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Nine Mile Point 1 Nuclear Power Station

SAFETY EVALUATION

GE Core Shroud Repair Design

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PART A -DESCRIPTION

Cracks have been observed in the core shrouds of several BWRs. The NRC issued Generic Letter 94-03 which requires inspection and/or repair. Although the shroud welds on Nine Mile Point 1 have not been completely examined, using the currently recommended non-destructive examination techniques, a repair is being prepared as a contingency, if the weld examination results show that shroud cracking is not acceptable for continued service. The total scope of the welds involved are welds H1 through H8, as shown in Figure 1. After evaluating alternative repair concepts, the installation of core shroud stabilizers and H8 weld brackets was chosen as the repair contingency for NMPC. The basic function is to provide a non-welded, mechanical solution to the problem of unacceptable core shroud welds, which may be found in Nine Mile Point 1.

The proposed shroud repair design is in accordance with the BWR Vessel Internal Project (VIP) shroud repair criteria (reference 17). The VIP criteria is met for NMP1 in a manner consistent with a similar NRC approved GE shroud repair design.

PART A.1 General

As shown in Figure 1, there are 9 horizontal welds in the Nine Mile Point 1 shroud. These welds are called H1 through H8, with the welds at the core plate support ring designated H6A and H6B. Weld H1 is the uppermost weld and weld H8 is the attachment of shroud support ring to the cone. Welds H1 through H6B are all of the circumferential welds in the shroud cylinders. Weld H7 is the shroud to shroud support ring weld. Weld H8 is the bimetallic weld of the shroud support ring to the shroud support cone. These welds were required to both vertically and horizontally support the core top guide, core support plate, and shroud head; and to prevent core flow bypass into the downcomer region. The core top guide and core support plate horizontally support the fuel assemblies and maintain the correct fuel channel spacing, thereby assuring control rod insertion.

The proposed modification will ensure the structural integrity of the core shroud by replacing the function of welds Hl through H8 of the core shroud with 4 stabilizer and 6 H8 weld bracket assemblies. Each stabilizer assembly attaches to the top of the shroud and to the shroud support cone. Each H8 weld upper bracket assembly attaches to the bottom of the shroud at the shroud to shroud support cone interface. The lower H8 bracket rests on the shroud support cone and is wedged in place between the upper H8 bracket and the RPV.

The design life of all repair hardware will be for twenty-five years (the remaining life of the plant, plus life extension beyond the current operating license), to include 20 Effective Full Power Years.

The proposed modification is bounded for 3, 4 or 5 recirculation pump operation, 105% core flow, and fluctuations in feedwater temperature during normal operations. The loss of feedwater heating with a scram would not adversely impact the tie rod assemblies due to their inherent elasticity and would not require inspection of the tie rod assemblies. The analyses and conclusions documented in this Safety Evaluation remain the same for the installation of tie-rod assemblies with or without H8 bracket supports.

Radially acting stabilizers (springs and limit stops) are used to maintain the alignment of the core shroud to the reactor pressure vessel (RPV) during lateral seismic loading. The set of stabilizers replace the structural functions of the shroud welds which are postulated to contain cracks. Each stabilizer assembly consists of an upper spring, an upper bracket and tie rod support, a tie rod, a mid-span tie rod support, a lower spring, a lower anchor assembly, and other minor parts. The tie rod provides the vertical load carrying capability from the upper bracket to the lower anchor assembly attached to the RPV core shroud support cone, and provides support for the springs. The vertical locations of the radial springs were chosen to provide the maximum support for the shroud, top guide, core plate, and therefore, the fuel assemblies. The upper spring provides radial load carrying capability from the shroud, at the top guide elevation, to the RPV. The lower spring provides radial load carrying capability from the shroud, at the core support plate elevation, to the RPV. The upper stabilizer bracket provides an attachment feature to the top of the shroud as well as restraint of the upper shroud welds. The mid-span tie rod support is installed to provide a limit stop for the shroud cylinder between the H4 and H5. The mid-span tie rod support which is preloaded against the RPV effectively divides the tie rod into two shorter, stiffer rods which increases the natural frequencies of the tie rod, thereby preventing unacceptable levels of flow induced vibrations.

The H8 weld brackets provide vertical support in the event of a complete H8 weld failure. Each H8 weld bracket assembly consists of an upper bracket, two toggle bolts, two shear keys and a lower bracket. The upper bracket provides the load path from the shroud to the lower bracket. The lower bracket transmits load to the shroud support cone and the RPV.

The primary forces applied to the stabilizers are from seismic events, LOCA differential pressure loads, and differential thermal expansion. The stabilizer assemblies and cracks in the shroud change the seismic response of the reactor internals. Thus, it was necessary to modify the seismic analysis of the reactor to include the effects of the cracks and the stabilizers. This dynamic analysis was performed in a iterative manner to determine the appropriate values of the spring constants of the upper and lower springs as well as the number of stabilizer assemblies required. It was determined that four stabilizer assemblies would be acceptable.

The primary forces on the H8 weld bracket are from seismic events and inlet recirculation LOCA differential pressure loads. Based on the shear loads transmitted from the shroud through the toggle bolts and shear keys, it was determined that six bracket assemblies would be acceptable.

The core shroud is a safety related component. As defined the FSAR, section IV.7.1.1, the core shroud is a stainless steel cylinder which surrounds the core and provides a barrier to separate the upward flow of coolant through the core from the downcomer recirculation flow. Mounted at the top of the shroud is the shroud head and steam-separator assembly. A discharge plenum at the top of the core provides a mixing chamber before the steam-water mixture enters the steam separators. The recirculation inlet and outlet plenums are separated by the shroud and the shroud support cone. The shroud support cone is designed to transition the differential expansion of the ferritic reactor vessel and austenitic stainless steel shroud without high stresses. The shroud support cone is fabricated from Inconel 600 plate, which has a coefficient of thermal expansion in-between carbon steel and stainless steel. The shroud support cone essentially carries all of the vertical weight of the core structure (except the fuel assembly weights transmitted to the guide tube) and the steam separator assembly. The shroud support cone also carries the differential upward pressure loading on the shroud under operating conditions; and the vertical and sidewise thrusts developed on the core and core structure during an earthquake.

