite doses during emergencies or for training purposes. Indications of these releases may result from Radiation Monitoring System (RMS) readings, onsite or offsite sample results, or contingency calculations if RMS and sample results are not available. These dose projections are performed utilizing an IBM compatible computer and the current version of the RACP. The Radiological Assessment Coordinator (RAC) and Environmental Assessment Coordinator (EAC) are responsible for implementing the dose projection process.

2.0 APPLICABILITY/SCOPE

The Emergency Dose Calculation Manual (EDCM) is applicable to all qualified Emergency Plan personnel involved in the projection of offsite doses during an emergency. This manual provides the methods used in performance of dose projections during emergency situations where radioactive material has been or is predicted to be released to the environment.

3.0 DEFINITIONS

3.1 BUILDING WAKE EFFECTS

Effects on the dispersion of an atmospheric release occurring at, near, or below the top of a building (or any structure). Air flow over and around the structure from the prevailing wind tends to drive the release down to the ground on the downwind side of the structure. This has two effects: it increases onsite concentrations dramatically, while slightly reducing concentrations downwind for a short distance. Far downwind concentrations are affected very little by building wake. Stack releases are high enough above the building so that building wake does not affect the plume significantly.

3.2 CONTINGENCY CALCULATION

A source term calculation performed in the absence of effluent radiation monitoring system or post accident sample data. It is a mathematical calculation based upon a conservative model of accident plant conditions.

3.3 DOSE CONVERSION FACTOR (DCF)

A parameter calculated by the methods and models of internal dosimetry, which indicates the committed dose equivalent (to the whole body or an organ) per unit activity inhaled or ingested. This parameter is specific to the isotope and the dose pathway. Dose conversion factors are commonly tabulated in units of mR/hr per curie inhaled or ingested or mR/hr per Ci/m^3 in air or water.

3.4 DOSE EQUIVALENT IODINE (I-131) (DEI)

DOSE EQUIVALENT IODINE (I-131) shall be that concentration of I-131 microcuries per gram which alone would produce the same thyroid dose as the quantity and isotopic mixture of I-131, I-132, I-133, I-134, and I-135 actually present.

3.5 ELEVATED RELEASE

An airborne effluent plume which is well above any building wake effects so as to be essentially unentrained. Reg. Guide 1.145 defines an elevated release point as being higher than two and one-half times the height of adjacent solid structures. The source of the plume may be elevated either by virtue of the physical height of the source above the ground elevation and buildings or by a combination of the physical height and the jet plume rise.

Elevated releases generally will not produce any significant ground level concentrations within the first few hundred yards of the source. Elevated releases generally have less dose consequence to the public due to the greater downwind distance to the ground concentration maximum compared to ground releases. All main stack releases at Oyster Creek are elevated releases.

3.6 EMERGENCY ACTION LEVEL (EAL)

Predetermined conditions or values, including radiation dose rates; specific levels of airborne, waterborne, or surface-deposited contamination; events such as natural disasters or fires; or specific instrument indicators which, when reached or exceeded, require implementation of the Emergency Plan.

3.7 EMERGENCY DIRECTOR (ED)

Designated onsite individual having the responsibility and authority to implement the Emergency Plan, and who will coordinate efforts to limit consequences of, and bring under control, the emergency.

3.8 EMERGENCY DOSE CALCULATION MANUAL (EDCM)

A controlled document describing the content, calculational methods, and use of the Radiological Assessment Computer Program (RACP).

3.9 EMERGENCY OPERATIONS FACILITY (EOF)

The Emergency Operations Facility serves as the primary location for management of the Corporation's overall emergency response. This facility is equipped for and staffed by the Emergency Support Organization to coordinate emergency response with off-site support agencies and to assess the environmental impact of the emergency. The EOF participates in accident assessment and transmits appropriate data and recommended protective actions to Federal, State, and Local Agencies.

3.10 EMERGENCY RESPONSE FACILITIES (ERF)

The primary locations for management of the Corporation's overall emergency response. These facilities are equipped for and staffed by the Emergency Support and Response Organizations to coordinate emergency response with offsite support agencies and assessment of the environmental impact of the emergency. The ERF participate in accident assessment and transmit appropriate data and recommended protective actions to Federal, State and Local agencies.

3.11 EMERGENCY PLANNING ZONE (EPZ)

A zone defined by a radial distance from the plant in which emergency planning considerations are given. There are two EPZs. The first is the Plume Exposure Pathway EPZ and is located at approximately ten miles in radius around the site. In this EPZ, emergency planning consideration is given in order to ensure that prompt and effective actions can be taken to protect the public and property in the event of an accident. The second EPZ is called the Ingestion Exposure Pathway EPZ and is located approximately 50 miles in radius around the site. Emergency planning considerations are given for the ingestion exposure pathway in this EPZ.

3.12 ENVIRONMENTAL ASSESSMENT COMMAND CENTER (EACC)

The EACC is located along side the EOF to provide a work area for the EACC staff. Under the direction of the EAC, environmental data are collected and dose projections performed in support of the EOF.

3.13 ENVIRONMENTAL ASSESSMENT COORDINATOR (EAC)

A member of the emergency support organization, the EAC assumes responsibility for dose projections and offsite field monitoring teams from the RAC when the EACC is activated. The EAC provides environmental data, calculations, and advice to the Group Leader R&EC.

3.14 EXIT VELOCITY AND PLUME RISE

Atmospheric dispersion and ground concentrations are in part dependent on release height. Higher release heights will cause lower maximum concentrations at ground level and will cause that maximum to occur further downwind than would a lower release height. The effective height of a stack is not only dependent on its physical height, but also on whether the plume rises or not. At high linear flow rates (exit velocity), the release plume behaves much like a geyser and rises in a jet flow above the stack. The height to which the jet flow rises becomes the effective stack height.

3.15 FINITE PLUME MODEL

Atmospheric dispersion and dose assessment model which is based on the assumption that the horizontal and vertical dimensions of an effluent plume are not necessarily large compared to the distance that gamma rays can travel in air. It is more realistic than the semi-infinite plume model because it considers the finite dimensions of the plume, the radiation build-up factor, and the air attenuation of the gamma rays coming from the cloud. This model can estimate the dose to a receptor who is not submerged in the radioactive cloud. It is particularly useful in evaluating doses from an elevated plume or when the receptor is near the effluent source.

3.16 GAUSSIAN PLUME EQUATION

An equation which takes input parameters of plume height, and lateral and vertical plume spread, and explicitly calculates the straight line Gaussian Plume Dispersion. The Gaussian Plume equation actually averages short term variations to produce a mean effective plume, so short term measurements of the plume may not be duplicated by the Gaussian Plume Model.

3.17 GROUND LEVEL RELEASE

An airborne effluent plume which contacts the ground essentially at the point of release either from a source actually located at the ground elevation or from a source above the ground elevation which has significant building wake effects to cause the plume to be entrained in the wake and driven to the ground elevation. Ground level releases are treated differently than elevated releases in that the X/Q calculation results in significantly higher concentrations at the ground elevation near the release point. Ground level X/Q values become essentially the same as elevated for larger distance downwind. All releases at Oyster Creek, other than main stack, are ground level releases.

3.18 Group Leader R&EC

Functions as point of control for radiological and environmental information for the ESD. This position is overall in charge of radiological and environmental controls effort.

3.19 LOW POPULATION ZONE (LPZ)

As defined in 10CFR100.3, "The area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident."

3.20 PROTECTIVE ACTION GUIDELINES (PAG)

Projected radiological dose or dose commitment values to individuals of the general population and to emergency workers that warrant protective action before or after a release of radioactive material. Protective actions would be warranted provided the reduction in individual dose expected to be achieved by carrying out the protective action is not offset by excessive risks to individual safety in taking the protective action. The PAG at OCNGS is based on the Environmental Protection Agency low-level guidelines of 1000 mR TEDE or 5000 mR thyroid. The PAG does not include the dose that has unavoidably occurred prior to the evacuation.

3.21 PROTECTIVE ACTION RECOMMENDATION (PAR)

Those actions recommended to the state of New Jersey to be taken during or after an emergency situation that minimize or eliminate the radiological hazard to the health and safety of the general public.

3.22 RADIATION MONITORING SYSTEM (RMS)

The system designed to detect, indicate, annunciate, and record the radiation level of effluent releases and radiation levels at selected locations inside the plant to verify compliance with applicable Code of Federal Regulations (CFR) limits. The RMS consists of the following subsystems: area monitoring, atmospheric monitoring, and liquid monitoring.

3.23 RADIOLOGICAL ASSESSMENT COORDINATOR (RAC)

A member of the initial response team of the emergency response organization. Specific responsibilities assigned to the RAC include directing offsite and onsite survey teams. The RAC is relieved of offsite radiological monitoring teams' responsibilities by the Environmental Assessment Coordinator (EAC). The RAC performs dose projections, supplies source term estimates to the EAC and ensures a timely, accurate dose projection until the EAC assumes responsibility for dose projection. The RAC's main responsibility is advising the ED of any radiological concerns. Initially the Group Radiological Controls Supervisor assumes the role of the RAC until relieved by the Initial Response Emergency Organization RAC.

3.24 RADIOLOGICAL ASSESSMENT SUPPORT ENGINEER (RASE)

Individuals assigned to assist the RAC in performing dose calculations, source term calculations, and overall assessment and control of radiological hazards.

3.25 RAGEMS I, RAGEMS II

The RAGEMS I and RAGEMS II Systems monitor gaseous effluent releases from the main stack and the turbine building stack, respectively. They monitor particulates, iodines, and noble gases.

3.26 REACTOR COOLANT SYSTEM (RCS)

This system contains the necessary piping and components to provide sufficient water flow to cool the reactor. This system provides for the transfer of energy from the reactor core to the turbine in the form of pressurized steam, acts as a moderator for thermal fission, and provides a boundary to separate fission products from the atmosphere.

