14.2.4 STEAM GENERATOR TUBE RUPTURE

14.2.4.1 General

A complete single tube break adjacent to the tube sheet in a steam generator is examined for two assumed situations. Since the reactor coolant pressure is greater than the steam generator shell side pressure, the contaminated reactor coolant discharges into the secondary system.

The activity release is limited by the concentration in the reactor coolant, which is conservatively assumed to arise from 1% defective fuel cladding. The activity release is further limited by operator action to terminate the primary to secondary fluid leakage and the releases from the affected steam generator to the atmosphere.

Method of Analysis

A detailed time sequence of events is presented from occurrence of the assumed steam generator tube rupture until the primary to secondary break flow and release from the affected steam generator to the atmosphere have been terminated. Resultant radionuclide releases to atmosphere have been evaluated ~~separately~~ assuming that off-site power ~~is available in one case and~~ is lost ~~in the other~~. ~~Finally, site boundary radiation exposures are calculated for each case~~.

The potential for an increased radioactive release to the environment due to steam generator tube bundle uncovery has been evaluated (Reference 3). Uncovery does not significantly increase the radiological consequences associated with the SGTR accident. The probability of a significant release due to non-SGTR events, including the effects of tube uncovery, is sufficiently low to exclude such events from consideration. The NRC agrees with the position that the effects of partial steam generator tube bundle uncovery on the iodine release for SGTR and non-SGTR events is negligible (Reference 4).

14.2.4.2 Analysis Assuming Minimum Auxiliary Feedwater and Off-Site Power are Available

The sequence of events following tube rupture is as follows:

1. Primary leakage takes place initially at a high rate (~~~80~~ ~87 lbm/sec) but rapidly drops to a lower leakage rate (~~~42~~ ~55 lbm/sec).

14.2.4.4 Radiological Consequences of a Steam Generator Tube Rupture Accident

This section presents an evaluation of the offsite consequences of a steam generator tube rupture accident. ~~Off-site dose projections are provided for the conditions of off-site power available and no off-site power.~~

Assumptions: The following assumptions were used in the analysis of the off-site consequences:

Insert 1

1. The equilibrium primary coolant activity is equivalent to 1% defective fuel. (Ref. Table 9.2-3) (See note 1 on page 14.2.4-9)

2. With primary to secondary leakage assumed prior to the postulated accident, the equilibrium activity in the secondary system is projected assuming the following:

   a. Primary to secondary leakage is evenly distributed in both steam generators.

   b. The iodine partition factor $\left(\frac{\text{Amount iodine/unit vol. gas}}{\text{Amount iodine/unit vol. liquid}}\right)$ is assumed to be 0.1 in steam generators and the blowdown tank.

   c. The iodine partition factor $\left(\frac{\text{Amount iodine/unit vol. gas}}{\text{Amount iodine/unit vol. liquid}}\right)$ is assumed to be 10^{-4} in condensers.

   d. The secondary system activity removal process consisted of radioactive decay, air ejector release, blowdown tank venting, and blowdown tank liquid discharge.

   e. The blowdown rate from the steam generators was continuous. Additional parameters used to calculate the equilibrium activities in the secondary system are presented in Table 14.2.4-1.

Insert 1 (on FSAR page 14.2.4-5 where marked)

1. Both pre-accident and accident initiated iodine spikes are analyzed. For the pre-accident iodine spike it is assumed that a reactor transient has occurred prior to the steam generator tube rupture and has raised the RCS iodine concentration to ~~60~~ 50 μCi/gm of dose equivalent (DE) I-131. For the accident initiated iodine spike, the reactor trip associated with the steam generator tube rupture creates an iodine spike in the RCS which increases the iodine release rate from the fuel to the RCS to a value 500 times greater than the release rate corresponding to the maximum equilibrium RCS Technical Specification concentration of ~~1.0~~ 0.8 μCi/gm of DE I-131. The duration of the accident initiated iodine spike is ~~1.8~~ 1.6 hours.

