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Effects of Boron Precipitation on Long-Term Core Cooling Capability Following LOCA......

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Carolina Power & Light Company

April 18, 1975

File: NG-3514 (R)

Serial: NG-75-553

DOCKETED USNRC APR 21 1975 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

Mr. George Lear, Chief
Operating Reactors Branch #3
Division of Reactor Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

50-261

RECEIVED APR 21 1975 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

Dear Mr. Lear:

H. B. ROBINSON UNIT NO. 2
LICENSE NO. DPR-23
EFFECTS OF BORON PRECIPITATION ON LONG-TERM
CORE COOLING CAPABILITY FOLLOWING LOCA

In your letter of March 14, 1975, you requested that Carolina Power & Light Company review the system capabilities and operating procedures for its H. B. Robinson Unit No. 2 Plant to assure that boron precipitation would not compromise long-term core cooling capability following a loss of coolant accident (LOCA).

We have performed the reviews suggested in your letter, and find that the concentration of boric acid in the post-LOCA recirculation phase can be controlled by injecting core cooling water into the reactor vessel via the existing Safety Injection System connections to the Reactor Coolant System hot leg piping. The basis for this control has been forwarded to the NRC staff by Westinghouse Electric Corporation in Reference 1. In their submittal, they recommend the initiation of hot leg injection at 24 hours after the accident. The attached operating procedures provide the means by which this initiation will be performed at the Robinson Plant in the event of a LOCA.

The Safety Injection System is designed such that, in the event of a postulated reactor coolant system pipe rupture, flow to the core from both hot leg injection lines is ensured even in the event of a single component failure. The system provides for redundant parallel hot leg injection isolation valves such that there will always be flow to both hot leg injection lines even if one valve cannot be opened. The system also provides the minimum combination of safeguard pumps, as discussed in Section 6.2 of the FSAR, for delivery of hot leg flow during post-accident recirculation, even in the event of the most conservative single failure.

4310

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Only the Safety Injection System hot leg isolation valves are potentially affected by the post-accident containment environment. However, as discussed in Section 6.2 of the FSAR, tests conducted during the design phase of the plant provided qualification of these valves for operation in the post-accident containment environment for the time period required.

It is the conclusion of Carolina Power & Light Company that the Safety Injection System configuration and our operating procedures are adequate to ensure continued effective long-term cooling following a LOCA, and that the effects of the phenomena of boron precipitation are adequately mitigated. In light of this, we do not recommend any modifications to the Robinson Plant. We trust the information provided in this letter is suitable for your use.

Yours very truly,

E. E. Utley
Vice-President
Bulk Power Supply

DBW:bn

Attachment

cc: Messrs. N. B. Bessac
T. E. Bowman
P. W. Howe
R. E. Jones
J. B. McGirt
D. B. Waters

Reference 1. Letter, C. L. Caso (Westinghouse) to T. M. Novak (USNRC), CLC-NS-309, April 1, 1975.

Carolina Power & Light Company

H. B. ROBINSON STEAM ELECTRIC PLANT

UNIT NO. 2

EMERGENCY INSTRUCTION: EI-1

INCIDENT INVOLVING REACTOR COOLANT SYSTEM DEPRESSURIZATION

DECEMBER 9, 1969

Recommend Approval [signature]
B. J. Furr
O & R Supervisor

Approved [signature]
G. P. Beatty
Plant Superintendent

H B ROBINSON STEAM ELECTRIC PLANT

UNIT NO. 2

EMERGENCY INSTRUCTION NO. CPL-EI-1

DECEMBER 9, 1969

INCIDENT INVOLVING REACTOR COOLANT SYSTEM

DEPRESSURIZATION

A. DISCUSSION

The behavior of the many nuclear plant parameters, which the operator can observe in the Control Room, will be similar in many respects following the initiation of either a loss of reactor coolant, a steam line rupture, or a steam generator tube leak. For instance, the symptoms of all three accidents which should immediately become apparent to the operator are falling pressurizer pressure and level, and in the case of slower accidents, increased charging pump speed prior to trip. The operator must determine the accident type as soon as possible so that he can carry out the required checks and initiate the relevant recovery procedure. A brief description of the accidents and objects of the recovery procedure are given below.