3.27 RELEASE DURATION

Release duration refers to the time interval during which radionuclides are released from the nuclear facility. Releases may be monitored, unmonitored, actual, or projected. The time interval used to estimate a release of unknown duration should reflect best estimates of the plant technical staff. In the absence of other information, seven hours is used as the expected release duration from the reactor building and one hour is used as the expected release duration from the turbine building.

3.28 RELEASE RATE

This term refers to the rate at which radionuclides are released to the environment. Normally, it will be expressed in uCi/sec.

3.29 SEMI-INFINITE PLUME MODEL

Dose assessment model which is based on the assumption that the dimensions of an effluent plume are large compared to the distance that gamma rays can travel in air. The ground is considered to be an infinitely large flat plate and the receptor is located at the origin of a hemispherical cloud of infinite radius. The radioactive cloud is limited to the space above the ground plane. The semi-infinite plume model is limited to immersion dose calculations.

3.30 SOURCE TERM

The activity release rate, or concentration of an actual release or potential release. The common units for the source term are Ci, Ci/sec, and Ci/cc, or multiples thereof (e.g., uCi).

3.31 STABILITY CLASS

A measure of the amount of mixing occurring between the plume and the atmosphere around the plume. Conditions which create good mixing are unstable and conditions which create poor mixing are stable. Pasquill stability classification is a breakdown of the relative atmospheric stability into seven groups, denoted as A through G, from most unstable to most stable. In the Pasquill stability classification system, stability is related to the change in temperature with height and the standard deviation of wind direction measurements. The more negative the change in temperature with increasing height, the more unstable the atmosphere is. Standard deviation of wind direction (σ_0) is not used in stability class determination in the RACP.

3.32 TECHNICAL SUPPORT CENTER (TSC)

Emergency response facility utilized by engineering personnel to provide engineering support for emergency operations. This is the location of the ED and the RAC.

3.33 TERRAIN FACTOR (TF)

The terrain height above plant grade at distances from the release point. The terrain factor accounts for increases in local ground level concentrations due to terrain effects. The terrain factor is the terrain height in meters at a given distance for each sector.

3.34 X/Q ("CHI over Q")

The dispersion factor of a gaseous release in the environment calculated by a point source gaussian dispersion model. Normal units of X/Q are sec/m^3. The X/Q is used to determine environmental atmospheric concentrations by multiplying the source term, represented by Q (in units of uCi/sec or Ci/sec) and X/Q. Thus, the plume dispersion, X/Q (sec/cubic meter) multiplied by the source term, Q (uCi/sec) yields an environmental concentration, X (uCi/m^3). X/Q is a function of many parameters including wind speed, stability class, release point height, building size, and release velocity.

4.0 POLICY

Substantive changes to the program will be reviewed and agreed to by Radiological Engineering, Emergency Preparedness, and Environmental Controls and documented by a revision to this procedure.

NOTE

Non-substantive changes to the computer program as determined by the program administrator may be implemented without a revision to this procedure.

4.1 Three (3) non-controlled copies of this procedure will be sent to the Licensing Manager, Oyster Creek.

5.0 PREREQUISITES

None

6.0 PRECAUTIONS

None

7.0 PROCEDURE

This section of the EDCM is divided into two sections, 7.1 Operation and 7.2 Theory.

7.1 Operation

This section will describe the operation of the RAC computer code including which calculation to use in different circumstances and what inputs are required for each calculation. The computer operator is urged to read sections 7.1.1 and 7.1.2 before beginning any calculations.

7.1.1 Computer Operation

The RAC computer code is run on computers in the Emergency Control Center (ECC), Technical Support Center (TSC), and the Emergency Operations Facility (EOF). In the control room the power switch is under the display monitor. In the TSC the power switch is mounted on the wall behind the computer.

At the EOF the master switch is under the cabinet where the computer is kept. The RAC code will automatically be loaded when the computer is turned on. Type "RAC" and hit the carriage return to load the program if it does not automatically load.

The initial screen (see Figure 1a) will be displayed at the beginning of the program. The user is given a choice of running either a "Real", "Drill" or "Training" version of the program. To execute the drill or training versions, it is necessary to change the zero (in the blue box adjacent to the applicable version) to a one and then press the F10 key. If only the F10 key is pressed without changing either of the zeros to one, the real version of the code will execute.

Figure 1a

RAC Program defaults to Real Version

To execute Drill Version enter 1 0

To execute Training Version enter 1 0

F10 Done

Figure 1b

PCS Auto Ventilation FMT readings Crest Utilities

Offsite Dose Projection
Program
for
Oyster Creek Nuclear Power Station
Rev 03-Revised Aug 12, 1999
Enter your location:

F10 Done

The next screen to display is shown on Figure 1b. The F1, F2, F3, F4, and F9 listed at the bottom of the screen refer to the function keys across the top of the keyboard. The functions displayed across the top of the screen are accessed through the use of "Hot Keys". In this case the "Hot Keys" are P, A, V, F, C, and U pressed in combination with the Alt key. For example, to access the AUTO function, hold down the Alt key and press the A key.

The program operates through a combination of full screen displays, pull down menus, and pop up windows. The function keys and "Hot Keys" which are active at the current position in the program are displayed on the top and bottom lines. When in the menus, choices are made by either directly pressing the letter which is highlighted in red or moving the hi-lite bar using the up and down arrow keys to the desired function, then pressing the Enter key. The ESC key will always back the user out of a function or calculation in the case of an error.

Full screen editing is used for all user input. Input fields are highlighted in blue. If numerical values are being entered, the minimum and maximum values which may be entered are displayed on either the top line or the bottom line of the screen. Move between the input fields using the up and down arrow keys or the enter key. Once all inputs have been entered, pressing the F10 key signifies the computer to accept the values displayed on the screen.

7.1.2 Overview

Upon initiation of the RAC code the operator must enter his/her location and depress the F10 key. The RAC code will automatically attempt to connect to PCS. Once the connection has been established, PCS data will automatically be entered into the computer, including RAGEMS data. If the initial connection to PCS fails, the operator must depress "ALT" and "P". The computer will again attempt to contact PCS. If two attempts to contact PCS fail, the RAC computer will then attempt to contact the RAGEMS computer. If neither connection is successful, the operator will receive an error message.

The RAGEMS system provides real time noble gas effluent monitoring and release point flow rates. Stack high range and low range monitor readings, flow rate, T.B. high and low range monitor readings, and T.B. vent flow rates are available from the PCS. Plant conditions such as Reactor Level, Power, Drywell Hydrogen, Containment Spray Flow, Stand-by Gas Demand, CHRRMS monitor and selected ARMS are also available from the PCS.

Any data points which are not valid are assigned a value of -1.0. Dose projections are broken down into three sections: source term, meteorology, and dose calculation. Meteorology should automatically be updated through contact with the met tower computer. Dose calculations are done with no input by the operator. The source term portion is where most of the inputs and operator decisions are required.

When "F1 Update All" or "F2 Source Term" is pressed the source term menu will appear. Source term calculations fall into three categories: Monitored, Unmonitored, and Contingency. Monitored releases use the RAGEMS monitors on the stack and turbine building vents to develop a source term for a release as it occurs.

Unmonitored calculations are for release points which are not monitored by RAGEMS. An isocondenser failure and an AOG accident are the two specific accidents currently available under this option. Also, a downwind Field Team reading may be used to develop a source term for any ground level release. Unmonitored release calculations may be used to develop a source term for either a release as it occurs or as a "what if" calculation. Contingency calculations provide generic methods to develop a source term for "what if" situations. Calculations are available for events which may happen in the drywell, reactor building, turbine building and the refuel floor.

The drywell calculation includes drywell venting via SBGTS, hardened vent via drywell, hardened vent via Torus and design drywell leakage within the reactor building.

At several places in the code the user is prompted for the most recent Dose Equivalent Iodine. This value can be obtained from chemistry or the STA report.

7.1.3 Source Term Calculations

7.1.3.1 Monitored

7.1.3.1.1 Stack

The stack source term calculation develops a source term based on the RAGEMS I monitored readings or PASS sample. If a RAGEMS I PASS sample is available, the sample will be used along with the stack flow rate to calculate the source term.

> NOTE
>
> Stack monitor readout is logarithmic. A value of less than 10 will read 0.

> NOTE
>
> Lo Range RAGEMS must be manually reset each time it has been shutdown.

If no RAGEMS I PASS sample is available, the RAGEMS I monitors are used. Three values may be entered: low range in cps, high range in amps, and high range in uCi/cc. The PCS will enter the high range value in uCi/cc and the low range value in cps.

If the amps reading is available it should also be manually entered to develop a meaningful source term. The program contains logic to choose between the values if more than one is entered. The stack flow rate will be entered by the PCS if available. If the stack flow rate is not available, entering "0" to this prompt will cause a fan flow table which prompts the user for fan status to appear.

SBGTS filtration should only be used if Stand-by Gas is running and the reactor building fans are isolated. Standby Gas status will be entered by the PCS.

> NOTE
>
> Drywell venting via hardened vent does not go through SBGTS.

The code can take credit for the iodine washout which would occur if the airborne activity is in the containment and the containment sprays are on. Choose these two options only if the release is from the drywell. Again, these two options will be indicated by the PCS.

Finally, the computer will ask for the core condition. If the user knows the current core condition it can be entered directly. Otherwise, the user chooses the "Not Sure" option and is prompted for plant conditions to determine the core condition. The required plant parameters will be displayed via the PCS connection, if applicable. The user may use the displayed values or enter different values.