2. The noble gas activity concentration in the RCS at the time the accident occurs is based on a fuel defect level of 1.0%. This is approximately equal to the Technical Specification value of $100/\bar{E}$ μCi/gm for gross radioactivity.

3. The iodine activity concentration of the secondary coolant at the time the steam generator tube rupture occurs is assumed to be equivalent to the Technical Specification limit of ~~1.2~~ 1.0 μCi/cc of I-131.

4. The amount of primary to secondary steam generator tube leakage in the intact steam generator is assumed to be equal to the Technical Specification limit for a single steam generator of 500 gallons/day.

5. No credit for iodine removal is taken for any steam released to the condenser prior to reactor trip and concurrent loss of offsite power.

6. An iodine partition factor in the steam generators is used as follows:

   ~~0.1~~ 0.01 (curies I/gm steam ÷ curies I/gm water)

7. All noble gas activity carried over to the secondary side is assumed to be immediately released to the outside atmosphere.

~~The equilibrium concentration of iodines and noble gases in the secondary side versus assumed primary to secondary leakage rates with primary coolant activities associated with 1% defective fuel are given in Figures 14.2.4-1 through 14.2.4-4. For a given leak rate, if the coolant activity is less than the equivalent 1% activity, secondary activity would be correspondingly lower.~~

8 ~~7~~. Thirty minutes after the postulated tube rupture accident the pressure between the faulted steam generator and the primary system is equalized. Approximately ~~92,405~~ ~~114,500~~ 123,600 lbs. of reactor coolant is discharged to the secondary side of the faulted steam generator. Also, approximately ~~67,065~~ ~~78,900~~ 74,000 lbs. of steam is released to the atmosphere via the ruptured steam generator during the time interval.

9 ~~8~~. Auxiliary feed water is available during the accident.

10 ~~9~~. ~~Six~~ Eight hours after the accident the residual heat removal system is placed into operation.

11 ~~10~~. ~~Six~~ Eight hours after the accident no further activity is released to the environment.

12 ~~11~~. The atmospheric dispersion factor (X/Q) at the site boundary (1200 meters) and at the boundary of the low population zone (9000 meter) are:

X/Q (sec/m³)

	0-2 HR	~~2-6~~ 0-8 HR
1200 meter	~~2.3x10⁻⁴~~ 5.0x10⁻⁴	~~[illegible]~~ NA
9000 meter	~~2.6x10⁻⁵~~ NA	~~1.3x10⁻⁵~~ 3.0x10⁻⁵

13 ~~12~~. Breathing rate used to calculate the thyroid dose for the accident is 3.47×10^{-4} m³/sec.

Consequences:

With primary coolant activity associated with 1% defective fuel and a primary to secondary leakage rate of .35 gpm, the activities of radioactive iodines and noble gases released over various time periods after the steam generator tube rupture are given in Table 14.2.4-2.

The thyroid doses and whole body doses at the site boundary and the boundary of the low population zone are given in Table 14.2.4-2. If the primary coolant activity is less than that equivalent to 1% failed fuel, the secondary system activity released and corresponding doses would be lower.

Because iodine is soluble in water, considerable separation will occur in the steam generator. The effective decontamination factor is a function of time, steam dump rate, and steam generator liquid mass as well as the partition coefficient as mentioned in the assumptions for the equilibrium activities listed above, a further partition factor of 10^{-4} is assumed in the main condenser. This is based upon an iodine partition factor of 10^{-4} or less from experiments performed in Canada and Russia.[1,2]

The thyroid and whole body doses presented in Table 14.2.4-3 are given for both conditions of offsite power available and not available. Under both circumstances, the exposure to the public as a result of a steam generator tube rupture would not be significant and are less than the permissible limits of 10 CFR Part 100.

14.2.4.5 Multiple Tube Ruptures

A much larger dose, e.g., whole body dose of 25 rem at the exclusion radius, can only result from the rupture of sufficient steam generator tubes to cause fuel cladding failure.