The cylindrical shroud is joined to the shroud support cone with a full penetration weld (H8). All of the core structure, except the shroud support cone and the springs in the fuel assemblies, are fabricated from austenitic stainless steel. The principal stresses produced in the shroud are due to differential pressure loading, differential thermal expansion, dead-weight loadings and earthquake loadings.

The stabilizers and H8 weld brackets were designed to the structural criteria specified in the Nine Mile Point 1 UFSAR. The UFSAR compares the calculated shroud stresses against the allowable stress (Sm) for all operating conditions and events. Allowable stress intensities for other stress combinations and accident conditions are not addressed in the UFSAR. For the local and local plus bending, the RPV purchase specification (reference 16) is used as a basis for using 1.5 Sm for the local and local plus bending. The basis for the additional 1.5 and 2.0 factors applied to the emergency and faulted events is consistent with the basis for other shroud repair applications. The method involved ratioing factors of safety. Equivalent factors of safety were not in the UFSAR for Nine Mile Point 1. The factors of safety that were used are consistent with other plants using the tie rod stabilizer shroud repair. It was judged that it was reasonable to also apply these to Nine Mile Point 1 to provide a consistent basis. All of the loads and load combinations specified in the UFSAR, that are relevant to the core shroud, were evaluated in the design.

The stabilizers are installed with a small tension preload of 3,000 lb., to ensure that all components are tight. The stabilizer assemblies will be thermally preloaded to 79,670 lb. when the reactor is at operating conditions. This results from the thermal expansion coefficient for the new stabilizer hardware being less than the thermal expansion coefficient of the shroud.

The H8 weld upper brackets are installed with a small tension preload of 1300 lb. in the toggle bolts. The lower bracket is captured by the upper bracket, the RPV, and the shroud support cone, see Figure 3.

Thus, if any or all of the H1 through H8 welds were completely cracked, the stabilizers and H8 weld brackets will vertically restrain the shroud such that no displacement will occur during normal operation, which minimizes potential leakage through the cracks.

The maximum permanent horizontal deflection of any part of the shroud that is not directly supported by either the upper or lower radial springs is limited to approximately 0.75 inch by mechanical limit stops. These stops do not perform this function unless a section of the shroud, for example between H4 and H5, becomes loose and a combined LOCA plus seismic event occurs. If this unlikely scenario occurs, the stops will limit the horizontal displacement to approximately 0.75 inch, which is equal to one half of the shroud wall thickness. A displacement equal to one half of the shroud wall thickness will not result in post event leakage's that prevent core cooling, because the shroud section still overlap each other by one half (0.75 inch) of the shroud wall thickness.

Wedges between the core support and the shroud (also called the Clamp/Spacer) are required at each stabilizer location to prevent relative motion of the core plate to the shroud. The four spacers are located in the annulus between the core support and the shroud and rest on the shroud ring. The wedges are held in place by clamping under the existing angle brackets that position the existing shield blocks. The annulus is measured at each location and the spacers are machined for a maximum clearance of 0.030 in. at the core plate elevation. In the event that welds H6A and H6B failed, the wedges would provide a direct load path from the core plate to the shroud to help distribute the lateral loads occurring during a seismic event. The shroud cylinder at this location is restrained in the lateral direction by the lower tie rod spring.

The upper and lower springs of the stabilizers are installed with a small radial preload such that they provide radial support for the shroud. During normal operation, the shroud and stabilizer springs radially expand due to thermal growth slightly more than the RPV, which increases the radial preload and assures that the springs provide lateral support for the shroud during normal operation.

The vertical location of the upper and lower springs was chosen to provide the maximum horizontal support for the fuel assemblies. The upper springs are at the top guide elevation and the lower springs are at the core support plate elevation. All of the horizontal support for the fuel assemblies is provided by the top guide and the core support plate.

The stabilizer, core plate wedges, and H8 weld bracket assemblies are designed and fabricated as safety related components. The installation of the stabilizer, core plate wedges, and H8 weld bracket assemblies will replace the functions of welds H1 through H8.

Figure 2 shows a core shroud stabilizer. At the top, each stabilizer assembly fits through two slots, which are machined into the non-safety related shroud head and steam separator assembly. The stabilizer upper bracket contacts the top surface and the inside surface of the shroud top flange. It then extends downward to below weld H3. It supports the upper spring and has a hole through which the tie rod passes. The tie rod is held against the upper bracket with a nut. The tie rod extends downward approximately 136 inches to the lower spring. At the middle of the tie rod there is a support between the tie rod and the RPV. The support is installed such that there is a radial force between the tie rod and the RPV. The support minimizes the potential for vibration of the stabilizer assembly. At the bottom, the tie rod threads into the lower spring. The lower spring has a pin at the bottom, which is attached to the clevis in the lower support. The lower support is bolted to the shroud support cone with two toggle bolts.

Figure 3 shows an H8 weld bracket assembly. The upper bracket is attached to the lower shroud by two toggle bolts. The upper bracket also includes two shear keys to help distribute the load. The upper bracket rests on the lower bracket which carries the vertical load to the shroud support cone and the RPV wall. The lower bracket is captured by the upper bracket and the RPV to shroud support cone interface.

All pieces of the stabilizer and H8 weld bracket assemblies are locked in place or captured by mechanical devices. The stresses in the stabilizer and H8 weld bracket components during normal plant operation are less than the normal event allowable stresses. The repair hardware is fabricated from intergranular stress corrosion resistant material. There is no welding in the construction or installation of the shroud repair hardware. The fast flux levels at the stabilizers and H8 weld brackets are well below the damage threshold which could result in the degradation of material properties. After 25 years of operation, the maximum fast fluence at the shroud repair components will be well below the value to cause damage. Therefore, it is very unlikely that a component will fail.

PART A.2 Materials

The stabilizers and H8 weld support brackets are fabricated entirely from the type 316, 316L stainless steel (both with a carbon content less than 0.02%) or alloy X-750. There is no welding required during fabrication or installation.

The material's stress corrosion cracking resistance is verified by applying sensitization testing per ASTM A262, Practice A or E. The shroud repair fabrication specification (reference 18) states that the successful completion of the sensitization testing shall be accepted as evidence of the correct solution heat treatment and water quenching, if time and temperature charts and water quenching records are not available.