7.1.3.1.2 Turbine Building

Because the turbine building has release points monitored by both the RAGEMS I and RAGEMS II systems, both are used for this calculation. If RAGEMS PASS samples are available, they are used along with the stack and turbine building vent flow rates to develop the source term. Be aware that the elevated and ground level wind directions may be different. In the absence of PASS samples, the RAGEMS monitors are used to develop the source term. If on-line, the PCS will enter the stack high range and low range readings, the stack

flow rate, the turbine building high and low range readings, and the turbine building vent readings and time after shutdown.

If the user has the high range reading in amps, it should be manually entered. The computer will pick which of the monitor readings to use.

If no RAGEMS PASS sample results have been entered, the computer will prompt the user for the core condition. If the core condition is known, it should be entered directly. Otherwise, the code will prompt the operator for plant conditions from which it will choose the core condition.

7.1.3.2 Unmonitored Releases

7.1.3.2.1 Field Monitoring Team Reading

A downwind field monitoring team reading may be used to develop a source term for a ground level release. The reading must be a closed window reading taken at the plume centerline. The distance to the site must be known in feet. Care should be taken when using this calculation with dose rates taken close to the plant.

Small errors in distance to the plant can lead to large errors in projected dose rates. This calculation may be used to perform a dose projection based on a ground level particulate release. The Deep Dose Equivalent (DDE) dose rates calculated will be accurate but the thyroid doses should be ignored.

7.1.3.2.2 Isocondenser Accident

The isocondenser accident will generate a source term based on the core condition or a reactor coolant sample, and the reactor pressure. This calculation assumes an entire tube bundle ruptures and thus is a worst case estimate only.

7.1.3.2.3 Augmented Offgas Accident

If a leak should develop in the Augmented Offgas (AOG) system this calculation can be used to develop a worst case source term. The coolant DEI is the only parameter needed. The calculation assumes the entire AOG flow is being released to the atmosphere.

7.1.3.3 Contingency Calculations

7.1.3.3.1 Drywell

The drywell contingency calculation is used to develop a source term based on activity contained in the drywell. The calculation determines a source term for containment venting or drywell leakage. The user is prompted to make a choice from four possible drywell leak paths:

1. Drywell hardened vent
2. Torus hardened vent
3. Drywell vent via SBGTS
4. Drywell design leakage.

The hardened vent release can be either the drywell directly to the stack or via the Torus. Venting hardened vent via Torus is preferred option as this allows for scrubbing of particulates during the venting evolution.

Normal containment venting is drywell venting via SBGTS. Drywell design leakage assumes Tech Spec leakage into the reactor building and venting via SBGTS. All of these release scenarios are elevated releases.

After the appropriate vent path is chosen, the user is asked if a drywell air sample is available. If so, it is used to determine the activity. Otherwise, the CHRRMS monitor reading is used along with time after shutdown to calculate the drywell airborne activity. After the drywell activity is calculated, the user is prompted for the leakrate. If the leak rate is not known, entering 0 to this prompt will activate the leak rate calculation utility (7.1.5.5.1). The drywell leak rate scenarios require the status of SBGTS and the stack flow rate to be known. Both will be entered by the PCS.

7.1.3.3.2 Reactor Building

The reactor building contingency generates a source term based on a known volume of reactor building. Reactor coolant concentration is based on either a reactor coolant sample or a core condition. Concentration based on core condition is the worst case for that core condition. The user is prompted for leak rate, how long the leak will last, stack flow, and the status of SBGTS.

If the RAGEMS connection has been made, the RAGEMS computer will enter the stack flow rate.

7.1.3.3.3 Turbine Building

The turbine building contingency generates a source term based on a known volume of reactor coolant being released to the turbine building. Reactor coolant concentration is based on either a reactor coolant sample or core condition.

Concentration based on core condition is worst case for that core condition.

The user is prompted for leak rate, how long the leak will last, stack flow rate, and if the turbine building vents have been isolated. If the vents are not isolated, the code asks for the total vent flow rate. This is the flow from all three turbine building vents.

The PCS computer will enter the stack flow rate and the turbine building vent flow rate.

7.1.3.3.4 Fuel Handling

The fuel handling contingency assumes the FSAR analysis release to determine a source term if spent fuel is damaged. As with all contingency calculations, this calculation gives a worst case source term. Required inputs are time after shutdown, stack flow rate, and SBGTS status. The PCS will enter the stack flow rate.

7.1.4 Meteorology

The RAC computer will call the met tower computer to obtain the current meteorological conditions. The meteorological input screen, (Figure 2), displays met data, chooses which parameters will be used, and allows the user to edit meteorological data.

Initially the user is allowed to edit only the parameters which are needed to perform a dose projection. For example, if an elevated source term exists, only the elevated data may be edited. If no source term exists, then no data may be edited. After the required data have been edited, the user is prompted to determine if he wishes to edit the data which is not needed. Answering "Y" to this prompt allows the user to edit the other meteorological parameters.

When the meteorological input screen is printed, the sectors affected by both a ground level release and an elevated release are printed at the bottom. This information is on the printout only, not the video display.

> NOTE
>
> The RAC Code does not account for seabreeze conditions. For seabreeze considerations refer to EPIP-OC-.31, Exhibit 2E.

FIGURE 2

Time: 11:32:35 Date: 02/28/1991

	A Sensor	B Sensor	USE	Units
33 Ft Wind Speed	7.6	7.9		Mph
150 Ft Wind Speed	9.9	MISSING		Mph
380 Ft Wind Speed	11.6	11.7	12	Mph
33 Ft Wind Direction	239.0	239.0		Degrees
150 Ft Wind Direction	244.0	MISSING		Degrees
380 Ft Wind Direction	239.0	239.0	239	Degrees
150 Ft - 33 Ft Delta T	-1.1	MISSING		Degrees F
380 Ft - 33 Ft Delta T	-3.2	-3.2	-3.2	Degrees F

Elevated Sector Affected ENE

Ground Sector Affected ENE

7.1.5 Other Functions

7.1.5.1 PCS Direct Connection

When first loaded, the RAC program automatically calls the PCS. When the connection is established, the user is prompted for his/her location. Enter this using the F10 key. To leave the PCS display press the ESC key. The PCS line will stay connected as long as the operator does not tell the computer to break the connection by pressing ALT-H while in the PCS display. To reconnect the PCS or access it while connected, press ALT-P.

Subsequent returns to the PCS display will show the most recent PCS data. The display will be automatically updated every 15 seconds as the PCS relays new data. Data is also updated even if the PCS display is not on the screen.

As long as the PCS connection is active, the computer will automatically enter PCS data points any time the user is prompted for RAGEMS information included in the PCS data set. Bad PCS data is assigned a value of -1.0. The PCS choice on the "Hot Key" line is highlighted when the PCS connection is active to allow the user to know it's status from anywhere in the program. If the computer does not connect with the PCS, the user must depress "ALT" and "P".

The computer will then make two more attempts to contact PCS. If these attempts are unsuccessful, it will attempt to connect to the RAGEMS computer. The following message will be displayed:

"Dialing RAGEMS Computer Please wait for about 60 seconds for RAGEMS DATA." If the computer connects with RAGEMS, "PCS" displayed in the upper left hand corner will change to "RAGEMS" and the RAGEMS data (stack high range and flow, turbine building high and low range and vent duct flow rates) will be displayed. The RAGEMS data will be transmitted to the RACP and the modem will hang up.

If the computer does not connect with PCS or RAGEMS, the operator will receive a warning.

7.1.5.2 Automatic Dose Projection

The Alt-A "Hot Key" will activate automatic dose projections with no input from the operator providing the PCS connection is active. If the Alt-A "Hot Key" is pressed without a computer connection, the operator will receive a warning. The operator will also receive the following warning: "WARNING! Do not use auto dose projection if Containment Spray is initiated." This warning is provided because auto dose projection does not consider the iodine scrubbing effect of Containment Spray.

Dose projections will be performed automatically, a minimum of every two minutes and a maximum of every fifteen minutes, when this option is active. All normal calculations are still available while in the automatic projection mode. Pressing the Alt-A "Hot Key" while in automatic turns the automatic function off. The computer determines the frequency of new dose projections based on the incoming data from the PCS.

The automatic dose projection uses data from the PCS or RAGEMS computer to determine release path, core damage, source term, and release duration. Met data are obtained by calling the met tower. When the automatic dose projection option is active, the Auto "Hot Key" will be highlighted.

7.1.5.3 Ventilation

A simplified ventilation diagram can be displayed on the screen by pressing the Alt-V "Hot Key". The diagram shows the release paths for monitored releases at oyster Creek. ESC returns the user to the main program.

7.1.5.3.1 Release Path Analysis

Pressing the F1 key while on the ventilation screen will perform a release path analysis. If the RAC computer is connected to the PCS, the analysis may be done with no input from the operator. Otherwise, the operator will be prompted for various RMS parameters. The output of this analysis is both to the screen and the printer. Recommendations are included on ways to verify the analysis.

> **CAUTION**
>
> This analysis is meant to be used as an aid only. It is in no way meant to replace sound engineering judgement.

7.1.5.4 Field Monitoring Team Readings

Alt-F activates the Field Monitoring Team (FMT) reading window where data from the FMT's are manually entered. As data are entered, the four most recent data points are retained by the computer for display on the final output screen.

Four input fields are required: time, FMT location, DDE dose rate, and thyroid dose rate. Thyroid dose rate is calculated in the field iodine calculation and is automatically entered in the FMT screen. Use the up and down arrow keys and the enter key to move between input fields. The left and right arrow keys and the backspace key are used to edit within a field. F10 enters the data as displayed on the screen.

If an error is discovered after data has been entered, enter "ERROR" in the time input field. This will allow the user to delete one of the existing FMT readings. By positioning the cursor at the reading to be deleted using the up and down arrow keys, then pressing F10, the reading is deleted from the computer memory.

The ESC key returns the user to the main program.

7.1.5.5 Utility Functions

Alt-U activates the utilities menu. Eight functions are available which are explained below.