1. LOSS OF COOLANT

This emergency results in a breach of the primary pressure boundary such that maximum charging flow and reactor coolant pump seal injection flow can no longer maintain pressurizer level. Safety injection and reactor trip will be initiated by the falling pressurizer pressure and level on a time scale dependent upon the magnitude of the break and injection flow will increase with decreasing reactor pressure. The accumulators will automatically discharge their fluid inventory when

the reactor coolant system pressure drops below the accumulator set point and in the case of rapid depressurization leading to very low reactor pressure, the residual heat removal pumps will commence injection and refill of the reactor vessel. Long term control and cooldown of the reactor coolant system is by recirculation of spilled reactor coolant from the containment sump. This

10.8 is carried out by the residual heat removal pump~~, or by~~ AND the high head pump taking suction from the outlet of the residual heat exchangers. Containment pressure increases due to the release of energy from the reactor coolant system to the containment and containment isolation, phase A, and containment ventilation isolation will result from the safety injection signal. Spray actuation and containment isolation, phase B, will occur at approximately 50% containment design pressure.

The main function of the operator in this type of accident is to carry out the changeover from the injection phase to the recirculation phase and to check for the possible existence of a leak in an injection line and carry out the relevent isolation procedure.

2. LOSS OF SECONDARY COOLANT

This emergency is the result of a break in a main steam, feedwater or blowdown line and it will result in a reduction in reactor coolant temperature and pressure at a rate which is dependent upon the size and location of the break. The reactor automatic protection system is designed to shut the plant down safely and this system, together with the action of the safety injection system in pumping boric acid to the reactor coolant, will ensure continued shutdown.

In the case of a full blowdown of one steam generator (this results from either a break upstream of a main steam stop valve or a break

downstream of the stop valves coupled with one failed valve) reactor coolant temperatures and pressures will have fallen to the region of 400°F and 700-1000 psi in two or three minutes and safety injection flow will be underway. The continued action of safety injection will re-pressurize the reactor system to the shut-off head of the pump with little change in reactor coolant temperature. At this stage water level will have returned in the pressurizer and in fact the pressurizer may be full of subcooled fluid. The subsequent course of the accident will be for reactor temperatures and pressure to increase under the influence of residual heat and a steady state condition will be attained when core temperatures are high enough to enable residual heat to be removed by the good steam generators. If no action is taken to reduce the temperature of the good steam generator by steam dump the reactor system will be re-pressurized to the pressurizer safety valve setting (2485 psi) with discharge of reactor fluid to the containment. Operator action should therefore aim to eliminate, or at least minimize, this effect by dumping steam from the good steam generators. At an early stage in the accident the operator should also isolate auxiliary feed-water flow to the faulty steam generator to protect it from thermal shock.

3. STEAM GENERATOR TUBE RUPTURE

This accident results in leakage of reactor coolant into the plant steam system and as a result pressurizer pressure and level will decrease leading to a low pressure reactor trip. The automatic reactor coolant cooldown following plant trip will drain the pressurizer of any remaining water, actuating safety injection. After passing through ~~a minimum dependent upon the size of the leak, the reactor pressure~~

will be increased to a stable value of about 1400 psi by the continued action of safety injection. In the absence of action by the operator, continued leakage into the steam generator together with auxiliary feedwater flow would result in the steam generator water level rising into the steam lines of the faulty steam generator as it becomes water solid.

Operator action should aim to minimize the contamination of the steam system by prompt isolation of the faulty steam generator. To achieve this, steam dump must be carried out using all steam generators initially and auxiliary feedwater flow to the faulty steam generator should be cut-off when it has been indentified.

The reactor automatic protection equipment is designed to shut the plant down safely in the event of any of the above emergencies and the safety injection system is designed to provide emergency core cooling and to maintain reactor shutdown.

The plant safeguards systems operate from outside power or from on-site emergency diesel power if outside power is not available.

B. SYMPTOMS

The following symptoms may arise in a plant which has undergone or is undergoing one of the above accidents.

1. Pressurizer low pressure alarm
2. Pressurizer low level alarm
3. Low Tavg Alarm
4. High containment pressure alarm
5. ~~Containment high radiation monitor alarm~~
6. Containment high sump level
7. Rapidly decreasing reactor coolant average temperature

8. Condenser air removal equipment radiation monitor alarm

9. Steam line low pressure alarm

10. Steam line high flow alarm

11. Low steam generator water level alarm

12. Steam flow/feedwater flow mismatch

13. High steam line differential pressure alarm

14. Increased charging pump speed

15. Steam generator blowdown high radiation alarm

C. IMMEDIATE ACTIONS

Automatic Actions

1. Safety injection "S" signal is generated by either coincidence of low pressurizer pressure and low pressurizer water level, or high containment pressure or high steam line differential pressure in any steam line or high steam line flow in coincidence with low steam line pressures or low Tavg.
2. Reactor trip, turbine trip, and bus transfer.
3. Tripping of the main feedwater pumps and closing of the main and bypass feedwater valves.
4. Both diesel generators start.
5. Non-essential equipment is tripped from the safeguards busses when voltage is lost and the safeguards equipment receive a signal to start sequentially in a pre-arranged order.
6. The containment isolation, phase A, containment ventilation and control room intake duct isolation signals are generated and the Isolation Valve Seal Water System is actuated.
7. Upon coincidence of high steam line flow and either low Tavg or low steam line pressure, the steam line stop valves close.