Operating experience with steam generators of the type used in this plant has not shown significant numbers of single gross and immediate tube failures. Small leaks in a single tube which caused erosion type damage to adjacent tubes have been reported, but did not cause a rupture of the adjacent tubes. Thus, if a single tube failure were postulated, it is probable that adjacent tubes would not

be damaged but any adjacent failure would be an erosion-caused leak rather than a sudden gross failure.

To perform a rigorous analysis of the flow dynamics of blowdown through multiple tube ruptures, one must understand and define mathematically the physical configuration of the ruptures. Because no reasonable mechanism exists for the multiple ruptures, it is instead just as meaningful to analyze the consequences of a pipe rupture, equivalent in terms of discharge rate to various multiples of the single tube discharge rate.

Such an analysis reveals that the core cooling system will prevent clad damage for break discharge rates equal to or smaller than that resulting from a broken pipe between 4 in. and 6 in. in diameter. The discharge rates which bracket the onset of cladding damage correspond to 18 and 40 times the discharge from a single severed steam generator tube. Actually, the ratio would be much larger owing to the fact that the discharge from a tube failure will be limited by the back pressure in the steam generator. Ultimately, the tube discharge would terminate when the reactor coolant system and the steam generator reached pressure equilibrium. The operator can initiate cooldown through the unaffected steam generator.

These conclusions are based on single-failure mode performances of the core cooling system. The core does not become uncovered by the calculated quiet level in those cases where cladding damage is found to be prevented.

The incredibility of multiple simultaneous tube failures is supported by the following reasoning:

1. At the maximum operating internal pressure the tube wall sees only about 1530 psi compared with a calculated bursting pressure in excess of 11,100 psi based on ultimate strength at design temperature.

2. The above margin applies to the longitudinal failure modes, induced by hoop stress. This failure mode is the least likely to cause propagation of failure tube-to-tube. An additional factor of two applies to ultimate pressure strength in the axial direction tending to resist double-ended failure (total factor of 14.6).

3. Failures induced by fretting, corrosion, erosion, or fatigue are of such a nature as to produce tell-tale leakage in substantial quantity while ample metal remains to prevent severance of the tube (a small fraction of the original tube wall section) as indicated by the margin derived in 2 above. Thus, any incipient failures that would develop to the point of severe leakage requiring a shutdown for plugging or repair, in accordance with Section 15.3.1 of the Technical Specifications, would happen long before the large safety margin in pressure strength is lost.

Note 1: It should be noted that the primary coolant activity assumed in this analysis differs with the maximum coolant activity limits of Technical Specification 15.3.1.c. The Technical Specification limits were first imposed on Unit 1 by NRC Confirmatory Order dated November 30, 1979, and later applied to Unit 2 as well. On April 4, 1983, the NRC issued License Amendments 71 and 76 for Units 1 and 2, respectively, incorporating these activity limits in the Point Beach Technical Specifications. These activity limits are based on a parametric evaluation conducted by the NRC of typical sites and are conservative for Point Beach Nuclear Plant. The technical specification limits ensure that the resulting 2-hour dose at the site boundary following a steam generator tube rupture does not exceed an appropriately small fraction of 10 CFR 100 limits. The specifications are identical to the Standard Technical Specifications for Westinghouse Pressurized Water Reactors, NUREG-0452, Revision 2.

REFERENCES - Section 14.2.4

1. L. C. Watson, A. R. Bancroft and C. W. Howlke, "Iodine Containment by Dousing in NPD-11" AECL-1130 Atomic Energy of Canada Limited, Chalk River, Ontario, October 27, 1960.

2. M. A. Styrikovich, O. I. Martynova, K. Ya. Katkovskaya, I. Ya. Dubrovskii, and I. N. Smirnova, "Transfer of Iodine from Aqueous Solutions to Saturated Vapor," Atomriaya Energiya, Vol. 17, No. 1, pp. 45-49, July 1964.