7.1.5.5.1 Leak Rate Calculation

The leak rate calculation uses Bernoulli's Equation to calculate an approximate leak rate for air, steam, or water based on the leak size in square feet and the driving pressure. If the calculation is for air, the air temperature is also needed.

The result is in cfm. Change of state resulting from either steam or water at elevated temperature and pressure being released to atmospheric pressure may be calculated if the enthalpy of the fluid in Btu/lb is known. The code will then calculate both steam and water leak rates in cfm.

7.1.5.5.2 Core Damage Estimation

A rough core damage estimation is done using the CHRRMS reading and time after shutdown. The result is in percent fuel melt. This calculation should only be used until a core damage calculation using EPIP-33 can be performed.

7.1.5.5.3 Field Iodine Measurement

This function will convert gross field data to a committed thyroid dose rate. The minimum data required are: gross silver zeolite cartridge reading in cpm, gross filter reading in cpm, background reading in cpm, sample flow rate in liters/min, sample time in minutes, and time after shutdown in hours. The FMT designation and location should also be entered.

The input data are entered as in all full screen editing functions as described in 7.1.1. The resulting committed thyroid dose rate is in mRem per hour of exposure. The time, location, and committed thyroid dose rate are automatically transferred to the Field Monitoring Team (FMT) data entry function (7.1.5.4) for display if the operator accepts the data from within the FMT data entry function.

7.1.5.5.4 Unit Conversions

A function is available which will convert units of measurement from one measuring system to another. Conversions are available for units of Length, Area, Volume, Flow, Speed, Pressure, Temperature, Dose, Equivalent Dose, and Activity.

On choosing the conversion function, another menu appears to allow the operator to choose which of the above measurements will be converted. The next menu allows the user to choose the units which the value is currently in, or put another way, the units to be converted from. The final menu chooses the units to be converted to. Once these choices have been made, enter the value to be converted using the F10 key. The result is the value in the new units.

For example, to convert 10 feet to meters, the conversion function is chosen from the utilities menu. On the second menu, units of length are chosen. Choose feet on the third menu, and meters on the fourth. Then enter 10 into the input field with the F10 key and the result is 3.05 meters.

The ESC key is used to backstep through the menus.

7.1.5.5.5 Semi-Infinite Cloud Approximation

Approximate total airborne concentration in uCi/cc and DAC for iodine are calculated based on a gamma reading, approximate cloud radius, and the time after shutdown. The gamma reading MUST be due entirely to airborne activity, not direct shine.

7.1.5.5.6 Calculator

A simple calculator which will add, subtract, multiply, and divide is the final function on the utilities menu. The calculator uses "Reverse Polish Notation" (RPN) logic. An example is the best way to explain.

To add 3.5 and 7.6 in the calculator function, enter 3.5 using the F10 key. Next enter 7.6 with F10 key. Finally, enter "+" with the F10 key. The result is 11.1. To then divide this number by 2, enter 2, then "/". The result is 5.55.

The symbols for the math functions are listed below.

+ addition
- subtract
* multiplication
/ division

7.1.5.5.7 Options

This choice will produce an additional menu of five choices. The first choice allows the user to change the phone numbers the code uses to connect to the met tower, RAGEMS computer, plant computer, and CREST computer. Usable phone numbers are:

Met Tower:	971-4519 or 971-4524
RAGEMS:	971-4758
PCS:	971-4435, 971-4107, 971-4168 or 971-4109
CREST:	777-4207, 777-4208, or 777-4210.

The second option allows the user to turn the RAGEMS alarm function on or off, and set the alarm setpoints. RAGEMS I low and high range and RAGEMS II low and high range monitor can be continually monitored, and if any exceed the setpoint, the PCS data display will appear on the screen. The display will not appear again in response to exceeding a setpoint until the alarm function is reset. The default for the alarms function is "on".

The third option allows the CREST reading to be automatically monitored, and the CREST display to appear if any reading exceeds the setpoint. The default condition is "on".

The fourth option, "MODEM", gives control of the communications lines to the various computers. Because of the sensitive nature of access to these computers, this option is password protected and only available to the system administrator. The final option is a "DOS" shell. Choosing this option allows the user to issue DOS commands while remaining connected with the external data links. To return to the RAC code, type "EXIT".

7.1.5.5.8 Gamma Dose Rates

This option displays the deep dose equivalent dose rates at site boundary, 2, 5, and 10 miles and maximum dose rate.

7.1.5.6 Crest System

Pressing ALT-C activates the CREST display. The computer will first dial into the NJ DEP computer and login to the system. Once the connection is complete, which takes about 40 seconds, a map of the EPZ will appear on the screen with the location and reading of the 16 Reuter-Strokes monitors. Any reading above the alarm setpoint (Section 7.1.5.5.7) will be in red. Pressing ESC returns to where the user was when the CREST display was activated. As long as the line is not hung up (ALT-H), subsequent activities of the CREST display will not have to go through the login process. Data is updated with one minute frequency. Access to CREST requires a password which is changed in the RACP support file "PHONE.NUM" on a quarterly basis by Emergency Preparedness or the Radiological Engineer assigned responsibility for the RACP.

7.1.6 Release Duration

Depending on the type of release, the computer may generate a default release duration. In the absence of better information, this value may be used for the release duration. Before using the default, check with the engineers, control room, TSC, and Parsippany or use your own judgement to determine if a better value is available.

If no default release duration exists in the computer, the operator must provide an estimate for the release duration.

> NOTE
>
> The default release duration approximates the radiological impact of the actual release. Assuming that the release rate is constant, the 7 hour or 1 hour release duration will approximate the actual release.

7.1.7 Final Output

The final output gives total dose, dose rate, and time to the PAG for both whole body and thyroid exposures for the site boundary, 2,5, and 10 miles. The distance to the maximums is also displayed for both whole body and thyroid along with the total dose, dose rate, and time to PAG for the maximum.

The center section of the display shows the most recently entered meteorological data. Below that are the four most recent field monitoring team readings. The maximums and wind directions are highlighted in yellow to distinguish the most important information.

A hard copy is made of this display (Figure 3) which also includes the Emergency Classification which is appropriate for the projected doses. The logic used to calculated the classification is:

Emergency Classification	Maximum Dose (mRem) within 10 miles	
	Whole Body	Thyroid
Unusual Event	0.1<= Dose < 10	0.5<= Dose < 50
Alert	10 <= Dose < 50	50 <= Dose < 250
Site Area Emergency	50 <= Dose <1000	250 <= Dose <5000
General Emergency	1000 <= Dose	5000 <= Dose

The classification is determined based on the most limiting of the maximum whole body dose and maximum thyroid dose. Finally, all inputs and assumptions used in obtaining the dose projection are listed. These may be used after the fact to reconstruct how the dose projection was done.

FIGURE 3

PCS Auto Ventilation TIME 16:09 FMT readings Crest Utilities

TOTAL EFFECTIVE DOSE EQUIVALENT				THYROID COMMITTED DOSE EQUIVALENT				
Dis. Miles	Dose mRem	Dose Rate mRem/Hr	Hours to PAG	Dis. Miles	Chi/Q Sec/M^3	Dose mRem	Dose Rate mRem/Hr	Hours to PAG
SB	5.46E+00	7.80E-01	>99	SB	2.33E-19	BKG	BKG	>99
2.0	6.09E+00	8.70E-01	>99	2.0	7.73E-07	3.04E-01	4.34E-02	>99
5.0	2.56E+00	3.65E-01	>99	5.0	6.45E-07	2.52E-01	3.61E-02	>99
10.0	1.08E+00	1.54E-01	>99	10.0	3.23E-07	1.26E-01	1.79E-02	>99
Max. Dose 1.1	7.43E+00	1.06E+00	>99	Max. Dose 2.8	8.46E-07	3.32E-01	4.74E-02	>99

MET DATA

Ground Wind Speed 16.4 mph
Ground Wind Dir (from) 225 degrees
Ground Stability Class D

Elevated Wind Speed 11.6 mph
Elevated Wind Dir (from) 239 degrees
Elevated Stability Class D

FIELD READINGS

Time	Location	WB Dose Rate	Th Dose Rate
		mRem/hr	mRem/hr
		mRem/hr	mRem/hr
		mRem/hr	mRem/hr
		mRem/hr	mRem/hr

F1 Update All F2 Source Term F3 Met Data F4 Update Dose F9 Quit

EMERGENCY CLASSIFICATION

NO CLASSIFICATION based on dose projections

ASSUMPTIONS / INPUTS USED

Time = 16:09 Date = 1/20/1994
Stack release calculation
Stack low range reading = 10000 cps
Stack high range reading = 1.000E-10 Amps
Stack high range reading = 4.000E-01 µCi/cc
Stack flow rate = 137500 cfm
Time after shutdown = 2.00 hours
Containment spray not considered
Clad damage spectrum chosen
(.03 noble gases, .02 iodines w/ partition factor of 1000)
SBGT operating
Release duration = 7.00 hours
Assumed gross elevated release rates:
1.58E+06 µCi/s Noble Gas, 1.65E+02 µCi/s Iodine
Assumed gross ground release rates:
0.00E+00 µCi/s Noble Gas, 0.00E+00 µCi/s Iodine

7.2 Theory

7.2.1 Source Term

The Source Term portion of the Oyster Creek RACP is used to generate the quantity and radionuclide composition of the radioactive material released (or available for release) to the environment. Releases are divided into three categories: monitored, unmonitored, and contingency. Monitored releases are from the two release points monitored by the RAGEMS system. Unmonitored releases are potential release points which are not included in the RAGEMS system. Contingency source terms attempt to generate a source term for the "what if" cases. The source term module calculates release rates by isotope in uCi/s.