8. If the containment pressure reaches the high-high containment pressure signal both containment spray pumps receive a start signal, their discharge valves an open signal, containment isolation phase B is initiated and all main steam line ~~stop~~ isolation valves receive a closing signal. 10.6

Manual Actions

In the event that the safeguards equipment has not been properly actuated, the operator should take action to place the equipment in operation manually.

1. Verify that reactor trip and safety injection initiation have both taken place following the "S" signal.

2. Verify that containment spray has taken place following the "P" signal.

3. Verify that the safety injection system is pumping in boric acid from boron injection tank and from the refueling water storage tank.

4. Verify with the monitor lights that the valves associated with safety injection are in the proper position after "S" initiation. (light indicates when valve is in safeguard position.

5. Verify that the main feedwater pumps have tripped and that the auxiliary feedwater pumps are actuated.

6. Check for proper operation of both diesel generators.

D. IDENTIFICATION OF ACCIDENT TYPE

The above manual actions are those which require the operator's immediate attention in the event of a large loss of reactor coolant or secondary fluid leading to rapid reactor trip and actuation of safety injection.

The operator will determine the accident type subsequently. However, in the event of a slow transient in which reactor trip is delayed for a few minutes the operator may be able to decide which type of fault has occurred prior to reactor trip and initiation of safety injection. Therefore, two cases arise and are dealt with below.

After Reactor Trip and S.I. Actuation

1. Observe the steam pressure in the steam generators.

2. If the pressure is rising or normal in the steam generators together with low pressurizer pressure and level, the accident is either a loss of coolant accident or a steam generator tube rupture. These can be distinguished as follows:

   (a) If there is an increase in containment pressure, a containment high radiation alarm, rising sump water level or any combination of these symptoms, the situation is uniquely defined as a loss of coolant accident.

   (b) If there is a condenser air removal equipment radiation alarm or a steam generator blowdown radiation alarm the accident is uniquely defined as a steam generator tube rupture.

3. If the pressure is abnormally low in one or more steam generators, coincident with low pressurizer pressure and level, the accident is a main steam line break.

4. In the case of a steam break, the approximate break location may be determined as follows:

   (a) All steam stop valves closed and similar behavior in each steam generator indicates that the break is downstream of these stop valves.

   (b) Pressure in one steam generator substantially lower than the others together with rising containment pressure indicates that the break is in the lower pressure steam line and inside the containment.

   (c) As in (b) above but with no increase in containment pressure,

rise in containment sump level and with all steam stop valves closed indicates a break in the lower pressure steam line outside the containment and upstream of the stop valve.

(d) As in (c) above with only two stop valves closed invokes two possibilities. If the lower pressure steam line is one with a closed stop valve the break is outside the containment and upstream of the closed stop valve, whereas if the higher pressure steam lines contain the closed valves the break is outside the containment but not upstream of the closed stop valve.

Before Reactor Trip and S.I. Actuation

In a slow loss of coolant accident or a steam generator tube rupture, Tavg will vary very little before reactor trip whereas a definite and continuous decrease in Tavg will be observed in the steam break accident. The loss of coolant accident and the tube rupture accident can then be differentiated as described above.

AFTER REACTOR TRIP & "S" SIGNAL

Low or falling pressurizer pressure & level

Abnormally low steam pressure in one or more steam generators indicates steam break

Verify by checking for:

1. Lower than normal steam generator levels.
2. A possible first out annunciation of:
   a) steam/feedwater flow mismatch
   b) low-low steam generator water level
   c) high steam line flow
   d) high steam line differential pressure

Go to detailed recovery procedure in emergency instruction ~~E-2~~ Appendix B

Rising or normal steam pressure in steam generators indicates loss of coolant or tube rupture

Either increasing containment pressure or containment high radiation alarm or rising sump water level indicates a loss of coolant

