CONTAINMENT SYSTEMS

IGNITION

HYDROGEN ~~MITIGATION~~ SYSTEM

LIMITING CONDITION FOR OPERATION

3.6.4.3 Both trains of the Hydrogen ~~Mitigation~~ System shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTION:

REPLACE ENTIRE PARAGRAPH WITH ATTACHED PARAGRAPH 1

~~With one train of the Hydrogen Mitigation System inoperable, restore the inoperable train to OPERABLE status within 7 days or decrease the surveillance interval of Specification 4.6.4.3a. from 92 days to 7 days on the OPERABLE train until the inoperable train is returned to OPERABLE status.~~

SURVEILLANCE REQUIREMENTS

4.6.4.3 Each train of the Hydrogen ~~Mitigation~~ System shall be demonstrated OPERABLE: CHANGE TO UPPERCASE "O" IGNITION

a. ~~At least~~ once per 92 days by energizing the supply breakers and verifying that at least 34 of 35 igniters are energized,~~*~~ ~~and~~ DELETE

CHANGE TO "C"

b. ~~At least~~ once per 18 months by verifying the temperature of each igniter is a minimum of 1700°F.

INSERT STATEMENT 1 FROM ATTACHED PAGE

CHANGE TO UPPER CASE "O"

~~*Inoperable igniters must not be on corresponding redundant circuits which provide coverage for the same region~~

DELETE STATEMENT

3/4.6.2 DEPRESSURIZATION AND COOLING SYSTEMS

The OPERABILITY of the Containment Spray System ensures that containment depressurization and cooling capability will be available in the event of a LOCA. The pressure reduction and resultant lower containment leakage rate are consistent with the assumptions used in the safety analyses. However, the Containment Spray System also provides a mechanism for removing iodine from the containment atmosphere, and therefore the time requirements for restoring an inoperable Spray System to OPERABLE status have been maintained consistent with those assigned other inoperable ESF equipment.

3/4.6.3 CONTAINMENT ISOLATION VALVES

The OPERABILITY of the containment isolation valves ensures that the containment atmosphere will be isolated from the outside environment in the event of a release of radioactive material to the containment atmosphere or pressurization of the containment and is consistent with the requirements of GDC 54 through 57 of Appendix A to 10 CFR Part 50. Containment isolation within the time limits specified for those isolation valves designed to close automatically ensures that the release of radioactive material to the environment will be consistent with the assumptions used in the analyses for a LOCA.

3/4.6.4 COMBUSTIBLE GAS CONTROL

The OPERABILITY of the equipment and systems required for the detection and control of hydrogen gas ensures that this equipment will be available to maintain the hydrogen concentration within containment below its flammable limit during post-LOCA conditions. Either recombiner unit is capable of controlling the expected hydrogen generation associated with: (1) zirconium-water reactions, (2) radiolytic decomposition of water, and (3) corrosion of metals within containment. These Hydrogen Control Systems are consistent with the recommendations of Regulatory Guide 1.7, "Control of Combustible Gas Concentrations Following a LOCA," March 1971.

~~The OPERABILITY of at least 34 of 35 igniters per train (68 of 70 for both trains) ensures that the Distributed Ignition System will maintain an effective coverage throughout the containment provided the two inoperable ignitors are not on corresponding redundant circuits which provide coverage for the same region. This system of igniters will initiate combustion of any significant amount of hydrogen released after a degraded core accident. This system is to ensure burning in a controlled manner as the hydrogen is released instead of allowing it to be ignited at high concentrations by a random ignition source.~~

REPLACE ENTIRE PARAGRAPH WITH ATTACHED PAGES FOR THE BASES SECTION

Insertions for Technical Specification 3.6.4.3

Paragraph 1

With one train of the Hydrogen Ignition System inoperable:

a. Restore the inoperable train to OPERABLE status within 7 days, OR

b. Perform surveillance requirement 4.6.4.3a once per 7 days on the OPERABLE train until the inoperable train is restored to OPERABLE status.

With no OPERABLE Hydrogen Ignitor in one containment region, restore one hydrogen ignitor in the affected containment region to OPERABLE status within 7 days, OR be in HOT STANDBY within 6 hours.

Statement 1

b. Once per 92 days, verify at least one hydrogen ignitor is OPERABLE in each containment region.

Replacement paragraphs for the Bases section.