7.2.1.1 Spectrum Determination

Except in cases where an actual RAGEMS or coolant sample is available, a precalculated spectrum must be assumed. The assumed spectrum takes two different forms depending on the type of calculation being performed. If the source term is being determined for a monitored release point, three spectra from Ref. 1 are used. These spectra represent assumed isotopic fractions for the 33 isotopes assumed to be present in an effluent stream.

These isotopes are:

Kr85	I131	Ru103	La140
Kr85m	I132	Ru106	Ce144
Kr87	I133	Te129m	Np239
Kr88	I134	Te131m	Y91
Xe131m	I135	Te132	Mo99
Xe133	Sr89	Sb127	Ba140
Xe133m	Sr90	Sb129	
Xe135	Sr91	Cs134	
Xe138		Cs136	
		Cs137	

Alternately, for unmonitored releases and contingency calculations, expected isotopic concentrations based on either the above spectrums, or modified by current or expected plant parameters such as Dose Equivalent Iodine, are used. The clad damage spectrum for these cases assumes 100% of the full power clad inventory is released to the reactor coolant. Fuel melt assumes 100% core inventory of the 33 isotopes is released to the reactor coolant. If the computer operator knows the core condition, he may directly choose the appropriate spectrum. If not, he is prompted by the code for plant parameters to determine the appropriate spectrum. Criteria for choosing spectra are:

Fuel Melt Drywell hydrogen ≥0.5%

CHRRMS ≥30,000 R/hr

Rx level < = 30" TAF for 1 hour or greater

Clad Damage	CHRRMS >1,000 and <30,000 R/hr
	Rx level ≤ 0" TAF
	Anticipated transient without scram (ATWS)
	Control rod drop
	Fuel handling accident
No Damage	All other cases

7.2.1.2 Monitored

Two release points are monitored by the RAGEMS system. The main stack is monitored by RAGEMS I, and the Turbine Building vents by RAGEMS II. Both systems consist of a high range ion chamber and low range scintillation detector which continually sample the effluent stream for noble gases. Flow indications are also available. For a more detailed description, see reference 9.2.

7.2.1.2.1 Stack

If a stack RAGEMS isotopic sample is available, the individual isotopic concentrations are multiplied by the stack flow rate to develop a source term. The stack flow rate is either available from the RAGEMS computer or calculated using fan status and rated flows.

In the absence of a stack RAGEMS sample, the RAGEMS monitors are used along with precalculated spectrums and the stack flow rate. RAGEMS information is either input directly from the RAGEMS computer as discussed in Section 7.2.4.1 or input manually by the computer operator. Points available from the RAGEMS systems and normal background levels where applicable, are:

Stack Low Range	0 cps
Stack High Range	1.0 E-13 Amps
Stack High Range	.00646 uCi/cc
Stack Flow Rate	(cfm)
T.B. Low Range	0 cpm

Feed Pump Room vent flow rate (cfm)

Operating Floor vent flow rate (cfm)

Lube Oil Bay vent flow rate (cfm)

Three different inputs from the RAGEMS I system are accepted by the computer. These are:

- Low range in cps from panels 1R and 10F (strip chart recorder)
- High range in amps from panel 1R
- High range in uCi/cc from the RAGEMS computer

Gross effluent noble gas concentration is then calculated as:

C_n = Ls/4.11E5 (1)

If $C_n > 0$ or $\leq .5$ this value is used.

If $C_n \leq 0$ or $C_n > .5$ and either of the high range readouts are on scale (above .01 uCi/cc) then:

If the RAGEMS computer stack hi-range is on scale:

$C_n = H_{us}$ (2)

Otherwise if Hus is not available

$C_n = H_a/4.06E-10$ (3)

Where C_n = total effluent noble gas concentration (uCi/cc)

Ls = RAGEMS I low range monitor activity (cps)

H_{us} = RAGEMS I computer hi-range reading (uCi/cc)

H_a = High range reading (amps)

4.11E5 = low range conversion factor $\frac{cps}{uCi/cc}$

4.06E-10 = high range conversion factor $\frac{amps}{uCi/cc}$

After the appropriate spectrum is chosen as described in 7.2.1.1, the spectrum is decayed for time after shutdown. If the Standby Gas Treatment System (SBGTS) is operating, the isotopic fraction for the iodines are reduced by a factor of 10 (90% efficient). The iodine fractions are further reduced by a factor of 10 if the release is from the Drywell and containment sprays are operating to take credit for iodine washout (Ref9.3). The decayed, filtered, and scrubbed isotopic fractions are then renormalized to 1.0 to give a prediction of the isotopic spectrum at the time of release.

Isotopic source term is then:

$$Ci = C_N * \frac{Fi}{\Sigma n} \qquad (4)$$

where:

C_N = gross noble gas source term

Ci = concentration of isotope i (uCi/cc)

Fi = release fraction of isotope i

$\Sigma n = \sum_{i=1}^{9} Fi$ = sum of noble gas fractions

i = 1 to 9 for noble gas isotopes

i = 10 to 14 for iodine isotopes

i = 15 to 33 for all other particulates

Because the RAGEMS sampling system contains iodine and particulate filters, the RAGEMS monitors detect only gross noble gas source term. Equation four calculates individual noble gas source terms by multiplying gross noble gas source term by the assumed isotopic release fractions.

The iodine isotopes are not measured by the RAGEMS system. Since only a noble gas gross concentration is calculated, an expected iodine to noble gas ratio is used. This calculated as:

$$Ring = \frac{\Sigma_I}{\Sigma_{ng}} \qquad (5)$$

Where Ring = iodine to noble gas ratio

$\Sigma_I = \sum_{i=10}^{14} Fi$ = sum of iodine fractions

The gross iodine concentration would then be

$$C_I = C_N * Ring \qquad (6)$$

Where C_I = total iodine effluent concentration (uCi/cc)

The isotopic iodine concentrations are:

$$Ci = C_I * \frac{Fi}{\Sigma_I} \quad (7)$$

or

$$Ci = C_N \frac{*\Sigma_I}{\Sigma_N} * \frac{Fi}{\Sigma_I} \quad (8)$$

which reduces to equation (4)

Isotopic source term is calculated as:

$$Si = Ci * FR * 472 \quad (9)$$

where:

FR = stack flow rate (cfm)

472 = conversion factor $\frac{cc/s}{cfm}$

Si = release rate of isotope i $\frac{uCi}{s}$

7.2.1.2.2 Turbine Building

The turbine building has two release points. The condenser bay exhausts to the main stack. The TB operating floor, feed pump room, and lube oil bay exhaust through vents which are monitored by the RAGEMS system. The isotopic source term for the portion of the release which goes to the main stack is calculated using the same method and constants outlined in 7.2.1.2.1 with the exception that no SBGTS filtering or containment spray washout exists.

Similar to the stack (7.2.1.2.1), if a Turbine Building RAGEMS sample is available, source term is determined using the isotopic concentrations and the total Turbine Building vent flow rate. Otherwise the RAGEMS II monitors are used to develop a source term.

The RAGEMS II system provides the following points which are available via the RAGEMS computer.

Turbine Building low range (cpm), Turbine Building high range (uCi/cc), Feed Pump Room vent duct flow rate (cfm) (fp vent), Operating Floor vent duct (TB stack) flow rate (cfm) (Op vent), and Lube Oil Bay vent duct flow rate (cfm) (Lb vent).

Gross effluent noble gas concentrations is calculated as:

$$C_N = L_T/5.032E6 \qquad (10)$$

If $C_N > 0$ or $\leq .5$ this value is used.

If $C_N \leq 0$ or $C_N > .5$ and the RAGEMS II high range monitor is on scale (above 0.01 uCi/cc) then

$$C_N = Hut \qquad (11)$$

where:

C_N = total effluent noble gas concentration $\frac{uCi}{cc}$

L_T = RAGEMS II low range monitor (cpm)

Hut = RAGEMS II high range monitor (uCi/cc)

5.032E6 = low range conversion factor (cpm/uCi/cc).

Total flow is the sum of the three vent flows

FR = Fp vent + Op vent + Lb vent

or a default value of 47,000 cfm is used.

Once the gross noble gas source term and flow rate have been calculated, the isotopic release rates are calculated using equations (4) and (9) of 7.2.1.2.1.

7.2.1.3 Unmonitored

Three methods of developing a source term during an unmonitored release are contained in the code. The most general is through the use of a downwind gamma reading to develop a source term. Accident-specific source term can be generated for an isocondenser failure and an AOG line break. The calculations are overly conservative because of the nature of an unmonitored release and should be treated as such.

7.2.1.3.1 Field Monitoring Team Reading

This calculation uses a downwind centerline gamma reading and the time after shutdown to develop an isotopic source term. The calculation assumes a clad damage spectrum since this is used in the majority of the severe FSAR accident analyses. The spectrum is decayed for time after shutdown, then renormalized to 1.0. Next, an assumed gross release rate of 1 uCi/cc and flow rate of 1000 cfm are used to perform a dose projection at the downwind distance where the gamma dose rate was taken.

This spectrum is:

Sia = 1.0 * Fi * 1000 * 472

where:

Sia	=	assumed isotopic source term (uCi/s)
1.0	=	assumed gross release concentration (uCi/cc)
Fi	=	isotopic fraction of isotope i
1000	=	assumed flow rate (cfm)
472	=	conversion factor (cc/s/cfm)

Using the resulting calculated dose rate, the source term is then calculated as:

Si = Sia * DRc/DRm

where:

Si = isotopic source term (uCi/s)

DRc = calculated dose rate using assumed isotopic source term

DRm = measured dose rate

7.2.1.3.2 Isocondenser Accident

At Oyster Creek two isolation condensers are used as part of the Emergency Core Cooling System. These isocondensers are shell and tube heat exchangers with steam from the reactor flowing through tubes, giving up energy to water on the shell side, condensing, and returning to the reactor. As the shell side water warms, it eventually begins to boil and releases steam to the atmosphere. In the event of a tube leak or rupture, a direct path exists for reactor coolant to be released to the atmosphere.