Go to detailed recovery procedure in ~~E-1~~ Appendix A

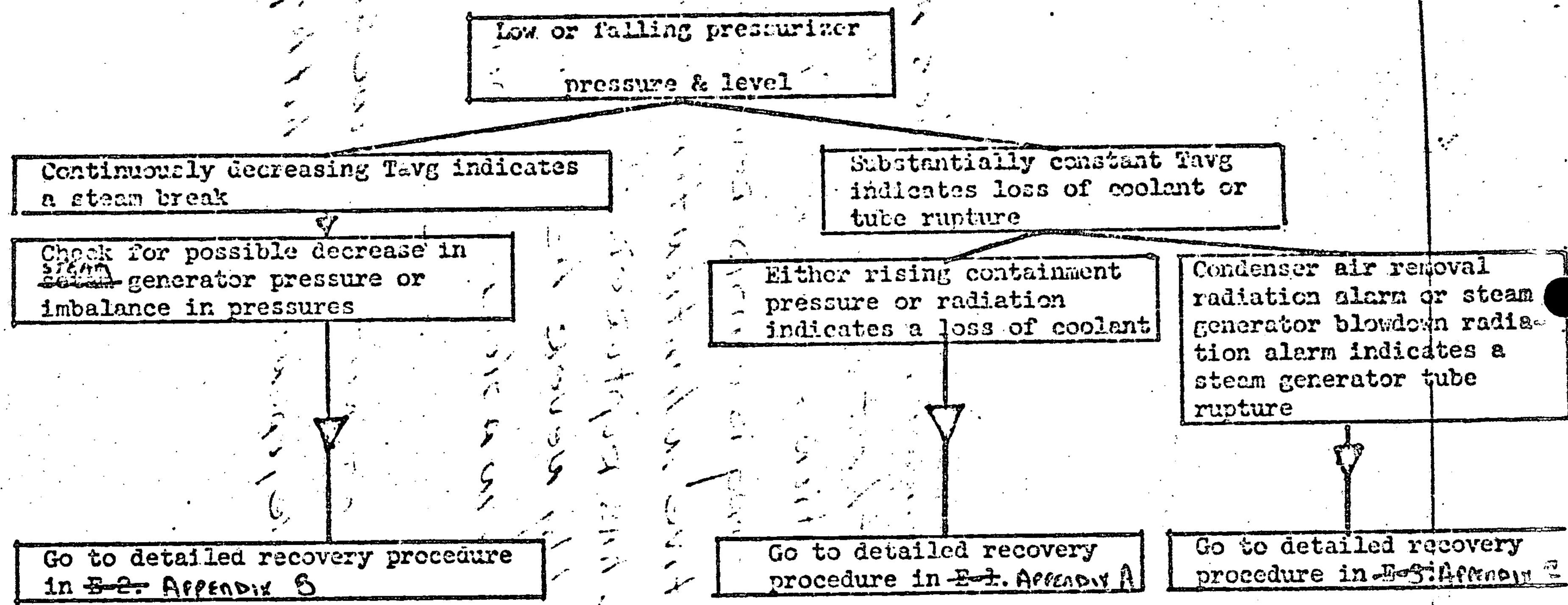
Condenser air removal equipment radiation alarm or steam generator blowdown radiation alarm or possible observed differential rate of rise of steam generator levels

Go to detailed recovery procedure in ~~E-3~~ Appendix C

AFTER REAC. TRIP & "S" SIGNAL

10.4

10.4



E. <u>AUTOMATIC ACTIONS FOLLOWING THE GENERATION OF THE SAFETY INJECTION SIGNAL</u>

1. Reactor trip, resultant turbine trip, automatic containment isolation containment ventilation isolation and control room intake duct isolation.

2. Normal feedwater isolation to the steam generators results in:

10.2 (a) Steam generator main feedwater pumps trip out of service.

(b) Steam generator main and bypass feedwater valves close.

3. Both diesel generators start and come up to speed.

4. The non-essential breakers will trip to prepare 480V BUS E1 and 480V BUS E2 for the subsequent safeguards starting sequence.

5. The following valves are actuated to the position indicated below at the initiation of the safeguards components starting sequence.

(a) The boron injection inlet and discharge valves SI-867A, SI-867B,
A-2 870A and 870B are opened.

(b) The hot leg injection line valves to the reactor coolant loops SI-866A and SI-866B do not receive an "S" signal. These valves are not to be opened for at least 10 minutes following a safety injection signal and then only if additional core flooding is considered necessary. Unless there is positive indication that a cold leg safety injection
10.11 line has ruptured. Normally the safety injection system delivers to the cold legs of the reactor coolant system until 24 hours after the accident. After 24 hours of injection to the cold legs open SI-866A and SI-866B and start one safety injection pump for each hot leg injection valve opened. Retain cold leg injection along with the hot leg injection.

(c) Core deluge valves from the residual heat removal pumps RHR-744A and RHR-744B are opened.

(d) The accumulator discharge valves SI-865A, SI-865B and SI-865C are opened.

(e) The boron injection tank recirculation return valves SI-841A and SI-841B are closed.