The upper and lower springs, upper nut, the upper stabilizer bracket and H8 weld support brackets are fabricated from Alloy X-750 (Ni-Cr-Fe) material that has been heat treated at 1975 ± 25°F followed by an air cool and age hardened to increase its strength.

As an Intergrannular Attack (IGA) control, a minimum of 0.030 inches of material is removed after the last exposure to acid pickling or high temperature annealing. This material is certified to ASTM B637, Grade UNS N07750. Alloy X750 was chosen because its inherent high strength was required, and because its coefficient of thermal expansion is less than that of the shroud. Alloy X750 is resistant to IGSCC at the stress levels the components will experience during operation.

The other components were fabricated from type 316 or 316L stainless steel material both with a carbon content less than 0.02%. The material was annealed at 1900°F to 2100°F followed by quenching in circulating water to a temperature below 400°F. All material was tested for evidence of sensitization. The tie rod threads were induction annealed after machining to remove a possible cold worked layer.

PART B -ANALYSIS

The applicable criteria and conformance to the criteria are as follows:

PART B.1 Repair Design Life (Criteria)

The design life of all repair hardware will be for twenty-five years (the remaining life of the plant, plus life extension beyond the current operating license), to include 20 Effective Full Power Years.

PART B.1.1 Repair Design Life (Conformance)

All repair hardware has been designed for a design life of twenty-five years (the remaining life of the plant, plus life extension beyond the current operating license), to include 20 Effective Full Power Years. This requirement is documented in reference 1.

Assuring an adequate design life is mainly a material selection and process control effort, for this equipment. The selection of low carbon stainless steels and high nickel alloys assures the best available materials for the nuclear reactor environment. Solution annealing and sensitization testing are imposed to guard against intergranular stress corrosion cracking (IGSCC). Process chemical controls are imposed to assure that contamination by heavy metal and chlorine or sulfur compounds will not occur. This is the same design selections and controls imposed for a standard forty year plant life. There is nothing in the equipment or installation that puts a specific limit on how long it can be used, such as creep or radiation degradation.

PART B.2 Safety Design Basis (Criteria)

To assure the safety design basis is satisfied and that the safe shutdown of the plant and removal of decay heat are not impaired, the repair hardware shall assure that the core shroud will maintain the following basic safety functions:

- To limit deflections and deformation to assure that the Emergency Core Cooling Systems (ECCS) can perform their safety functions during anticipated operational occurrences and accidents.
- Maintain partitions between regions within the reactor vessel to provide correct coolant distribution, for all normal plant operating modes.
- Provide positioning and support for the fuel assemblies, control rods, incore flux monitors, and other vessel internals and to ensure that normal control rod movement is not impaired.

PART B.2.1 Safety Design Basis(Conformance)

PART B.3 Flow Partition (Criteria)

Repairs to the core shroud are not required to totally prevent leakage from the core region into the downcomer annulus. However, the design shall ensure that cracked welds do not separate under normal operations as a minimum. Design will account for leakage from the region inside the shroud into the annulus region during normal operation. The leakage should not exceed the minimum subcooling required for proper recirculation pump operation and the core bypass flow leakage requirements assumed in the reload safety analysis shall be maintained. The design will also verify acceptable leakage through the flow partition resulting from weld separation during accident and transient events.

PART B.3.1 Flow Partition(Conformance)

PART B.3.1.1 Leakage Flow Evaluation

The hardware designed to repair the shroud with identified cracks for Nine Mile Point 1 requires the machining of several holes into the shroud head flange for the installation of the upper support. There are a total of eight holes. Each of these holes will have some clearance, which will allow a small amount of leakage flow to bypass the steam separation system. As part of the stabilizer design, the shroud support cone will have eight holes, which also allow a small amount of core flow leakage through the clearance between the holes and the mating bolts. As part of the H8 weld bracket design, the lower shroud will have 24 holes, which also allow a small amount of core flow leakage through the clearance between the holes and the mating bolts and shear keys. In addition, there are nine welds in the shroud that may develop cracks, either above or below the core plate elevation. These cracks present another leakage flow path for the core flow. The combined leakage through nine failed welds is negligible.

The flow areas for leakage through the holes in the lower shroud and the cone are based on taking into account the curvature of the shroud and cone surfaces and the flat surface of the mating repair part. It is conservatively assumed that bolt tension does not cause deflection of the adjacent parts.

The results show that the leakage flows from the repair holes result in a combined leakage of about 0.70% of core flow at 100% rated power and 85 to 100% rated core flow. The leakage flows for 100% rated power and 100% rated core flow are summarized in the Table 1. These leakage flows are based on applicable loss coefficients and reactor internal pressure differences (RIPDs) across the applicable shroud components. The loss coefficients account for the flow blockage from the applicable bracket configurations. Leakage from the shroud head repair holes is assumed to be two-phase fluid at the core exit quality. Leakage from the remaining paths below the top guide support ring is

considered single-phase liquid. All of the leakage flows bypass the steam separators and dryers. The leakage flows below the core plate support ring also bypass the core.

The steam portion of the leakage flow will contribute to increasing the carryunder from the steam separators. The impacts of the flow leakage on the steam separation system performance, core monitoring, abnormal transient evaluation, emergency core cooling system (ECCS) performance and fuel cycle length is evaluated and summarized in the following subsections.

PART B.3.1.2 Steam Separation System

The shroud head leakage flow includes steam flow, which effectively increases the total carryunder in the downcomer by a maximum of about 0.02% at 100% rated power and 85 to 100% rated core flow. The carryunder from the separators is based on the applicable separator test data at the lower limit of the operating water level range. The combined effective carryunder from the separators and the shroud head leakage at 85 to 100% rated core flow is about 0.17%, and is less than the design value of 0.25%. The impact of the flow leakage along with the associated carryunder increase is considered in the following subsections.

PART B.3.1.3 Core Monitoring

The impact of the leakage results in an overprediction of core flow by about 0.6% of core flow. This overprediction is small compared to the core flow measurement uncertainty of

5%, for non-jet pump plants used in the Maximum Critical Power Ratio (MCPR) Safety Limit evaluations. Additionally, the decrease in core flow resulting from the overprediction results in only about 0.2% decrease in calculated MCPR. Therefore, it is concluded that the impact is not significant.