A single isocondenser consists of two U-shaped tube bundles, each with 36 tubes. Because it is not practical to determine the number of tubes which are leaking, this calculation assumes an entire tube bundle to have ruptured.

Coolant leak rate is calculated:

LRc = 165000 * $(Pr/2.5)^{1/2}$ * .016/60

where:

LRc = coolant leak rate (cfm)

165000 = rated flow rate through tube bundle at 2.5 lb pressure drop (lb/hr)

Pr = reactor pressure (PSIA)

2.5 = pressure for rated flow (PSIA)

0.16747 = specific volume of water (ft^3/lb)

60 = minutes per hour

The coolant concentration is obtained either from a reactor coolant sample if one is available or precalculated spectra as described in 7.1.1.1. If the precalculated no damage spectrum is used, which represents the normal coolant concentrations, it is adjusted to current conditions by rationing the actual DEI to that assumed for the spectrum.

The resulting coolant isotopic concentrations are then multiplied by the calculated leak rate to give an isotopic source term in uCi/s.

7.2.1.3.3 Augmented Offgas Accident

The Augmented Offgas (AOG) system is used to hold up and filter the effluent from the air ejectors before it is released via the stack to the atmosphere. This calculation assumes a normal AOG isotopic spectrum as developed in Reference 9.4.

The release spectrum can be modified to match current conditions by the use of a current DEI. This value is rationed to the DEI of the assumed normal coolant to modify the assumed release concentrations. A standard AOG flow rate of 122 cfm is used.

7.2.1.4 Contingency Calculations

Contingency calculations attempt to develop a source term for the "what if" cases before a release actually begins. Four contingency calculations are available.

Because these are contingency calculations and assumptions must be made, it must be stressed that the calculations are worst case for a given accident.

7.2.1.4.1 Drywell

The drywell contingency calculation is used to develop a source term for an actual or hypothetical accident in the drywell. A drywell isotopic air sample is either directly input by the operator or calculated based on the Containment High Range Radiations Monitoring System (CHRRMS). If the CHRRMS is used, gross concentration is calculated:

$$C_D = DR_c * 813 * 1E6/8.8E9$$

where:

C_D = gross containment airborne concentration (uCi/cc)

813 = gross activity (Ci) per R/hr in containment, see Reference 5

1E6 = conversion (uCi/Ci)

8.8E9 = free air volume of drywell and Torus (cc) Reference 9.9

DR_C = CHRRMS monitor reading (R/hr)

The CHRRMS reading is then used to choose an isotopic spectrum as outlined in 7.2.1.1. After the spectrum is decayed for time after shutdown and renormalized, drywell isotopic concentration can be calculated:

$$C_{Di} = C_D * fi$$

where:

C_{Di} = concentration of isotope i in the drywell

fi = decayed and renormalized isotopic fraction of isotope i

After the isotopic concentrations are either entered or calculated as outlined above, the release rate from the drywell is needed. This calculation addresses four release paths. The first is drywell hardened vent. The Drywell hardened vent assumes venting directly to the stack. The user is asked for the leakrate.

Isotopic source terms are:

$$S_i = C_{Di} * \text{dwleakrate} * 472 *$$

where:

S_i = isotopic release rate (uCi/S)

dwleakrate = drywell leakrate via hardened vent (cfm)

472 = conversion factor (cc/s / cfm)

The second release calculation is TORUS hardened vent. The drywell is vented through the TORUS with which scrubs particulates. Isotopic source terms are:

$$S_i = C_{Di} * dwleakrate * 472 * FFi$$

where:

S_i = isotopic release rate (uCi/S)

dwleakrate = drywell leakrate via hardened vent (cfm)

472 = conversion factor (cc/s / cfm)

FFi = filtration factor 1.0 for noble gases, 0.01 for paticulates and halogens.

The third release is drywell venting via SBGTS. This release path gives a flow rate of 2600 cfm from the drywell to the main stack. Isotopic source terms are:

$$S_i = C_{Di} * 2600 * 472 * FFi$$

where:

S_i = isotopic release rate (uCi/S)

2600 = maximum flow rate through SBGTS (cfm)

472 = conversion factor (cc/s / cfm)

FFi = filtration factor 1.0 for noble gases, 0.1 for halogens and particulates.

The last release calculation which can be calculated is the release due to normal drywell leakage. The drywell leakage is calculated as a function of drywell pressure as:

$$DL = .632 * (P_D/35)^{1/2} * 472$$

where:

DL	=	drywell leakage (cc/s)
.632	=	Tech Spec drywell leakage at 35 psi (cfm)
35	=	Tech Spec drywell pressure (psi)
P_D	=	Drywell pressure (psi)

This value, when multiplied by the drywell isotopic concentrations, yields an isotopic source term.

7.2.1.4.2 Reactor Building

The reactor building contingency calculates a release rate based on a volume of coolant released to the reactor building. Coolant concentration is either manually input or assumed based on the entered spectrum as outlined in 7.2.1.1 with the "No Damage" spectrum corrected for current DEI.

Isotopic source term is then calculated as:

$S_i = C_i$ * (LR*LT*3785/5.04E10)*2600*FF_i*472

if SBGTS is on and

$S_i = C_i$ * (LR*LT*3785/5.04E10)*65000*472

if SBGTS is off

where:

S_i	=	isotopic release rate (uCi/s)
C_i	=	isotopic coolant concentration (uCi/cc)
LR	=	leak rate (gpm)
LT	=	leak time (minutes)
3785	=	conversion factor (cc/gal)
5.04E10	=	volume of reactor building (cc) Reference 9
2600	=	SBGTS flow (cfm)
65000	=	reactor building fan flow (cfm)
FF_i	=	filtration factor; 1.0 for noble gases, 0.1 for iodines
472	=	conversion factor $\left(\frac{cc/s}{cfm}\right)$

7.2.1.4.3 Turbine Building

The turbine building contingency calculates a source term based on a volume of coolant released to the turbine building. Because the turbine building has both elevated (main stack) and ground level (TB vents) release points, both elevated and ground level source terms are developed.

Reactor coolant concentration is either manually input or assumed based on the entered spectrum as outlined in 5.2.1.1 with the "No Damage" spectrum corrected for current DEI. Elevated source term is:

$S_i = C_i$*(LR*LT*3785/1.0E11)*86000*472

where:

S_i	=	isotopic release rate (uCi/s)
C_i	=	isotopic coolant concentration (uCi/cc)
LR	=	leak rate (gpm)
LT	=	leak time (minutes)
3785	=	conversion factor (cc/gal)
1.0E11	=	volume of turbine building (cc) Reference 9
86000	=	turbine building fan flow (cfm)
472	=	conversion factor (cc/s / cfm)

and the ground level source term, if the vents are not isolated is:

$$S_i = C_i * (LR*LT*3785/1.0E11) * F_{TB} * 472$$

where:

F_{TB} = total turbine building vent flow (cfm)

= Operating Floor vent flow + Pump Room vent flow + Lube Oil Bay vent flow

7.2.1.4.4 Fuel Handling

The fuel handling accident contingency develops a source term for a fuel handling accident. This calculation assumes a fuel bundle is dropped onto the core with damage resulting to 124 fuel rods (FSAR analysis). One hundred percent of the gap activity contained in the rods is released to the refuel floor. At T=O the gap activity contained in 124 fuel rods by isotope is:

Kr 85	38.9 Ci
Kr 85m	1670 Ci
Kr 87	3280 Ci
Kr 88	4750 Ci
Xe 131m	699 Ci
Xe 133	11900 Ci
Xe 133m	418 Ci
Xe 135	2370 Ci
Xe 138	11900 Ci
I 131	3960 Ci
I 132	5570 Ci

I 133	7890 Ci
I 134	8820 Ci
I 135	6960 Ci
Te129m	1.2 Ci
Te131m	3.1 Ci
Te132	28 Ci
Sb127	1.4 Ci
Sb129	7.7 Ci
Cs134	870 Ci
Cs136	348 Ci
Cs137	545 Ci

These values were calculated using total gap activity from Reference 3 and multiplying by 124/34720 to represent the fraction of fuel pins damaged. These activities are first decayed for the time after shutdown, then considered to be released to the refuel floor atmosphere. Release rates are calculated:

$S_i = R_i$*1.0E6/2.0E10*1270*472*FF_i

if SBGTS is running, or

$S_i = R_i$*1.0E6/2.0E10*31700*472

if SBGTS is not running

where:

R_i = decayed amount of isotope i release (Ci)

1.0E6 = conversion (uCi/Ci)

2.0E10 = refuel floor volume (cc)

1270	=	maximum flow rate from refuel floor with SBGTS on (cfm)
31700	=	maximum flow rate from refuel floor with reactor building fan on (cfm)
S_i	=	isotopic release rate (uCi/s)
472	=	conversion factor $\left(\frac{cc/s}{cfm}\right)$
FF_i	=	filtration factor 1.0 for noble gases 0.1 for iodines

7.2.2 Meteorology

Normally, meteorological parameters are obtained through a direct connection, via modem, with the Forked River met tower. If the connection cannot be completed, or the operator wishes to manually enter meteorological parameters, full screen editing allows both elevated (380 ft) and ground level (33 ft) parameters to be input. The code initially allows only those parameters which are necessary to perform a dose projection based on the source term to be entered. For example, if only an elevated source term exists, only the elevated parameters may be edited. If no source term above background exits, initially no editing will be allowed.

After the needed parameters are entered, the computer asks the operator if he wishes to edit the values which will be displayed on the meteorology section of the final output, but not needed for the calculations.