6. Safeguards equipment for the injection phase will receive a signal to start sequentially in the following order.

TRAIN A (Safeguards Bus E 1 Energized)

a. Safety injection pump A

b. Safety injection pump B

c. Residual heat removal pump A

d. Service water pump A and service water booster pump

e. Service water pump B

f. Containment fan HVH-1

g. Containment fan HVH-2

h. Auxiliary feedwater pump A

TRAIN B (Safeguards Bus E 2 Energized)

a. Safety injection pump C

b. (If bus E 1 is not energized safety injection pump B is running with Train B)

c. Residual heat removal pump B

d. Service water pump C and service water booster pump.

e. Service water pump D.

f. Containment fan HVH-3.

g. Containment fan HVH-4.

h. Auxiliary feedwater pump B

NOTE: The containment spray pumps, actuated by the containment spray "P" signal, are automatically loaded on the safeguards busses anytime after busses are energized.

7. The containment isolation, phase A, signal will be generated and close the following isolation valves:

CVC-200A	Letdown orifice isolation
CVC-200B	Letdown orifice isolation
CVC-200C	Letdown orifice isolation
CVC-204A	Letdown line isolation
CVC-204B	Letdown line isolation
PS-956A	Sample line isolation (pressurizer steam)
PS-956B	Sample line isolation (pressurizer steam)
PS-956C	Sample line isolation (pressurizer liquid)
PS-956D	Sample line isolation (pressurizer liquid)
PS-956E	Sample line isolation (hot leg)

A-4

Delete

~~PS-956E~~	~~Sample line isolation (hot leg)~~
PS-956F	Sample line isolation (hot leg)
PS-956G	Sample line isolation (accumulator)
PS-956H	Sample line isolation (accumulator)
RC-HC-516	Pressurizer relief tank to gas analyzer
RC-HC-519A	Primary water to pressurizer relief tank
RC-HC-519B	Primary water to pressurizer relief tank
RC-HC-553	Pressurizer relief tank to gas analyzer
CC-HC-739	Component cooling from excess letdown heat exchanger
SI-855	Nitrogen supply for the accumulators
WD-1721	Reactor coolant drain tank pump discharge
WD-1722	Reactor coolant drain tank pump discharge
WD-1723	Containment sump to waste holdup tank
WD-1728	Containment sump to waste holdup tank
WD-1786	Vent header from reactor coolant drain tank
WD-1787	Vent header from reactor coolant drain tank
WD-1789	Gas analyzer from reactor coolant drain tank
WD-1794	Gas analyzer from reactor coolant drain tank
SGB-FCV-1930A	Steam generator A blowdown line
SGB-FCV-1930B	Steam generator A blowdown line
SGB-FCV-1931A	Steam generator B blowdown line
SGB-FCV-1931B	Steam generator B blowdown line
SGB-FCV-1932A	Steam generator C blowdown line
SGB-FCV-1932B	Steam Generator C blowdown line
SGB-FCV-1933A	Steam generator A sample line
SGB-FCV-1933B	Steam generator A sample line
~~SGB-FCV-1934A~~	~~Steam generator B sample line~~

SGB-FCV-1934B Steam generator B sample line

SGB-FCV-1935A Steam generator C sample line

SGB-FCV-1935B Steam generator C sample line

RM-1 Radiation Monitoring Pump outlet

RM-2 Radiation Monitoring Pump inlet

RM-3 Containment Outlet

RM-4 Containment Inlet

8. The containment isolation phase A signal, initiates Isolation Valve Seal Water System (IVSWS) by opening valves IVSW-PCV-1922A and IVSW-PCV-1922B.

9. The containment ventilation isolation signal will be generated and the following isolation valves will close.

HVAC-V12-6	V12-13
HVAC-V12-7	V12-10
HVAC-V12-8	V12-11
HVAC-V12-9	V12-12

10. The steam driven auxiliary feedwater pump will start automatically on loss of voltage on 4160 V busses 1 and 4 or Lo-Lo level in two steam generators.

11. Each accumulator will begin discharging its contents to its respective loop when the loop pressure drops below the gas pressure in the accumulator.

B. AUTOMATIC ACTIONS FOLLOWING THE GENERATION OF THE HIGH-HIGH CONTAINMENT PRESSURE SIGNAL

1. The spray pumps start and their discharge valves SI-880A, SI-880B, SI-880C and SI-880D, into the containment open.

2. All main steam line isolation valves close.

3. The containment isolation phase B signal will be generated and close the following isolation valves:

CVC-381	Reactor coolant pump seal water return line.
CC-FCV-626	Reactor coolant pump thermal barrier cooling water return line.
CC-735	Reactor coolant pump thermal barrier cooling water return line.
CC-716A	Reactor coolant pump cooling water inlet line.
CC-716B	Reactor coolant pump cooling water inlet line.
CC-730	Reactor coolant pump bearing oil cooler cooling water return line.