3/4.6.4.3 Hydrogen Ignition System (HIS)

BACKGROUND

The HIS reduces the potential for breach of primary containment due to a hydrogen oxygen reaction in post accident environments. The HIS is required by 10 CFR 50.44, "Standards for Combustible Gas Control Systems in Light-Water-Cooled Reactors" (Ref. 1). and Appendix A, GDC 41, "Containment Atmosphere Cleanup" (Ref. 2), to reduce the hydrogen concentration in the primary containment following a degraded core accident. The HIS must be capable of handling an amount of hydrogen equivalent to that generated from a metal water reaction involving 75% of the fuel cladding surrounding the active fuel region (excluding the plenum volume).

10 CFR 50.44 (Ref. 1) requires units with ice condenser containments to install suitable hydrogen control systems that would accommodate an amount of hydrogen equivalent to that generated from the reaction of 75% of the fuel cladding with water. The HIS provides this required capability. This requirement was placed on ice condenser units because of their small containment volume and low design pressure (compared with pressurized water reactor dry containments). Calculations indicate that if hydrogen equivalent to that generated from the reaction of 75% of the fuel cladding with water were to collect in the primary containment, the resulting hydrogen concentration would be far above the lower flammability limit such that, if ignited from a random ignition source, the resulting hydrogen burn would seriously challenge the containment and safety systems in the containment.

The HIS is based on the concept of controlled ignition using thermal ignitors, designed to be capable of functioning in a post accident environment, seismically supported, and capable of actuation from the control room. A total of 70 ignitors are distributed throughout the various regions of containment in which hydrogen could be released or to which it could flow in significant quantities. The ignitors are arranged in two independent trains such that each containment region has at least two ignitors, one from each train, controlled and powered redundantly so that ignition would occur in each region even if one train failed to energize.

When the HIS is initiated, the ignitor elements are energized and heat up to a surface temperature $\geq$ 1700 F. At this temperature, they ignite the hydrogen gas that is present in the airspace in the vicinity of the ignitor. The HIS depends on the dispersed location of the ignitors so that local pockets of hydrogen at increased concentrations would burn before reaching a hydrogen concentration significantly higher than the lower flammability limit. Hydrogen ignition in the vicinity of the ignitors is assumed to occur when the local hydrogen concentration reaches 8.5 volume percent (v/o) and results in 100% of the hydrogen present being consumed.

APPLICABLE SAFETY ANALYSES

The HIS causes hydrogen in containment to burn in a controlled manner as it accumulates following a degraded core accident (Ref. 3). Burning occurs at the lower flammability concentration, where the resulting temperatures and pressures are relatively benign. Without the system, hydrogen could build up to higher concentrations that could result in a violent reaction if ignited by a random ignition source after such a buildup.

The hydrogen ignitors are not included for mitigation of a Design Basis Accident (DBA) because an amount of hydrogen equivalent to that generated from the reaction of 75% of the fuel cladding with water is far in excess of the hydrogen calculated for the limiting DBA loss of coolant accident (LOCA). The hydrogen concentration resulting from a DBA can be maintained less than the flammability limit using the hydrogen recombiners. The hydrogen ignitors, however, have been shown by probabilistic risk analysis to be a significant contributor to limiting the severity of accident sequences that are commonly found to dominate risk for units with ice condenser containments. As such, the hydrogen ignitors are considered to be risk significant in accordance with the NRC Policy Statement.

LCO

Two HIS trains must be OPERABLE with power from two independent, safety related power supplies.

An OPERABLE HIS train consists of 34 of 35 ignitors energized on the train.

Operation with at least one HIS train ensures that the hydrogen in containment can be burned in a controlled manner. Unavailability of both HIS trains could lead to hydrogen buildup to higher concentrations, which could result in a violent reaction if ignited. The reaction could take place fast enough to lead to high temperatures and overpressurization of containment and, as a result, breach containment or cause containment leakage rates above those assumed in the safety analyses. Damage to safety related equipment located in containment could also occur.

Requiring OPERABILITY in MODES 1 and 2 for the HIS ensure its immediate availability after safety injection and scram actuated on a LOCA initiation. In the post accident environment, the two HIS subsystems are required to control the hydrogen concentration within containment to near its flammability limit of 4.1 v/o assuming a worst case single failure. This prevents overpressurization of containment and damage to safety related equipment and instruments

In MODES 3 and 4 both the hydrogen production rate and total hydrogen production after a LOCA would be significantly less than that calculated for the DBA LOCA. Also, because of the limited time in these MODES, the probability of an accident requiring the HIS is low.