7.2.2.1 Stability Class

The difference in temperature between two heights (T) is used as a measure of the atmospheric stability. Based on the ΔT, one of the Pasquill-Gifford stability classes is chosen. Specific criteria are as follows:

Stability Class	Delta T (380-33ft) Elevated	Delta T (150-33ft) Ground
A	< -3.61	< -1.22
B	-3.61 to -3.24	-1.22 to -1.10
C	-3.23 to -2.86	-1.09 to -0.97
D	-2.85 to -0.96	-0.96 to -0.33
E	-0.95 to 2.84	-0.32 to 0.95
F	2.85 to 7.58	0.96 to 2.55
G	>7.59	>2.56

ΔT is in degrees Fahrenheit.

7.2.2.2 Windspeed

Although elevated wind speed is input by the operator or the met tower computer, the elevated wind speed is adjusted for the height of the stack using the equation

$$WS_A = WS_E * 368.1 * P/380$$

where:

WS_A = adjusted wind speed (mph)

WS_E = entered wind speed (mph)

368.1 = physical stack height (ft)

380 = height of elevated sensors (ft)

p = 0.25 if A, B, or C stability
0.33 if D stability
0.50 if E, F, or G stability

The lowest adjusted wind speed allowed is 0.5 mph.

7.2.2.3 Wind Direction

Both elevated and ground level wind direction are entered in degrees 'from'. Wind direction 'to' is calculated by adding 180° if the wind direction is less than 180° or subtracting 180° if the wind direction is greater than 180°. The sector the wind is blowing into is based on the following ranges.

Sector	Degrees	Sector	Degrees	Sector	Degrees
N	350-11	SE	125-146	W	260-281
NNE	12-34	SSE	147-169	WNW	282-304
NE	35-56	S	170-191	NW	305-326
ENE	57-79	SSW	192-214	NNW	327-349
E	80-101	SW	215-237		
ESE	102-124	WSW	238-259		

7.2.3 Dose Projections

Two separate models are used by the RAC code to calculate whole body and thyroid dose rates. TEDE dose rates are calculated using a finite gamma model which calculates dose rates from both an overhead cloud and immersion. Thyroid dose rates are calculated using a semi-infinite cloud model.

7.2.3.1 Release Height

At Oyster Creek the only elevated release point is the main stack. All other release points are considered ground level with a release height of 0. Elevated release height is:

$$H_R = 112.2 + P_r - T_f$$

where:

H_R	=	effective release height (meters)
112.2	=	physical stack height (meters)
P_R	=	plume rise calculated using the Briggs Plume Rise Equations (Ref. 13)
T_f	=	terrain factor based on downwind distance and wind direction (meters)

7.2.3.2 Building Wake Effect

For ground level releases a building wake effect is calculated which is used as a virtual source distance. The distance simulates the building wake effect of the reactor building. The virtual distances for each of the seven stability classes are 209, 209, 209, 284, 483, 734, and 1219 meters, respectively. The virtual distance is added to the actual downwind distance before the dose projection is performed.

7.2.3.3 Finite Model

The OCNGS RACP model calculates external whole body gamma dose rate using a finite model for both ground and elevated releases. The finite gamma dose algorithm is licensed from Dr. John Hamawi of Entech Engineering through Pickard, Lowe, & Garrick, Inc (PL&G). (Dr. Hamawi was the author of the dose integral routine listed in Appendix F of Reg. Guide 1.109). The dose is computed by multiplying the dose rate by the expected duration of release. The finite gamma dose algorithm in the OCNGS RAC model has the same structure as Pickard, Lowe & Garrick's MIDAS finite gamma dose algorithm. The basis for the algorithm is a three dimensional array of finite gamma factors. These finite gamma factors are pre-computed three dimensional numerical integrations which appear in the theory of the finite cloud model and represent the spatial distribution of the radioactive material in the finite plume. These factors depend upon the plume dimensions at the downwind distance of interest, the plume elevations, and the average gamma energy of the nuclide mix in the cloud. They are sometimes referred to as "gamma X/Q" in the literature although they are not derived from typical X/Q calculations.

The finite gamma factors in the array correspond to 28 downwind distances, 6 heights above ground, and 6 energy groups. Specifically, the downwind distances are: 400, 500, 600, 700, 800, 900, 1000, 1250, 1500,1750, 2000, 2250, 2500, 3000, 3500, 4000, 4500, 5000, 5500, 6000, 6500, 7000, 7500, 8000, 9000, 10000, 15000, and 20000 meters. The 6 heights above ground are: 0, 50, 100, 150, 250, and 500 meters. The six energy groups are: 0.032, 0.081, 0.15, 0.25, 0.53, and 1.0 MeV. The abundances of the noble gases for the six energy groups were taken from MIDAS or calculated using the same methods used by PL&G.

For effective release heights other than the 6 fixed heights, the finite gamma factors are extrapolated to that height. For downwind distances other than the 28 fixed downwind distances, the finite gamma factor of the nearest fixed distance is assigned to that distance, i.e., no horizontal interpolation is done, as is consistent with MIDAS.

The OCNGS RAC model explicitly includes the contribution of I-131, I-132, I-133, I-134, and I-135 to the external whole body gamma dose, as well as the particulates. This method of handling the contribution from the radioiodines is more accurate than the method used in MIDAS. The abundances of the radioiodines were taken from the Radioactive Decay Data Tables, D.C. Kocher, 1981. All radionuclides are decayed during plume travel.

A more detailed discussion of the finite model is contained in Appendix A.

7.2.3.4 Semi-Infinite Model

The OCNGS RAC model calculates the thyroid dose rate due to inhalation of I-131, I-132, I-133, I-134, and I-135. The thyroid dose rate is proportional to X/Q. The program uses the dose factors from Table 5.2, EPA-400. The dose is computed by multiplying the dose rate by the expected duration of the release.

The radioiodines are decayed during plume travel time. The decay constants for I-131 through I-135 are from the Radiological Health Handbook, Reference 6.

The thyroid dose rate at distance d is then:

$$DR(d) = \frac{X}{Q}(d) * \sum_{i=1}^{5} Si * DF_i$$

where:

DR(d) = thyroid dose rate at distance d (mRem/hr)

$\frac{X}{Q}(d)$ = chi over Q at distance d (s/m3)

S_i = release rate of isotope i (Ci/s)

DF_i = dose factor for isotope i

specific dose factors are:

Rem Per $\frac{\mu Ci\ h}{Cm3}$	
1.3E6	I131
7.7E3	I132
2.2E5	I133
1.3E3	I134
3.8E4	I135

The basis for the X/Q calculation is the Gaussian diffusion equation.

X/Q is calculated as:

$$\frac{X}{Q}(d) = \frac{1}{WS_A * .45 * \sigma_y * \sigma_z \pi} \text{ EXP} \left[\frac{-HR^2}{2\sigma_z^2}\right]$$

where:

WS_A = adjusted wind speed for the release height (mph)

.45 = conversion factor

σ_y = lateral plume spread (m)

σ_z = vertical plume spread (m)

HR = effective release height (m)

The lateral plume spread, σy is calculated using the following equations from reference 9.14.

σy = 465.11628 * X * tan (.017453293 * (Ci - di * logx))

where x = downwind distance, (Km)

Ci, di = coefficients based on stability class as given below

Stability Class	Ci	di
A	24.1670	2.5334
B	18.3330	1.8096
C	12.5000	1.0857
D	8.3330	0.72382
E	6.2500	0.54287
F	4.1667	0.36191
G	4.1667	0.36191

For G stability, the calculated value is equal to the F stability value from the above equation. This value is then multiplied by .6667 to obtain σy for G stability (reference 9.11).

The vertical plume spread, σ_z is calculated using the following equation from reference 9.14.

$$\sigma_z = A_i * X^{bi}$$

The coefficients, A_i and b_i , are functions of stability class and downwind distance. Because the coefficients are more complex than those for σy, they will not be listed here. The interested user is referred to reference 9.14.

7.2.3.5 Maximum Calculation

Maximum whole body dose rate is calculated by performing both ground level and elevated dose projections, if appropriate, at the site boundary, 400, 500, 600, 700, 800, 900, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 3000, 3218, 3500, 4000, 4500, 5000, 5500, 6000, 6500, 7000, 7500, 8000, 8500, 9000, 10000, 15000, 16090, and 20000 meters. The ground level and elevated values for each distance are then added and compared to find the highest value. Maximum thyroid dose rate is calculated in the same way except that dose rates are calculated at the site boundary, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000, 2500, 3000, 3218, 3500, 4000, 4500, 5000, 5500, 6000, 6500, 7000, 7500, 8000, 8500, 9000, 10000, 11000, 12000, 13000, 14000, 15000, 16000, and 16090 meters.

7.2.4 Other Functions

Several other functions exist, which although not required for dose projections, add considerably more power and user friendliness to the code. These functions are activated by "Hot Keys" which can be used at any place in the code. Combinations of pull down menus and pop up windows are used to simplify the machine/user interface.

7.2.4.1 PCS Direct Connection

The Plant Computer System is physically located on the first floor of the Site Emergency Building (SEB). A direct feed was established from the PCS to a personal computer, also located in the SEB. This personal computer has four available lines which are called, via modem, to obtain plant data. RAGEMS and RMS data are also included.

Several parameters are also calculated by the PC based on inputs from the PCS. Time after shutdown, lowest reactor water level, and how long the reactor level was below -30" are examples of these. The PC operates continually, always ready to relay data from the PCS to a RAC computer. New data is transmitted every 15 seconds.

When the PCS Hot key is pushed, the RAC computer first looks to see if a modem is available. If not, the message "No modem for PCS connection" will be displayed within five seconds. Otherwise the RAC computer will dial and connect to the PC in the SEB. After the user logs on with his location, data transmission begins. Up to four RAC computers may be connected to the SEB computer at the same time.