APPENDIX A

DETAILED RECOVERY PROCEDURE - LOSS OF REACTOR COOLANT

A. DISCUSSION

The objectives of this procedure are as follows:

1. Provide emergency core cooling to prevent damage to the fuel cladding and release of excessive radioactivity.
2. Provide long-term control and cooldown of the reactor by recirculation of spilled reactor coolant, injected water, and containment spray system drainage.
3. Adjust the chemistry of the spray solution to increase the effectiveness of iodine removal from the containment atmosphere when required.

B. SYMPTOMS (Unique to loss of reactor coolant)

1. Rising containment pressure.
2. High containment radiation alarm.
3. Rising water level in the containment sump.

C. IMMEDIATE ACTIONS

Automatic Actions

Refer to the automatic actions following the generation of the safety injection signal and the high-high containment pressure signal.

Manual Actions

1. Injection Phase
   (a) Manually reset safety injection as soon as the startup sequencing of safeguards equipment is completed.
   (b) If required, immediately after the hot leg high head injection valves SI-866A and SI-866B are opened compare the injection flow through FI-932 and FI-933 and verify that the loss of coolant accident is not the result of a break.

in one of these lines between the RCS and check valve SI-874A or SI-874B. If the flow down one header is significantly greater than the other, close both isolation valves SI-866A and SI-866B.

(c) Trip the residual heat removal pumps to prevent residual heat removal loop pressurization if the Reactor Coolant System pressure is still above 130 psig 15 minutes after the accident.

(d) Close the accumulator isolation valves SI-865A, 865B, and 865C if the accumulator pressure is less than 250 psig.

(e) Check the status of the control room ventilation to ensure that control room intake duct isolation has occurred and that emergency recirculation has been initiated.

(f) Stop the diesel generators provided outside power has not been interrupted.

2. When the refueling water storage tank low level alarm is actuated, stop one safety injection pump and one containment spray pump.

3. When the refueling water low level alarm is actuated, terminate injection flow as follows:

   (a) Stop the operating safety injection, containment spray and residual heat removal pumps.

   (b) Close valves SI-856A, SI-856B, SI-864A and SI-864B to isolate the refueling water storage tank.

D. SUBSEQUENT ACTIONS

1. Recirculation Phase

(a) Verify the valve status as follows:

SI valves closed - 860A, 860B, 861A, 861B, 862A, 862B, 863A, 863B, 864A, 864B, 865A, 865B, 865C, 841A, 841B, 855, 856A, 856B.

Valves open - SI-866A, SI-866B, 870A, 870B, SI-869, RHR-744A and RHR-744B, SI-867 AND SI-867 B.

(b) Verify that the cooling water low flow alarm to the residual heat removal, containment spray and safety injection pumps are not actuated.

NOTE: The backup component cooling heat exchanger may be placed in service at this time by opening the service water valve and the component cooling water valve.

2. High Head Recirculation with Spray (Flow path using residual heat removal Pump A).

(a) Open valves SI-863A or 863B.

(b) Close valves RHR-744A and RHR-744B.

(c) Establish component cooling flow to "A" residual heat exchanger by opening RHR-749A and verify RHR-749B is closed.

(d) Open valves SI-860A and SI-861A and start residual heat removal pump "A" and two safety injection pumps to establish recirculation flow.

(e) Check the recirculation flow on FI-940 and FI-943.

(f) Start "A" C.V. spray pump and control flow reading of approximately 1160 gpm on FI-958A.

(g) Throttle SI-845C until a 12 gpm reading is obtained on FI-949.

(h) When the level in the spray additive tank reaches 0%, close SI-845C or SI-845B and 845A.

3. After recirculation has been established, secure the turbine in accordance with approved procedures.

4. For a coincident station blackout the following additional actions are required:

   (a) Verify automatic start of the steam driven auxiliary feedwater pump.

   (b) Ensure that a battery charger is operating.

5. Manually reset containment isolation by depressing the reset button.

6. Weekly sample recirculation loop fluid to determine solution boron concentration and pH and made necessary adjustments.

7. Small Break

In case of small break, characterized by a slowly decreasing RCS pressure,
10.8 additional actions can be taken to help RCS depressurization.

   (a) Sample each steam generator secondary side.

      (1) Manually reset containment isolation signal.

      (2) Open the blowdown sample isolation valves.