3. O. J. Mendler, "The Effect of Steam Generator Tube Uncovery on Radioiodine Release," WCAP-13132, January 1992.

4. R. C. Jones, U.S. NRC, Letter to L. A. Walsh, WOG, "Westinghouse Owners Group - Steam Generator Tube Uncovery Issue," March 10, 1993, Attachment to WOG-93-066 dated March 31, 1993.

TABLE 14.2.4-~~2~~ 1

THYROID DOSES AND WHOLE BODY DOSES
STEAM GENERATOR TUBE RUPTURE ACCIDENT

A. *With Pre-Accident Iodine Spike* ~~With Off Site Power (condensers are available)~~

0 - 2 HOUR DOSE AT SITE BOUNDARY			0 - ~~6~~ 8 HOUR DOSE AT LPZ		
THYROID		~~WHOLE~~ γ- BODY	THYROID		~~WHOLE~~ γ- BODY
3.5	REM	9.5×10^{-2}	0.23	REM	6×10^{-3}
~~15.1~~		~~4.4~~ ~~8.1~~	~~1.8~~		
~~28.2~~		~~4.42×10^{-2}~~	~~3.5~~		~~5.0×10^{-3}~~
~~5.6x10~~		~~1.17x10~~	~~5.5x10~~		~~1.31x10~~

B. *With Accident Initiated Iodine Spike* ~~No Off Site Power (condensers are not available)~~

0 - 2 HOUR DOSE AT SITE BOUNDARY			0 - ~~6~~ 8 HOUR DOSE AT LPZ		
THYROID		~~WHOLE~~ γ- BODY	THYROID		~~WHOLE~~ γ- BODY
1.7	REM	9.5×10^{-2}	0.13	REM	6×10^{-3}
~~3.6~~		~~4.4~~	~~0.45~~		
~~16.7~~		~~4.42×10^{-2}~~	~~2.2~~		~~5.0×10^{-3}~~
~~5.5x10~~		~~1.17x10~~	~~5.5x10~~		~~1.31x10~~

~~NOTE:~~

~~1. Fuel Defect = 1%~~

~~2. Primary to Secondary Leak Rate = .35 GPM~~

1.0 GENERAL

Potassium iodide, a stable iodine, saturates the iodine receptors in the thyroid gland, preventing unnecessary thyroid gland exposure from radioiodine.

2.0 REFERENCES

2.1 Letter Erwin S. Huston, M.D., dated November 6, 1980, and attachment "Protection Against Radioactive Iodines."

2.2 NRC Information Notice No. 88-15: "Availability of U.S. Food and Drug Administration (FDA)-Approved Potassium Iodide for Use in Emergencies Involving Radioactive Iodine," April 18, 1988.

2.3 NUREG-1210, "Public Protective Actions - Predetermined Criteria and Initial Actions," Volume 4, "Pilot Program: NRC Severe Reactor Accident Incident Response Training Manual," February 1987.

2.4 Memo NPM 91-0273, "Potassium Iodide - Issuance Dose Level", dated February 7, 1991.

3.0 PRECAUTIONS

3.1 Potassium iodide will only be administered to personnel as approved by Company Medical Services personnel consistent with this procedure.

3.2 The use of potassium iodide will be authorized by the Health Physics director and/or the rad/con waste manager.

3.3 To be effective, potassium iodide must be taken within 1 to 2 hours after exposure to radioiodine. If potassium iodide is administered more than 4 hours after an individual has suffered an acute ingestion or inhalation of radioiodine, its effectiveness as a thyroid blocking agent is less than 50 percent.

3.4 After an initial dose (one tablet) of potassium iodide has been administered, its continued use on a daily basis will be determined by Company Medical Services personnel, or by a designated physician.