If the computer in the SEB does not answer, the user must depress "ALT" and "P". The RAC computer will make two more attempts to contact PCS. If unsuccessful, the RAC computer will attempt to call the RAGEMS computer. If the RAGEMS computer answers, a Logon and Password will be sent and when accepted, the RAC computer will receive data directly from the RAGEMS computer.

In this case only RAGEMS I high range and stack flow, and RAGEMS II high and low range and vent flows will be available to the code. After RAGEMS data is transmitted, the RAC computer will hang up from the RAGEMS computer.

Finally, if no connection is made to the PCS or RAGEMS computers, the user is warned that no connection was available.

7.2.4.2 Automatic Dose Projection

With the direct connection made to the PCS computer, the computer will monitor the PCS data and perform dose projections as conditions change with no operator input.

The computer looks at the PCS data to determine where a monitored release is coming from as described in 7.2.4.3.1. The computer then determines a core damage spectrum as outlined in 7.2.1.1.

A source term is then calculated as outlined in 7.2.1.2.1, if the release is from the Reactor Building. The release duration is assumed to be seven hours. If the release is determined to be from the Turbine Building a source term is calculated as outlined in 7.2.1.2.2 and the release duration is assumed to be one hour.

A new projection is performed when either RAGEMS low range monitor changes by 25%, or either high range monitor changes by .2 uCi/cc with a minimum time between calculations of two minutes. If conditions are not changing, a new projection will be performed every fifteen minutes to update the meteorological data. Auto dose projection does not consider the effects of Containment Spray operation.

7.2.4.3 Ventilation

A graphic depiction of the monitored release paths is available. The diagram is very simplified, showing vent paths, Reactor Building and Turbine Building fans, and stand-by gas.

7.2.4.3.1 Release Path Analysis

To determine the release paths, airborne activities calculated from RMS readings and appropriate dilution factors are compared to RAGEMS readings. Airborne concentrations are calculated from the CHRRMS and monitors A-4, C-6, C-9 and C-10 by assuming their readings to be due to a semi-infinite cloud of Xe-133.

The concentrations are then diluted by assumed flow rates for the Rx Bldg fans, SBGTS, Turbine Bldg vents, and Condenser Bay fans, and compared to the concentration measured by the RAGEMS systems. A calculated concentration greater than .01 for the ARMS and .1 for CHRRMS of the concentration measured by RAGEMS at the release points is considered a good match.

7.2.4.4 Field Monitoring Team Readings

Time, location, DDE dose rate, and thyroid dose rate from field monitoring teams may be entered for display on the final output. No calculations are performed.

7.2.4.5 Utility Functions

7.2.4.5.1 Leak Rate Calculation

A leak rate based on the driving pressure and size of the leak can be calculated.

Bernoulli's equation.

$$P_1 + h_1dg + \frac{1}{2}dv_1^2 = P_2 + h_2dg + \frac{1}{2}dv_2^2$$

is used.

where:

P_1, P_2 = pressure in state 1 and 2 (psig)

h_1, h_2 = height above reference plane (ft)

d = density (lbm/ft^3)

g = gravitational constant ($32.2\ ft/s^2$)

V_1, V_2 = velocities (ft/s)

Assuming:

$h_1=h_2$, $P_2=0$, and $V_1=0$

then:

$$P_1 = ½½dV_2^2$$

or the potential energy in the form of pressure is equal to the kinetic energy of the moving fluid.

Solving for the velocity of the fluid and multiplying by the leak area:

$$LR=A*(P_1*144/d*2*32.2)^{½} *60$$

where:

LR = leak rate (cfm)

144 = conversion factor (in^2/ft^2)

32.2 = conversion factor $\left(\frac{lbm/ft}{lbf/Sec^2}\right)$

60 = conversion factor (s/min)

A = leak area (ft^2)

The densities used in this equation are

2.23 lbm/ ft^3 for steam

46.4 lbm/ ft^3 for water

$8.07E^{-2} * \left(\frac{427}{T+427}\right) * \left(\frac{P1+14.7}{14.7}\right)$ lbm/ft^3 for air

where:

T = air temperature (°F)

An assumption is made in Bernoulli's equation that the fluid is incompressible. Although this will lead to some error when used for steam or air, it will provide a good leak rate approximation.

The above calculation does not account for the change of state which will take place when the approximately 520°°F water or steam is released to atmospheric pressure.

IF the operator knows the enthalpy of the fluid, the code will correct for change of state and give the resulting leak rate of both steam and water. To determine these, first the quality is calculated:

$$X = \frac{h-hf}{(hg-hf)}$$

where:

X = quality

h = enthalpy of fluid (Btu/lb)

hf = saturated liquid enthalpy at 1 atmosphere (Btu/lb)

hg = saturated vapor enthalpy at 1 atmosphere (Btu/lb)

The water leak rate is then

Lw = d*LR*(1-X)*.016747

and the steam leak rate is

Ls = d*LR*X*26.799

where:

Lw = water leak rate (cfm)

Ls = steam leak rate (cfm)

.016747= specific volume of water at 1 atmosphere (ft3/lbm)

26.799 = specific volume of steam at 1 atmosphere (ft3/lbm)

7.2.4.5.2 Core Damage Estimation

The percentage of fuel melt is estimated using the CHRRMS reading. Emergency Plan Procedure EPIP-OC-.33 Reference 7, contains graphs which relate CHRRMS reading to percent noble gas released and percent noble gas released to percent core melt. Curve fitting to these graphs gives:

D = C * CR

where:

D = % core damage

C = conversion factor

3.021E-4 if TAS < 1.0 hr

4.982E-4 if 1.0 < = TAS < 2.0 hr

6.749E-4 if 2.0 < = TAS < 4.0 hr

1.018E-3 if 4.0 < = TAS < 8.0 hr

1.676E-3 if 8.0 < = TAS < 24 hr

3.796E-3 if 24 < = TAS < 72 hr

7.604E-3 if TAS > = 72 hr

TAS = Time After Shutdown (hr)

CR = CHRRMS reading (R/hr)

7.2.4.5.3 Field Iodine Measurements

The Oyster Creek Field Monitoring Teams (FMT's) use a RADECO air sampler with a silver zeolite cartridge and paper filter to draw air samples to determine thyroid committed dose. The cartridge and filter are counted with an E-140 with a HP-270 probe. FMT's report gross filter count rate, gross cartridge count rate, background count rate, sampler flow rate, and sample time to the EAC or RAC, as appropriate. Using these values gross airborne iodine concentration is calculated:

C=[(Z-B)/.0039+(F-B)/.10]/(f*St*1000*2.22E6)

where:

C	=	airborne iodine concentration (uCi/cc)
Z	=	silver zeolite cartridge reading (cpm)
B	=	background reading (cpm)
F	=	filter paper reading (cpm)
.0039	=	counting efficiency for silver zeolite cartridge
.10	=	counting efficiency for filter paper
f	=	sample flow rate (liter/min)
St	=	sample time (min)
2.22E6	=	conversion factor (dpm/uCi)
1000	=	conversion factor (cc/liter)

Thyroid committed dose rate is then found by multiplying this concentration by a dose factor for the expected iodine spectrum. At power this spectrum is expected to be:

I-131	11.9%
I-132	16.8%
I-133	23.8%
I-134	26.6%
I-135	21.0%

These values are first decayed for time after shutdown, then renormalized. The dose factor is then:

$$DF = \sum_{i=1}^{5} fi\ Dfi$$

where:

DF = dose factor for iodine spectrum

$$\frac{Rem}{\mu Ci - hr/cm3}$$

fi = decayed and renormalized fraction of isotope i

DFi = dose factor for isotope I

$$\frac{Rem}{\mu Ci - hr/cm3}$$

7.2.4.5.4 Unit Conversions

A unit conversion function is included to facilitate calculations. The utility will convert units of length, area, volume, flow, speed, pressure, temperature, dose, equivalent dose, and activity between different measurement systems. In all cases except temperature conversion, the entered value is multiplied by a conversion factor to obtain a value in the new units. Temperature conversions use the following relationships:

$$F = \frac{9}{5}C+32$$

$$R = F+459$$

$$K = C+273$$

where:

F	=	degrees Fahrenheit
C	=	degrees Celsius
R	=	degrees Rankin
K	=	degrees Kelvin

7.2.4.5.5 Semi-Infinite Cloud Approximation

A semi-infinite cloud approximation can be used to approximate total airborne concentration and total iodine DAC. The entered dose rate is first corrected to a semi-infinite dose rate by solving

$D_f = uxDR_s$

for DR_s.

where D_f = measured finite dose rate

u = linear absorption coefficient for gamma rays in air (m^{-1})

x = estimated radius of finite cloud (meters)

DR_s = semi-infinite dose rate (mR/hr)

Total airborne concentration is calculated as:

$$C = \frac{DR_S}{9.0E5} * Ea$$

where:

C = approximate airborne concentration (uCi/cc)

Ea = average gamma energy (MeV)

9.0E5 = numerical conversion factor

Ea is determined as a function of time after shutdown. Ea varies from .54 MeV at TAS = 0 to .772 at times greater than one hour.

DAC is calculated

DAC = .188 * .00119 * C / 2.0E-8

where:

.188 = conversion between total iodine and DEI for this spectrum

.00119= fraction of release which is iodine

2.0E-8 = 1 DAC for I-131

7.2.4.5.6 Calculator

A calculator utility is available which uses "Reverse Polish Notation" (RPN) logic to perform addition, subtraction, multiplication, and division.

8.0 RESPONSIBILITIES

8.1 Radiological Assessment Coordinator and the Environmental Assessment Coordinator are responsible for implementing the dose projection process.

8.2 Emergency Preparedness is responsible for the maintenance of the RACP, equipment, and facilities necessary to operate the code.

8.3 Radiological Engineering is responsible for technical oversight of the RACP.

9.0 REFERENCES

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