      (3) Observe the sample line radiation monitor RM19.

      (4) If the blowdown sample isolation valves automatically close, due to high radiation level, determine which steam generator is leaking, isolate it and dump steam from the other steam generators.

   (b) If radiation level is acceptable, transfer steam dump control from Tavg control to pressure control.

   (c) If the condenser is not available, use atmospheric steam relief.

   (d) Slowly increase the rate of steam dump and begin cooldown of the Reactor Coolant System.

   (e) The reactor coolant pumps can continue to run if the following conditions are met:

(1) The reactor coolant pressure is within the limits shown by the pressure temperature curve, Figure GP-3 of operating instruction GP-1.

(2) Component cooling water and seal injection flow have been re-established.

(3) The No. 1 seal static leak rate is normal.

(f) Switch to recirculation when the RWST low-low level alarm is actuated.

8. Low Head Recirculation with Spray (to be used only if no High Head Safety Injection Pumps are operable. Flow path using RHR Pump "A")

(a) Open SI-860A and SI-861A and start residual heat removal pump A.

(b) Ensure that component cooling flow is established to the residual heat exchanger in service by opening RHR-749A.

(c) Open SI-863A or SI-863B.

(d) Start a spray pump and limit flows as follows:

(1) 1160 gpm on FI 958A

(2) 2250 gpm on FI 605

Flow through FI 605 may be controlled by throttling RHR 744 "A" and "B". This may be accomplished by pulling the control fuses at the valves main breakers when desired flows are obtained.

(e) Throttle SI-845C until a 12 gpm reading is obtained on FI-949.

(f) When the level in the spray additive tank reaches 0%, close SI-845C or SI 845B and SI 845A.

NOTE: (1) Spray should be stopped during recirculation if:

1. Diverting recirculation flow to spray deprives the core of sufficient flow to ensure core flooding.

DETAILED RECOVERY PROCEDURE - STEAM LINE RUPTURE

A. DISCUSSION

The objectives of this procedure are as follows:

1. Establish stabilized temperature and pressure conditions prior to plant cooldown.
2. Minimize the energy release due to the break.
3. Prevent the pressurizer safety valves from lifting by dumping steam from the good steam generators.
4. Isolate the auxiliary feedwater flow to the faulty steam generator to protect it from thermal shock.

B. SYMPTOMS (UNIQUE TO STEAM BREAK)

1. Continuously decreasing Tavg.
2. Abnormally low pressure in one or all steam generators.

C. IMMEDIATE ACTIONS

Automatic Actions:

Refer to the automatic actions following the generation of the safety injection signal and the containment high-high pressure signal.

Manual Actions:

A-6 1. Manually reset safety injection as soon as the start-up sequencing of safeguards equipment is completed (~~opening of the hot leg high head injection line valves indicates completion of the start-up sequence~~). Delete
2. Verify that the steam dump valves and the atmosphere relief valves are closed to ensure that the emergency has not resulted from an inadvertent opening of these valves.
3. Due to the arrangement of main steam isolation valves and check valves, it is impossible for more than one steam generator to blowdown to ambient pressure even in the event of failure of one isolation valve. Therefore, determine if one steam generator has blowdown by observation of steam pressure and isolate the auxiliary feedwater flow to that steam generator.

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D. SUBSEQUENT ACTIONS

1. Stop both residual heat removal pumps.

2. Outside power is available:

(a) If, in addition to outside power being available, the stop valve in a good steam line is open, place the steam dump on manual control and commence a controlled steam dump from the good steam generators.

(b) If the stop valve in the good steam lines are closed, it will be impossible to obtain the required steam dump to the condenser. In this case, the power operated relief valves should be used to remove steam from the good steam generators.

NOTE: In case (a) above when the reactor coolant temperature reaches a minimum and begins to increase, rapidly decrease pressure in the good steam generator as necessary to stabilize temperatures. In case (b) above, reactor temperatures will stabilize at some level which is dependent upon the minimum pressure which can be achieved by atmospheric steam relief and thereafter will slowly decrease.

(c) Regulate level in the good steam generators using the auxiliary feedwater pumps.

(d) Stop the diesel generators, provided outside power has not been interrupted.

(e) When water level returns in the pressurizer, stop the safety injection pumps.

(f) When reactor temperatures have stabilized, establish the reactor systems necessary for a controlled shutdown to the cold condition.

(g) Cooldown in accordance with pertinent steps in GP-1 Overall Plant Operating Procedures.

3. Blackout Condition

(a) If outside power is not available, steam dump to the condenser is not possible regardless of the position of the main steam stop valves. Therefore, carry out steam relief to atmosphere to rapidly reduce pressure in the good steam generators.