PART B.3.1.4 Anticipated Abnormal Transients

The computer code used to evaluate performance under plant anticipated abnormal transients and calculate fuel thermal margin includes carryunder as one of the inputs. The effect of the increased carryunder due to shroud repair leakage results in greater compressibility of the downcomer region and, hence, a reduced maximum vessel pressure. Since this is a favorable effect, the thermal limits (MCPR) are not impacted.

PART B.3.1.5 Emergency Core Cooling System

The limiting condition is the recirculation discharge line break. The severity of the limiting event is primarily determined by the core spray flow to the upper plenum region. The leakage through the shroud repair holes does not have an impact on the core spray flow or the cooling to the fuel rods or fuel channel. There is no impact on the MAPLHGR and LHGR limits. Therefore, the ECCS results are unchanged by the shroud leakage.

PART B.3.1.6 Fuel Cycle Length

The increased carryunder due to shroud bracket-hole leakage results in an increase in the core inlet enthalpy by about 0.1 BTU/lb., compared with the no leakage condition. The combined impact of the reduced core inlet subcooling and the reduced core flow due to the leakage results in a minor effect (~1.2 days) on fuel cycle length and is considered negligible.

PART B.3.1.7 Conclusion

The impact of the leakage flows through the shroud repair holes and failed welds on the steam separation system performance, core monitoring, fuel thermal margin, ECCS performance and fuel cycle length have been evaluated. The results show that at rated power and 85 to 100% rated core flow the leakage flow from the repair holes is predicted equal to a maximum combined leakage of about 0.7% of core flow. This leakage flow is sufficiently small so that the steam separation system performance, core monitoring, fuel thermal margin and fuel cycle length remain adequate. Also, the impact on ECCS performance is sufficiently small to be judged insignificant, and, hence, the licensing ECCS evaluation for the normal condition with no shroud leakage is applicable.

PART B.4 Flow Induced Vibration(Criteria)

The repair shall be designed to address the potential for vibration, and to keep vibration to an acceptable level. The natural frequency of the repaired shroud, including the repair hardware, shall be determined. The vibratory stresses shall be less than the allowable stresses of the repair materials. Forcing functions to be considered include the coolant flow and the vibratory forces transmitted via the end point attachments for the repair. Testing may be used as an alternative or to supplement the vibration analysis.

This is well below the 28 Hz lowest natural frequency of the stabilizer assembly. This combination satisfies the standard GE design goal of a factor of three between excitation frequency and lowest natural frequency. Therefore, FIV has been addressed and has no impact on the repair hardware or other reactor internals, such as incore instrumentation. A FIV analysis of the H8 bracket supports is included in the final stress report.

PART B.5 Loading on Existing Internal Components(Criteria)

Increased stress on existing internal components, used in the repair, is acceptable as long as the current plant licensing basis are met. Increases in applied load shall be demonstrated to be acceptable.

- The repair shall be designed so as to produce acceptable loading on the original structure of the shroud, consistent with the criteria provided herein.
- The repair should minimize stresses introduced into the shroud consistent with the criteria provided so as to not aggravate further shroud cracking.
- The repair should minimize the loading on the supporting structures of the shroud, such as the shroud support cone and the RPV wall, to stay within the original design allowable stresses of these structures.

PART B.5.1 Loading on Existing Internal Components(Conformance)

- Stresses on the original structure of the shroud, which are directly impacted by the shroud repair hardware, have been demonstrated to be acceptable. The results of this evaluation are documented in references 4 and 5, for all of the postulated accidents.
- For normal operating conditions, the preload on the tie rods of 79,670 lb. each will be carried by the shroud at four locations approximately equally spaced around the circumference. The stress levels on the welds H1 through H8 are bounded by the conditions occurring at weld H8. The results of the analysis on weld H8 demonstrate that the maximum impact of the installed tie rod during normal operating conditions on stress intensity is approximately 0.04% (increase in total stress intensity) or -6.44% (decrease in membrane + bending stress intensity). The membrane stress intensity decreases by 6.22%. With the exception of the total stress intensity that increases very slightly on one surface, all stress intensities actually drop a small amount as a result of tie rod preload. This impact is considered to be minimal and therefore verifies that the tie rod has an insignificant impact on the existing welds (H1 through H8). Stresses on the supporting structure of the shroud, which are directly impacted by the shroud repair hardware, have been demonstrated to be acceptable. The results of this evaluation are documented in references 4 and 5, for all of the postulated accidents.

- Stresses on the supporting structure of the shroud, which are directly impacted by the shroud repair hardware, have been demonstrated to be acceptable. The results of this evaluation are documented in references 4 and 5, for all of the postulated accidents.

The transients described in the Nine Mile Point 1 FSAR Chapter XV (reference 3) were reviewed and the bounding upset thermal event for the tie rod assembly is described below.

An upset condition wherein cold water is introduced into the annulus while the reactor inlet plenum remains at 545°F. This situation could potentially occur with the loss of feedwater followed by restoring the feedwater flow, but without heating. Typical conservative assumptions leading to this event are described in reference 20. The scenarios for these events are generic although the specific details may differ depending on the vintage of the plant.

The NMP-1 load definition document, reference 19, does not include annulus temperatures for this event, but the temperatures are shown in detail on later plant thermal cycle diagrams. The thermal cycle diagrams for other plants shows the temperature inside the shroud drops by 15°F from operating temperature while the annulus temperature drops as low as 300°F. This event results in the largest temperature difference between the shroud and annulus. Similar temperature conditions are assumed to be applicable for NMP-1. Assuming the temperature inside the NMP-1 shroud remains at 545°F while the annulus temperature drops to 300°F adds margin to the temperature difference. This event is compared with other transients described in the Nine Mile Point 1 FSAR Chapter XV (reference 3) and is considered the bounding upset thermal event for the tie rod assembly. Blowdown events may result in more rapid cooling, but both the shroud and repair hardware are cooling at a similar rate and the net thermal effects are not as severe.

PART B.5.1.1 Seismic Analysis

A detailed seismic analysis was performed as documented in reference 6. The mathematical model used for the analysis included the reactor building, shield wall/pedestal, RPV, reactor internals, and the repair modification hardware. The structural modeling data were obtained from the information contained in the UFSAR, licensing basis calculations/reports, and design drawings. The model was analyzed using the SAP4G07 computer program (Reference 10).