In MODES 5 and 6, the probability and consequences of a LOCA are reduced due to the pressure and temperature limitations of these MODES. Therefore, the HIS is not required to be OPERABLE in MODES 3, 4, 5 and 6.

ACTIONS

One Train Inoperable, Action a. and b.

With one HIS train inoperable, the inoperable train must restored to OPERABLE status within 7 days or the OPERABLE train must be verified OPERABLE frequently by performance of SR 4.6.4.3a. The 7 day Completion Time is based on the low probability of the occurrence of a degraded core event that would generate hydrogen in amounts equivalent to a metal water reaction of 75% of the core cladding, the length of time after the event that operator action would be required to prevent hydrogen accumulation from exceeding this limit, and the low probability of failure of the OPERABLE HIS train. The Alternative Required Action **b**, by frequent surveillances, provides assurance that the OPERABLE train continues to be OPERABLE.

Both trains in One Containment Region Inoperable

This condition is defined as one containment region with no OPERABLE hydrogen ignitor. (No Train A or Train B ignitor operable at the same containment location) Thus, while in this condition, or in this condition and the above described condition simultaneously, there would always be ignition capability in the adjacent containment regions that would provide redundant capability by flame propagation to the region with no OPERABLE ignitors.

This action calls for the restoration of one hydrogen ignitor in each region to OPERABLE status within 7 days. The 7 day Completion Time is based on the same reasons given under the above action for one train inoperable.

Inability To Restore At Least One Hydrogen Ignitor To Operable Status Within the Action Time

The unit must be placed in a MODE in which the LCO does not apply if the HIS subsystems cannot be restored to OPERABLE status within the associated Completion Time. This is done by placing the unit in at least MODE 3, HOT STANDBY, within 6 hours. The allowed completion time of 6 hours is reasonable, based on operating experience, to reach MODE 3 from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS (SR)

SR 4.6.4.3a

This SR confirms that ≥ 34 of 35 hydrogen ignitors can be successfully energized in each train. The ignitors are simple resistance elements. Therefore, energizing provides assurance of OPERABILITY. The allowance of one inoperable hydrogen ignitor is acceptable because, although one inoperable hydrogen ignitor in a region would compromise redundancy in that region, the containment regions are interconnected so that ignition in one region would cause burning to progress to the others (i.e., there is overlap in each hydrogen ignitor's effectiveness between regions). The Frequency of 92 days has been shown to be acceptable through operating experience.

SR 4.6.4.3b

This SR confirms that the two inoperable hydrogen ignitors allowed by SR 4.6.4.3a (i.e., one in each train) are not in the same containment region. The Frequency of 92 days is acceptable based on the Frequency of SR 4.6.4.3a, which provides the information for performing this SR.

SR 4.6.4.3c

A more detailed functional test is performed every 18 months to verify system OPERABILITY. All ignitors, including normally inaccessible ignitors, are visually checked for a glow to verify that they are energized. Additionally, the surface temperature of each ignitor is measured to be ≥1700 F to demonstrate that a temperature sufficient for ignition is achieved. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown that these components usually pass the SR when performed at the 18 month Frequency, which is based on the refueling cycle. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

REFERENCES

1. 10 CFR 50.44.
2. 10 CFR 50, Appendix A, GDC 41.
3. FSAR, Section 6.2.
4. An Analysis of Hydrogen Control Measures at McGuire Nuclear Station, as Revised by Revision 9 to be Applicable to Catawba Nuclear Station.

ATTACHMENT 5

REPRINTED TS PAGES

CONTAINMENT SYSTEMS

HYDROGEN IGNITION SYSTEM

LIMITING CONDITION FOR OPERATION

3.6.4.3 Both trains of the Hydrogen Ignition System shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTION:

With one train of the Hydrogen Ignition System inoperable:

a. Restore the inoperable train to OPERABLE status within 7 days, OR

b. Perform surveillance requirement 4.6.4.3a once per 7 days on the OPERABLE train until the inoperable train is restored to OPERABLE status.

With no OPERABLE Hydrogen Ignitor in one containment region, restore one hydrogen ignitor in the affected containment region to OPERABLE status within 7 days, OR be in HOT STANDBY within 6 hours.

SURVEILLANCE REQUIREMENTS

4.6.4.3 Each train of the Hydrogen Ignition System shall be demonstrated OPERABLE:

a. Once per 92 days by energizing the supply breakers and verifying that at least 34 of 35 ignitors are energized.

b. Once per 92 days, verify at least one hydrogen ignitor is OPERABLE in each containment region.

c. Once per 18 months by verifying the temperature of each ignitor is a minimum of 1700°F.