(b) Stop the safety injection pumps when level returns in the pressurizer.

(c) Reactor temperatures will stabilize at some level dependent upon the minimum pressure achieved in the good steam generators and thereafter will slowly decrease.

(d) When outside power is returned to the plant, establish the reactor systems necessary for a controlled shutdown to the cold condition.

(e) Cooldown in accordance with pertinent steps in GP-1 Overall Plant Operating Procedure.

DETAILED RECOVERY PROCEDURE - STEAM GENERATOR TUBE RUPTURE

A. DISCUSSION

The objectives of this procedure are as follows:

1. To reduce the reactor coolant system pressure below, the steam generator atmospheric relief valve setting and minimize the discharge of radioactive material to the outside atmosphere.
2. To maintain the ability to remove the necessary residual heat from the reactor coolant system.
3. To maintain the system natural circulation by assuring sufficient over-pressure over localized coolant fluid temperatures.
4. To prevent overflooding of the faulty steam generator and water-slugging the steam lines.

B. SYMPTOMS - (Unique to Tube Rupture)

1. Condenser air removal equipment radiation monitor alarm.
2. Steam generator blowdown radiation monitor alarm and blowdown isolation and sample valves closed.
3. Low or decreasing feedwater flow to one steam generator (prior to trip).

C. IMMEDIATE ACTIONS

Automatic Actions

Refer to the automatic actions following the generation of the safety injection signal.

Manual Actions (after trip)

1. Reduce auxiliary feedwater flow as necessary to the steam generators to maintain the minimum water level reached as no-load temperature and pressure are established.

   NOTE: If the water level increases in one steam generator, completely isolate auxiliary feedwater flow to that steam generator.

2. If outside power is available, verify that condenser steam dump maintains the no-load Tavg (or that the steam dump valves are closed if Tavg is less than 547 °F), and transfer steam dump to steam header pressure control.

3. Manually reset safety injection as soon as the startup sequencing of safeguards equipment is completed (~~opening of the hot leg high head injection line valves indicates completion of the startup sequence~~ Delete).

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4. Verify that two service water pumps are operating.

5. Stop both residual heat removal pumps. (Pressure in the Reactor Coolant System is above pump shutoff head).

D. <u>SUBSEQUENT ACTIONS</u>

1. As the water level returns in the pressurizer, stop one safety injection pump.

2. If outside power is available:

(a) Reduce steam header pressure with condenser steam dump until the reactor coolant system pressure reaches approximately 1000 psig. This must be done slowly so that indicated pressurizer water level remains on scale.

(b) Identify the faulty steam generator.

(1) If the high water level alarm is actuated for any steam generator, when no auxiliary feedwater flow is added, assume that this steam generator is the leaking one.

(2) If the faulty steam generator is not apparent (increasing water level), sample all steam generators secondary side to identify it.

a. Manually reset containment isolation.

b. Alternatively open the blowdown sample isolation valves and determine sample activity on the blowdown radiation monitor.

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(c) Stop auxiliary feedwater to the faulty steam generator.

(d) Isolate the faulty steam generator by closing its main steam stop valve.

(e) When steam pressure in the faulty steam generator rises to about 1000 psi terminate tube leakage as follows:

(1) Stop the safety injection pump

(2) Re-establish charging pump operation and maintain pressurizer water level.

(3) Re-establish pressurizer heaters to maintain approximately 1000 psi pressure in system.

(f) Establish the reactor systems necessary for a normal cooldown.

(g) Continue plant cooldown to a cold condition by steam dump to the condenser in accordance with normal cooldown procedure.

3. Blackout Condition

(a) If the faulty steam generator is not apparent (increasing water level) sample each steam generator to identify it.

(b) Stop auxiliary feedwater flow and isolate the affected steam generator by closing its main steam stop valve after RCS pressure ≲ 1000 psig.

(c) Use atmospheric steam dump from the unaffected steam generators to establish 850 psig in the unaffected steam generators and maintain this pressure by regulating the atmospheric relief valves.

(d) Terminate tube leakage as follows:

(1) Stop the safety injection pump.

(2) Reduce RCS pressure to 1000 psig using pressurizer power operated relief valves.

(3) Re-establish charging pump operation and maintain pressurizer water level.

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A-1 (4) Energize 480V Bus 1, or 2A or 2B with the diesel and re-establish pressurizer heaters to maintain approximately 1000 psig pressure in system.

A-4 (e) When outside power returns proceed with plant cooldown to cold shutdown condition by steam dump to the condenser from the unaffected steam generators in accordance with normal plant cooldown ~~procedure~~ PROCEDURE.

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