An axisymmetric, lumped mass model of the RPV and internals was constructed incorporating the masses and structural properties of the various structural components. Hydrodynamic masses were calculated and included in the model to account for the dynamic coupling of the fluid mass with the solid mass. The stiffness properties of the repair modification hardware (top/bottom springs and tie rods) were incorporated in the model. The model being axisymmetric, the equivalent rotational stiffness offered by the tie rod system was included in the model. The top and bottom lateral spring

stiffnesses were incorporated in the model at the top guide and bottom core plate locations respectively.

Additionally, six brackets are designed at the interface between the shroud and the conical shroud support skirt, 60 degrees apart, under the assumption that the H8 weld is cracked 360 degrees, through-thickness. The primary function of this H8 Support is to support the shroud in the vertical direction against vertical displacement, should the H8 weld fail completely. The seismic analysis evaluated the scenario where the H8 weld failed, and the corresponding downward load on the H8 support due to the moment caused by the horizontal seismic motion, was taken into account.

The licensing basis horizontal Design Basis Earthquake load (DBE) is documented in the NMP-1 Design Criteria Document (DCD-115). A synthetic time history with a zero period acceleration (ZPA) of 0.11g was generated based on the horizontal DBE spectra at 2.5%, 5%, and 7.5% oscillator damping, in accordance with the guidelines of the NRC Standard Review Plan (NUREG-0800). This time history load was used as the DBE load in this seismic analysis.

Vertical seismic inertia load was not analyzed using the computer model. However, the structure being very stiff in the vertical direction, the vertical zero period acceleration (ZPA) was taken as 2/3 of the horizontal (= 2/3 × 0.11 = 0.073g), as a multiplier of the deadweight effects.

Consistent with the licensing basis, DBE was the only seismic load evaluated. The DBE results were used for upset as well as emergency and faulted conditions.

Ground acceleration transient response analysis by modal superposition method was used for the time history analysis.

Analysis iterations were performed to reflect the scenarios wherein through-thickness, 360 degrees, circumferential cracks were postulated at the various weld locations in the shroud, including uncracked and all-welds-cracked conditions. The cracks were represented as hinges or rollers depending upon the assumed crack condition and the loading event. For an upset condition wherein the crack does not separate, the crack plane was modeled as a hinge (i.e., with no moment resistance at the crack plane). For an emergency or faulted event involving LOCA, the possibility of the shroud lifting momentarily at the crack plane exists. Under such conditions, the crack plane was modeled as a roller (i.e., with no lateral shear or moment resistance at the crack plane). Nine such governing cracked scenarios were evaluated including the uncracked case, resulting in maximum loads and displacements for the repair modification hardware design.

The maximum permanent horizontal deflection of the shroud that is not directly supported by either the upper or lower springs is limited to 0.75 inch by mechanical limit stops. In the unlikely scenario that welds H4 and H5 becomes loose and a combined

LOCA plus seismic event occurs, the stops serve to limit the horizontal displacement to 0.75 inch, which is equal to one half of the shroud wall thickness. These stops do not affect the validity of the linear seismic analysis.

The licensing basis condition was simulated by additionally analyzing the model without the tie rod/spring modifications and without any cracks, to form a benchmark run. The resultant component loads based on the current shroud repair seismic analysis were compared with those of the benchmark run. The comparison showed insignificant changes in the results. Also, it is worth noting that the loads in the internal components reduce once the cracks occur. This is due to the fact that as the shroud rigidity is decreased, the fuel is isolated, and the seismic load is mainly carried by the stabilizer springs and the tie-rods.

PART B.6 Annulus Flow Distribution(Criteria)

The design shall not adversely affect the normal flow of water in the annulus region, or the normal balance of flow in this region. The design shall not adversely restrict the flow of water into the recirculation suction inlet.

PART B.6.1 Annulus Flow Distribution(Conformance)

The design does not adversely affect the normal flow of water in the annulus region, or restrict the flow in any way that would adversely affect normal balance of flow in this region. The design does not adversely restrict the flow of water into the recirculation suction inlet.

PART B.7 Emergency Operating Procedure (EOP) Calculations(Criteria)

Inputs to the EOP calculations, such as bulk steel residual heat capacity and reduction of reactor water inventory shall be addressed based on repair hardware mass and water displacement.

PART B.7.1 Emergency Operating Procedure (EOP) Calculations(Conformance)

Inputs to the EOP calculations have been addressed and are documented in Reference 22 and it has been concluded that there are no significant impacts on the EOP Appendix C calculations.

PART B.8 Radiation Effects on Repair Design(Criteria)

The design of the repair shall account for the affects of irradiation relaxation utilizing end-of-life fluence on the materials.

PART B.8.1 Radiation Effects on Repair Design(Conformance)

The design of the repair accounts for the affects of irradiation relaxation utilizing end-of-life fluence on the materials. In accordance with Reference 1, the design considers an End-of-Life preload relaxation for the upper and lower springs. The radiation level is less than the limit contained in the UFSAR (section XVI A.2.7.3.2). The basis for this is documented in reference 11 (design basis for reference 1).

PART B.9 Thermal Cycles(Criteria)

The repair hardware shall consider the effects of thermal cycles for the remaining life of the plant. Analysis shall use original plant RPV thermal cycle diagrams. The design shall assume a number of thermal cycles equal to or greater than the number assumed in the original RPV design. Alternatively, thermal cycles defined by actual plant operating data may be employed if technically justified. Using this thermal cycle information repair components and the repaired shroud shall be evaluated for fatigue loading along with any other design vibratory loads.

PART B.9.1 Thermal Cycles(Conformance)

The repair hardware considered the effects of thermal cycles for the remaining life of the plant as documented in Reference 5. The stresses resulting from the thermal cycles have been evaluated by a fatigue analysis. The results show that its effect on fatigue life of the plant is negligible.

PART B.10 Chemistry/Flux(Criteria)

The design shall recognize the use of existing and anticipated water chemistry control measures for BWRs and shall consider the affects of neutron flux on any materials used in the repair.