CONTAINMENT SYSTEMS

BASES

3/4.6.2 DEPRESSURIZATION AND COOLING SYSTEMS

The OPERABILITY of the Containment Spray System ensures that containment depressurization and cooling capability will be available in the event of a LOCA. The pressure reduction and resultant lower containment leakage rate are consistent with the assumptions used in the safety analyses. However, the Containment Spray System also provides a mechanism for removing iodine from the containment atmosphere, and therefore the time requirements for restoring an inoperable Spray System to OPERABLE status have been maintained consistent with those assigned other inoperable ESF equipment.

3/4.6.3 CONTAINMENT ISOLATION VALVES

The OPERABILITY of the containment isolation valves ensures that the containment atmosphere will be isolated from the outside environment in the event of a release of radioactive material to the containment atmosphere or pressurization of the containment and is consistent with the requirements of GDC 54 through 57 of Appendix A to 10 CFR Part 50. Containment isolation within the time limits specified for those isolation valves designed to close automatically ensures that the release of radioactive material to the environment will be consistent with the assumptions used in the analyses for a LOCA.

3/4.6.4 COMBUSTIBLE GAS CONTROL

The OPERABILITY of the equipment and systems required for the detection and control of hydrogen gas ensures that this equipment will be available to maintain the hydrogen concentration within containment below its flammable limit during post-LOCA conditions. Either recombiner unit is capable of controlling the expected hydrogen generation associated with: (1) zirconium-water reactions, (2) radiolytic decomposition of water, and (3) corrosion of metals within containment. These Hydrogen Control Systems are consistent with the recommendations of Regulatory Guide 1.7, "Control of Combustible Gas Concentrations Following a LOCA," March 1971.

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CONTAINMENT SYSTEMS

BASES

3/4.6.4.3 Hydrogen Ignition System (HIS) (Continued)

10 CFR 50.44 (Ref. 1) requires units with ice condenser containments to install suitable hydrogen control systems that would accommodate an amount of hydrogen equivalent to that generated from the reaction of 75% of the fuel cladding with water. The HIS provides this required capability. This requirement was placed on ice condenser units because of their small containment volume and low design pressure (compared with pressurized water reactor dry containments). Calculations indicate that if hydrogen equivalent to that generated from the reaction of 75% of the fuel cladding with water were to collect in the primary containment, the resulting hydrogen concentration would be far above the lower flammability limit such that, if ignited from a random ignition source, the resulting hydrogen burn would seriously challenge the containment and safety systems in the containment.

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When the HIS is initiated, the ignitor elements are energized and heat up to a surface temperature ≥ 1700 F. At this temperature, they ignite the hydrogen gas that is present in the airspace in the vicinity of the ignitor. The HIS depends on the dispersed location of the ignitors so that local pockets of hydrogen at increased concentrations would burn before reaching a hydrogen concentration significantly higher than the lower flammability limit. Hydrogen ignition in the vicinity of the ignitors is assumed to occur when the local hydrogen concentration reaches 8.5 volume percent (v/o) and results in 100% of the hydrogen present being consumed.

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The HIS causes hydrogen in containment to burn in a controlled manner as it accumulates following a degraded core accident (Ref. 3). Burning occurs at the lower flammability concentration, where the resulting temperatures and pressures are relatively benign. Without the system, hydrogen could build up to higher concentrations that could result in a violent reaction if ignited by a random ignition source after such a buildup.

CONTAINMENT SYSTEMS

BASES

3/4.6.4.3 Hydrogen Ignition System (HIS) (Continued)

The hydrogen ignitors are not included for mitigation of a Design Basis Accident (DBA) because an amount of hydrogen equivalent to that generated from the reaction of 75% of the fuel cladding with water is far in excess of the hydrogen calculated for the limiting DBA loss of coolant accident (LOCA). The hydrogen concentration resulting from a DBA can be maintained less than the flammability limit using the hydrogen recombiners. The hydrogen ignitors, however, have been shown by probabilistic risk analysis to be a significant contributor to limiting the severity of accident sequences that are commonly found to dominate risk for units with ice condenser containments. As such, the hydrogen ignitors are considered to be risk significant in accordance with the NRC Policy Statement.

LCO

Two HIS trains must be OPERABLE with power from two independent, safety related power supplies.

An OPERABLE HIS train consists of 34 of 35 ignitors energized on the train.