3.5 Rosters of WE and security personnel approved to use potassium iodide as a blocking agent will be maintained at the operations support center, site boundary control center, and the control room. Personnel not authorized to take potassium iodide are marked "NOT APPROVED" on the appropriate roster.

3.6 A copy of the pharmaceutical company instructions for the use of potassium iodide tablets is reproduced on Attachment A to this procedure. This is furnished for information only.

4.0 STORAGE LOCATION

Single dose 130 mg tablets of potassium iodide will be stored in the emergency lockers located at the operations support center, site boundary control center, and the control room. The shelf life of potassium iodide tablets are as indicated on the pharmaceutical container.

5.0 ADMINISTRATION

In the event of an emergency, potassium iodide will be administered to authorized personnel if the projected dose to the thyroid is likely to exceed 25 rem.

If the projected dose to the thyroid is not likely to exceed 25 rem, the issuance of potassium iodide (to authorized personnel) is at the discretion of the Health Physics director and/or the rad/con waste manager.

6.0 THYROID DOSE CALCULATIONS

The dose to the thyroid from airborne concentrations of radioiodine may be calculated as follows.

6.1 Inhaled Conversion Factors, rads/μCi:

I-131	1.480 rads/μCi
I-132	0.054 rads/μCi
I-133	0.400 rads/μCi
I-134	0.025 rads/μCi
I-135	0.124 rads/μCi

6.2 Breathing Rates

6.2.1 Assume 1.25E06 cc/hour (= 3.47E-04 m^3/sec.) for short exposure times or exposures while working.

6.2.2 Assume 8.35E05 cc/hour (= 2.32E-04 m^3/sec.) for long exposure times (in excess of a single day).

6.3 If the concentration of each iodine isotope is not known, conservatively use the dose factor for I-131, given above, as illustrated in the example in Step 6.5.

6.4 The total amount of radioiodine inhaled in μCi is calculated by multiplying the average airborne concentration in μCi/cc by the breathing rate in cc/hour by the total time of exposure in hours. The thyroid dose in rads is then calculated by multiplying the total amount in μCi by rads/μCi in the above table.

6.5 Example

Gross Iodine = 5.4E-07 μCi/cc in air

Breathing Rate = 1.25E06 cc/hour

Expected Exposure Time = 1 hour

I-131 rads/μCi = 1.48

Calculation:

(5.4E-07 μCi/cc) (1.25E06 cc/hour) (1.48 rads/μCi) (1 hour)

= 0.999 rads Thyroid Dose

7.0 DOSE ACCOUNTABILITY FOR EXPOSURES TO AIRBORNE RADIOIODINE

7.1 It is imperative that accurate exposure times and radioiodine concentrations encountered be maintained for each individual's exposure to an airborne radioiodine environment for dose calculation purposes.

7.2 The following minimum information should be documented for each exposure.

7.2.1 Date and time

7.2.2 Names of individuals involved

7.2.3 Duration of exposure

7.2.4 Concentrations of airborne radioiodine

7.2.5 Reference to specific analysis by sample number or manner in which concentration of airborne radioiodine was derived.

ATTACHMENT A

This attachment is furnished for information only. The administration of potassium will be as stated in Procedure EPIP 5.2.

Patient Package Insert For

THYRO-BLOCK®
TABLETS
(POTASSIUM IODIDE TABLETS, USP)
(pronounced poe-TASS-e-um EYE-oh-dyed)
(abbreviated: KI)

TAKE POTASSIUM IODIDE ONLY WHEN PUBLIC HEALTH OFFICIALS TELL YOU. IN A RADIATION EMERGENCY, RADIOACTIVE IODINE COULD BE RELEASED INTO THE AIR. POTASSIUM IODIDE (A FORM OF IODINE) CAN HELP PROTECT YOU.