PART B.10.1 Chemistry/Flux(Conformance)

Since the shroud repair hardware has been designed to the original construction requirements for the shroud , the existing and anticipated water chemistry control measures have been addressed and will have no effect on the repair hardware. The affects of neutron flux the materials used in the repair were considered. As stated in Reference 1, the maximum radiation levels will have no effect on material properties.

PART B.11 Loose Parts Consideration(Criteria)

Repair hardware mechanical components shall be designed to minimize the potential for loose parts inside the vessel. The design repair shall use mechanical locking methods for threaded connections. All parts shall be captured and held in place by a method that will last for the design life of the repair.

PART B.11.1 Loose Parts Consideration(Conformance)

Repair hardware mechanical components have been designed to minimize the potential for loose parts inside the vessel. The design repair uses mechanical locking methods (such as crimped jam nuts) for threaded connections. All parts are captured and held in place by a method such as pinning, staking, spring retainers, interference fits, and crimping that will last for the design life of the repair.

PART B.11.1.1 Evaluation of the Consequences of Loose Parts

All pieces of the stabilizer and H8 weld bracket assemblies are locked in place with mechanical devices. For example, the core plate wedge clamp contains a hook that latches under the angle bracket and maintains the assembly's position during thermal cycles or vibration. The stresses in the stabilizer components during normal plant operation are less than the normal event allowable stresses. The repair hardware is fabricated from stress corrosion resistant material. Therefore, it is very unlikely that a component will fail. However, if one stabilizer is postulated to fail during normal plant operation, there would be no consequence to the shroud (even if it is cracked) or to the other three stabilizers. The leakage through a cracked shroud may increase very slightly, but it would be difficult to detect. The plant would continue to operate until the next refueling outage, when the broken stabilizer would most likely be detected and repaired. The postulated broken component may fall to the shroud support cone or may be sucked into the recirculation pump. The consequences of the postulated loose stabilizer piece would be consistent with the consequence of other postulated loose pieces.

PART B.12 Inspection Access(Criteria)

The repair design shall be such that inspection of reactor internals, reactor vessel, ECCS components and repair hardware is facilitated. The installed repair hardware shall not interfere with refueling operations and shall permit servicing of internal components. All parts shall be designed so that they can be removed and replaced. This is to provide full access to the annulus area for other possible future inspections and/or maintenance/repair activities that may prove necessary in the future.

PART B.12.1 Inspection Access(Conformance)

The repair design permits inspection of the reactor internals, the reactor vessel, ECCS components and the repair hardware. The installed repair hardware will not interfere with refueling operations, and permits servicing of internal components. All parts have been designed so that they can be removed and replaced.

PART B.13 Crevices(Criteria)

The repair design shall be reviewed for crevices to assure that criteria for crevices immune to stress corrosion cracking acceleration are satisfied.

PART B.13.1 Crevices(Conformance)

The selection of the materials for the repair design assures that criteria for crevices shown to be immune to stress corrosion cracking acceleration are satisfied.

The design has considered crevices and its impact on stress corrosion cracking by using materials which are highly resistant to Intergranular Stress Corrosion Cracking (IGSCC). The material's IGSCC resistance is verified by applying GE procedures (as required by Reference 18) which meet or exceed ASTM A262 Practice A or E.

PART B.14 Materials(Criteria)

All materials used shall be in conformance with the BWR VIP requirements.

PART B.14.1 Materials(Conformance)

All materials used are in accordance with the BWR VIP requirements in a manner consistent with a similar NRC approved GE shroud repair design, as discussed in Section A.2.

PART B.15 Maintenance/Inspection(Criteria)

The designed repair shall minimize the need for future inspections and maintenance of the repair components. The designed repair shall minimize the requirement for future inspections of the affected shroud joints.

PART B.15.1 Maintenance/Inspection(Conformance)

The designed repair minimizes future inspections and maintenance of the repair components. The inspection procedures are documented in Reference 15. The designed repair eliminates the need for future inspections of the affected shroud joints.

PART B.16 Installation Issues(Criteria)

Tooling/equipment used for installation of repair components shall be evaluated in accordance with Reference 9 and shall consider the following:

- Heavy loads
- Shutdown System Status (N+1)
- Rigging
- Hole Cutting Method

PART B.16.1 Installation Issues(Conformance)

Tooling/equipment used for installation of repair components have been evaluated in accordance with Reference 9 and considered the following:

PART B.16.1.1 Heavy loads

Load cells are used whenever any heavy item is installed or removed from the vessel. Personnel have been trained on full scale mockup in installation techniques necessary to protect delicate items. Tooling/ equipment has been designed in accordance with NUREG-0612 and has been load tested to 300% of the loads being lifted. Certifications are maintained in the Project Quality Assurance file.

PART B.16.1.2 Shutdown System Status (N+1)

Shutdown system status (N+1) will be maintained as documented in References 13 and 14.

PART B.16.1.3 Rigging

Rigging will be done in accordance with approved procedures (References 8 and 9).

PART B.16.1.4 Hole Cutting Evolution

All holes will be cut by an EDM process. The EDM process has been qualified by GE procedure (Reference 12). All personal involved in this process have been certified by GE.

PART B.17 Existing Reactor Internals(Criteria)

The design shall not rely on existing reactor internals or components to carry loads that have experienced cracking in the industry (e.g. shroud head bolt lugs, stub tubes).

PART B.17.1 Existing Reactor Internals(Conformance)

The design does not rely on existing reactor internals or components to carry loads that have experienced cracking in the industry (e.g. shroud head bolt lugs, stub tubes).

PART C -UNREVIEWED SAFETY QUESTION DETERMINATION

1. Could the proposed change or activity increase the probability of occurrence of an accident previously evaluated in the SAR?

   No. The affected plant systems and components will be capable of performing their intended functions with the stabilizers and H8 weld brackets installed. This modification replaces the function provided by core shroud horizontal welds. As the modification is being provided to the plant's safety-related design requirements, the probability of a component failure is not increased. The stabilizers and H8 weld brackets impose a negligible change to the plant operating conditions. The stabilizers and H8 weld brackets will not interact with any component assumed to initiate an accident in the UFSAR. Nor will the failure or presence of a stabilizer or H8 weld bracket initiate an accident evaluated in the UFSAR.