Operation with at least one HIS train ensures that the hydrogen in containment can be burned in a controlled manner. Unavailability of both HIS trains could lead to hydrogen buildup to higher concentrations, which could result in a violent reaction if ignited. The reaction could take place fast enough to lead to high temperatures and overpressurization of containment and, as a result, breach containment or cause containment leakage rates above those assumed in the safety analyses. Damage to safety related equipment located in containment could also occur.

Requiring OPERABILITY in MODES 1 and 2 for the HIS ensure its immediate availability after safety injection and scram actuated on a LOCA initiation. In the post accident environment, the two HIS subsystems are required to control the hydrogen concentration within containment to near its flammability limit of 4.1 v/o assuming a worst case single failure. This prevents overpressurization of containment and damage to safety related equipment and instruments

In MODES 3 and 4 both the hydrogen production rate and total hydrogen production after a LOCA would be significantly less than that calculated for the DBA LOCA. Also, because of the limited time in these MODES, the probability of an accident requiring the HIS is low.

In MODES 5 and 6, the probability and consequences of a L are reduced due to the pressure and temperature limitations of these MODES. Therefore, the HIS is not required to be OPERABLE in MODES 3, 4, 5 and 6.

CONTAINMENT SYSTEMS

BASES

3/4.6.4.3 Hydrogen Ignition System (HIS) (Continued)

ACTIONS

One Train Inoperable Action a. and b.

With one HIS train inoperable, the inoperable train must restored to OPERABLE status within 7 days or the OPERABLE train must be verified OPERABLE frequently by performance of SR 4.6.4.3a. The 7 day Completion Time is based on the low probability of the occurrence of a degraded core event that would generate hydrogen in amounts equivalent to a metal water reaction of 75% of the core cladding, the length of time after the event that operator action would be required to prevent hydrogen accumulation from exceeding this limit, and the low probability of failure of the OPERABLE HIS train. The Alternative Required Action b, by frequent surveillances, provides assurance that the OPERABLE train continues to be OPERABLE.

Both trains in One Containment Region Inoperable

This condition is one containment region with no OPERABLE hydrogen ignitor. (No Train A or Train B ignitor operable at the same containment location) Thus, while in this condition B, or in this condition and the above condition simultaneously, there would always be ignition capability in the adjacent containment regions that would provide redundant capability by flame propagation to the region with no OPERABLE ignitors.

This action calls for the restoration of one hydrogen ignitor in each region to OPERABLE status within 7 days. The 7 day Completion Time is based on the same reasons given under the above action for one train inoperable.

Inability To Restore At Least One Hydrogen Igniter To Operable Status Within the Action Time

The unit must be placed in a MODE in which the LCO does not apply if the HIS subsystems) cannot be restored to OPERABLE status within the associated Completion Time. This is done by placing the unit in at least MODE 3 within 6 hours. The allowed Completion Time of 6 hours is reasonable, based on operating experience, to reach MODE 3 from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS (SR)

SR 4.6.4.3a

This SR confirms that ≥ 34 of 35 hydrogen ignitors can be successfully energized in each train. The ignitors are simple resistance elements.

CONTAINMENT SYSTEMS

BASES

3/4.6.4.3 Hydrogen Ignition System (HIS) (Continued)

Therefore, energizing provides assurance of OPERABILITY. The allowance of one inoperable hydrogen ignitor is acceptable because, although one inoperable hydrogen ignitor in a region would compromise redundancy in that region, the containment regions are interconnected so that ignition in one region would cause burning to progress to the others (i.e., there is overlap in each hydrogen ignitor's effectiveness between regions). The Frequency of 92 days has been shown to be acceptable through operating experience.

SR 4.6.4.3b

This SR confirms that the two inoperable hydrogen ignitors allowed by SR 4.6.4.3a (i.e., one in each train) are not in the same containment region. The Frequency of 92 days is acceptable based on the Frequency of SR 4.6.4.3a, which provides the information for performing this SR.

SR 4.6.4.3c

A more detailed functional test is performed every 18 months to verify system OPERABILITY. Each glow plug is visually examined to ensure that it is clean and that the electrical circuitry is energized. All ignitors (glow plugs), including normally inaccessible ignitors, are visually checked for a glow to verify that they are energized. Additionally, the surface temperature of each glow plug is measured to be ≥1700 F to demonstrate that a temperature sufficient for ignition is achieved. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown that these components usually pass the SR when performed at the 18 month Frequency, which is based on the refueling cycle. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

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