IF YOU ARE TOLD TO TAKE THIS MEDICINE, TAKE IT ONE TIME EVERY 24 HOURS. DO NOT TAKE IT MORE OFTEN. MORE WILL NOT HELP YOU AND MAY INCREASE THE RISK OF SIDE EFFECTS. *DO NOT TAKE THIS DRUG IF YOU KNOW YOU ARE ALLERGIC TO IODIDE.* (SEE SIDE EFFECTS BELOW.)

INDICATIONS
THYROID BLOCKING IN A RADIATION EMERGENCY ONLY.

DIRECTIONS FOR USE
Use only as directed by State or local public health authorities in the event of a radiation emergency.

DOSE
Tablets: ADULTS AND CHILDREN 1 YEAR OF AGE OR OLDER: One (1) tablet once a day. Crush for small children.
BABIES UNDER 1 YEAR OF AGE: One-half (1/2) tablet once a day. Crush first.

Take for 10 days unless directed otherwise by State or local public health authorities.

Store at controlled room temperature between 15° and 30°C (59° to 86°F). Keep container tightly closed and protect from light.

WARNING
Potassium iodide should not be used by people allergic to iodide. Keep out of the reach of children. In case of overdose or allergic reaction, contact a physician or the public health authority.

DESCRIPTION
Each white, round, scored, monogrammed THYRO-BLOCK® TABLET contains 130 mg of potassium iodide. Other ingredients: magnesium stearate, microcrystalline cellulose, silica gel, and sodium thiosulfate.

HOW POTASSIUM IODIDE WORKS
Certain forms of iodine help your thyroid gland work right. Most people get the iodine they need from foods, like iodized salt or fish. The thyroid can "store" or hold only a certain amount of iodine.

In a radiation emergency, radioactive iodine may be released in the air. This material may be breathed or swallowed. It may enter the thyroid gland and damage it. The damage would probably not show itself for years. Children are most likely to have thyroid damage.

If you take potassium iodide, it will fill up your thyroid gland. This reduces the chance that harmful radioactive iodine will enter the thyroid gland.

WHO SHOULD NOT TAKE POTASSIUM IODIDE
The only people who should not take potassium iodide are people who know they are allergic to iodide. You may take potassium iodide even if you are taking medicines for a thyroid problem (for example, a thyroid hormone or antithyroid drug). Pregnant and nursing women and babies and children may also take this drug.

HOW AND WHEN TO TAKE POTASSIUM IODIDE
Potassium iodide should be taken as soon as possible after public health officials tell you. You should take one dose every 24 hours. More will not help you because the thyroid can "hold" only limited amounts of iodine. Larger doses will increase the risk of side effects. You will probably be told not to take the drug for more than 10 days.

SIDE EFFECTS
Usually, side effects of potassium iodide happen when people take higher doses for a long time. You should be careful not to take more than the recommended dose or take it for longer than you are told. Side effects are unlikely because of the low dose and the short time you will be taking the drug.

Possible side effects include skin rashes, swelling of the salivary glands, and "iodism" (metallic taste, burning mouth and throat, sore teeth and gums, symptoms of a head cold, and sometimes stomach upset and diarrhea).

A few people have an allergic reaction with more serious symptoms. These could be fever and joint pains, or swelling of parts of the face and body and at times severe shortness of breath requiring immediate medical attention.

Taking iodide may rarely cause overactivity of the thyroid gland, underactivity of the thyroid gland, or enlargement of the thyroid gland (goiter).

WHAT TO DO IF SIDE EFFECTS OCCUR
If the side effects are severe or if you have an allergic reaction, stop taking potassium iodide. Then, if possible, call a doctor or public health authority for instructions.

HOW SUPPLIED
THYRO-BLOCK® TABLETS (Potassium Iodide Tablets, USP) are white, round tablets, one side scored, other side debossed 472 WALLACE, each containing 130 mg potassium iodide. Available in bottles of 14 tablets (NDC 0037-0472-20).

WALLACE LABORATORIES
Division of
CARTER-WALLACE, INC.
Cranbury, New Jersey 08512

IN-0472-03 Rev. 5/94