2. Could the proposed change or activity increase the consequences of an accident evaluated previously in the SAR?

   No. The calculated Peak Clad Temperature (PCT) will remain below 2200°F, and all structures, systems and components (SSC) used to mitigate the (radiological) consequences of the accidents in the SAR are independent of the stabilizers and H8 weld brackets, and thus, the consequences of the accidents will not be affected. The abnormal events in the UFSAR that potentially could be affected by the installation of the stabilizers and H8 weld brackets were evaluated, and they remain unchanged.

   The stabilizers and H8 weld brackets impose a negligible change to the plant operating conditions, and thus, the LOCA and transient analyses remain valid, as discussed in Part B.2.3.

   LOCA-Radiological analysis is based on the plant's engineered safety features (ESF) functioning within design parameters, and the radioactive material source terms. The stabilizers and H8 weld brackets will not adversely affect any ESF, and thus, the ESF functions will not be affected. The radioactive material source terms are based on the regulatory limit PCT of 2200°F. As the PCT for Nine Mile Point 1 will remain below this regulatory limit, the source terms will not be affected. Therefore, the consequences of the LOCA-Radiological analysis will not change.

   The MSLB analysis release is limited by the capacity of the MSL Flow Restrictors, and uses UFSAR allowables for source terms. As the installation of stabilizers and H8 weld brackets will not affect either of these, the consequences of the MSLB analysis will not change.

As described in Part B.2.5.1, seismic analyses show that the stabilizers and H8 weld brackets will remain functional following an earthquake.

3. Could the proposed change or activity increase the probability of occurrence of a malfunction of equipment important to safety evaluated previously in the SAR?

    No. The stabilizers and H8 weld brackets are designed and constructed as safety related components. No adverse equipment interactions will be created by installing the stabilizers and H8 weld brackets. The Installation Processes and Tooling (Including EDM and Honing) will not adversely effect safety related equipment, as discussed previously. Therefore, the probability of equipment malfunctions is not increased.

4. Could the proposed change or activity increase the consequences of a malfunction of equipment important to safety evaluated previously in the SAR?

    No. The installation of stabilizers and H8 weld brackets ensures that the shroud, even if cracked, will perform its safety functions. Thus, consequences of a malfunction of equipment important to safety is not increased. The stabilizers and H8 weld brackets perform a passive function that does not interface with any equipment that is used to mitigate the radiological consequences of a malfunction in the UFSAR. As noted in Part B.2.3.4, the effects of the stabilizers and H8 weld brackets on the consequences of potentially affected transients are negligible. As the stabilizers do not adversely affect equipment "Important to Safety," the consequences of all transients will not change. The Installation Processes and Tooling (Including EDM and Honing) will not adversely effect safety related equipment, as discussed previously. Therefore, there is no increase to the consequences of component malfunctions.

5. Could the proposed change or activity increase the probability of occurrence of an accident of a different type than any evaluated previously in the SAR?

    No. The stabilizers and H8 weld brackets are designed to the structural criteria specified in the Nine Mile Point 1 UFSAR. All of the loads and load combinations specified in the UFSAR, that are relevant to the core shroud, have been evaluated, and are within design allowables. The stabilizers do not add any new operational/failure mode or create any new challenge to safety-related equipment or other equipment whose failure could cause a new type of accident. In addition, the stabilizers and H8 weld brackets do not create any new component/system interactions or sequence of events that lead to a new type of accident.

    It has been postulated that if a core shroud had a 360° crack and a MSLB accident occurred, the upper shroud and the top fuel support could lift. If

the top fuel support lifted sufficiently, the tops of the fuel bundles could move (shift), which might prevent the control blades from completely inserting (partial scram). This event would be an accident of a different type. However, the core shroud stabilizers would prevent the shroud from moving, and thus, prevent the top fuel support from lifting.

It has been postulated that if the H8 weld had a 360° crack and an inlet RSLB accident occurred, the shroud could be displaced vertically downward. If the shroud moves down, the core plate would move with it. This movement could potentially damage the fuel, depending on the displacement and vertical acceleration. Sufficient movement may also disengage the core spray inlets. Other reactor internals may be impacted. This event would be an accident of a different type. However, the H8 weld support brackets would prevent an unacceptable degree of vertical displacement during this event.

Therefore, the modification does not increase the probability of occurrence of an accident of a different type than any evaluated previously in the SAR.

6. Could the proposed change or activity create the possibility of a malfunction of equipment important to safety of a different type than any evaluated previously in the SAR?

No. The stabilizers and H8 weld brackets structurally replace the shroud horizontal welds. The stabilizers and H8 weld brackets are fabricated from stress corrosion resistant material and have low applied stresses during normal operation. There is no welding in the construction or installation of the stabilizers or H8 weld brackets. A single failure of a stabilizer or H8 weld brackets is highly unlikely. Even if it occurred, the failure will not adversely affect other safety-related equipment. This postulated condition has not been specifically analyzed but is enveloped by other conditions that have been analyzed. During normal operation each stabilizer has a vertical force of approximately 80 Kips (due to thermal preload) and a horizontal force of less than 10 Kips (due to preload). If one stabilizer is postulated to fail, the other three stabilizers will carry the additional vertical load which will result in a total vertical load for each stabilizer of approximately 103 Kips. During the upset thermal loading condition, the vertical load in each stabilizer is approximately 188 Kips. Since the allowable stress intensities are the same for normal and upset conditions, the three remaining stabilizers will be acceptable for normal operation. The insignificant increase in leakage through postulated cracks will not affect normal operation or Emergency Core Cooling System (ECCS) performance after the postulated failure of one stabilizer. All equipment assumed to operate in the transient analyses, and the safety-related structures, systems and

components will not be adversely affected by the stabilizers. All components interacting with the stabilizers and H8 weld brackets will perform their intended functions. The stabilizers and H8 weld brackets do not increase challenges to or create any new challenge to equipment. The stabilizers and H8 weld brackets do not create any new sequence of events that lead to a new type of malfunction. The Installation Processes and Tooling (Including EDM and Honing) will not adversely effect safety related equipment, as discussed previously. Therefore, the possibility of a different type of component malfunction than evaluated in the SAR is not created.

7. Does the proposed activity reduce the margin of safety as defined in the basis for any Technical Specification?

No. The Technical Specifications and their Bases are not affected by the installation of stabilizers and H8 weld brackets. No safety analysis referenced in a Bases will change. No design allowable of licensed acceptance limit for the plant will be exceeded. Therefore, the installation of core shroud stabilizers and H8 weld brackets will not affect the margin of safety of any Technical Specification Bases.

PART D -CONCLUSION

This evaluation has investigated the installation of core shroud stabilizers and H8 weld brackets at Nine Mile Point 1. The plant licensing bases have been reviewed. This review demonstrates that stabilizers can be installed (1) without an increase in the probability or consequences of an accident or malfunction previously evaluated, (2) without creating the possibility of an accident or malfunction of a new or different kind from any previously evaluated, (3) and without reducing the margin of safety in the bases of a Technical Specification. Therefore, installation of core shroud stabilizers and H8 weld brackets does not involve an unreviewed safety question.

PART E. -REFERENCES

1. GE-NE Specification: 25A5583, Rev. 2, "Shroud Repair Hardware, Design Specification"
2. GE-NE Specification: 25A5586, Rev. 1, "Shroud Repair Code, Design Specification"
3. UFSAR, Rev. 12, Nine Mile Point 1
4. GE-NE Document: 24A6426, Rev. 1, "Reactor Pressure Vessel Stress Report"
5. GE-NE-B13-01739-04, Rev. 0, "Shroud Repair Hardware Stress Analysis"
6. GE-NE-B13-01739-03, Rev. 0, "Seismic Design Report of Shroud Repair for Nine Mile Point 1 Nuclear Power Plant"
7. NRC Generic Letter 94-03, July 25, 1994, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors"
8. Niagara Mohawk Procedure: N1-MMP-GEN-914, "Lifting of Miscellaneous Heavy Loads"
9. GE-NE Specification: 386HA852, "Reactor Servicing Tools"
10. GE-NE Document: NEDO-10909, Rev. 7, "SAPG07, Static and Dynamic Analysis of Mechanical and Piping Components by Finite Element Method"
11. GE-NE Document: DRF B13-01739, "Nine Mile Point 1 Shroud Stabilization"
12. GE-NE Procedure: NM-SM-TP&P-04, "EDM Actuators"
13. Niagara Mohawk Procedure: N1-ODG-11, "Outage Safety Assessment"
14. Niagara Mohawk Procedure: NIP-OUT-01, "Shutdown Safety"
15. GE-NE, "Post Inspection Plan"
16. GE-NE Specification: 21A1104, Rev. 0, "Specification for Reactor Pressure Vessel"
17. BWROG VIP Core Shroud Repair Design Criteria, Rev. 1, September 12, 1994
18. GE-NE Specification: 25A5584, Rev. 1, "Fabrication of Shroud Repair Components"
19. GE-NE Drawing: 237E434, Rev. 5, "Reactor Vessel Loadings" GE Drawing
20. GE-NE Specification: 383HA718, Thermal Cycles, Reactor Vessel and Nozzle, Description Basis and Assumptions

21. GE-NE-A0003981-1-13, Rev. 1, "Performance Impact of Shroud Repair Leakage for NMP1", 12/15/94

22. Niagara Mohawk Document: SO-EOP-M018,

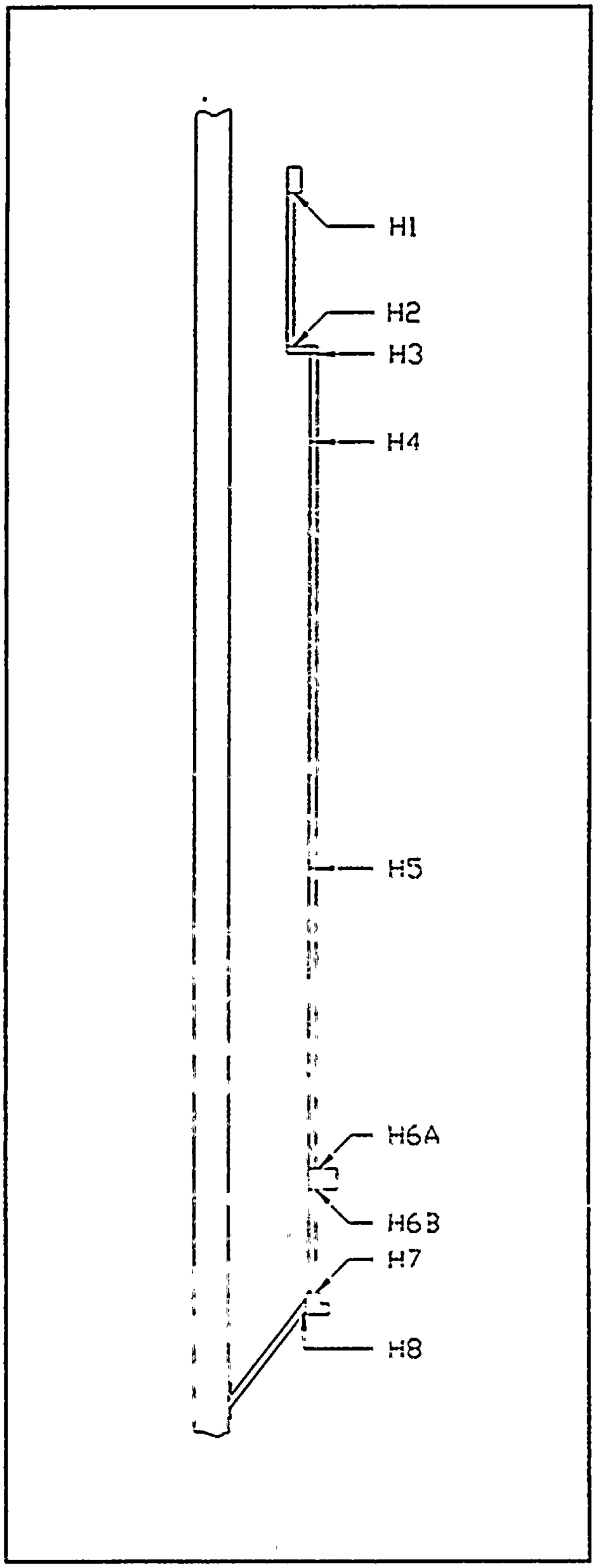

Figure 1 : Horizontal Weld Locations

[illegible]

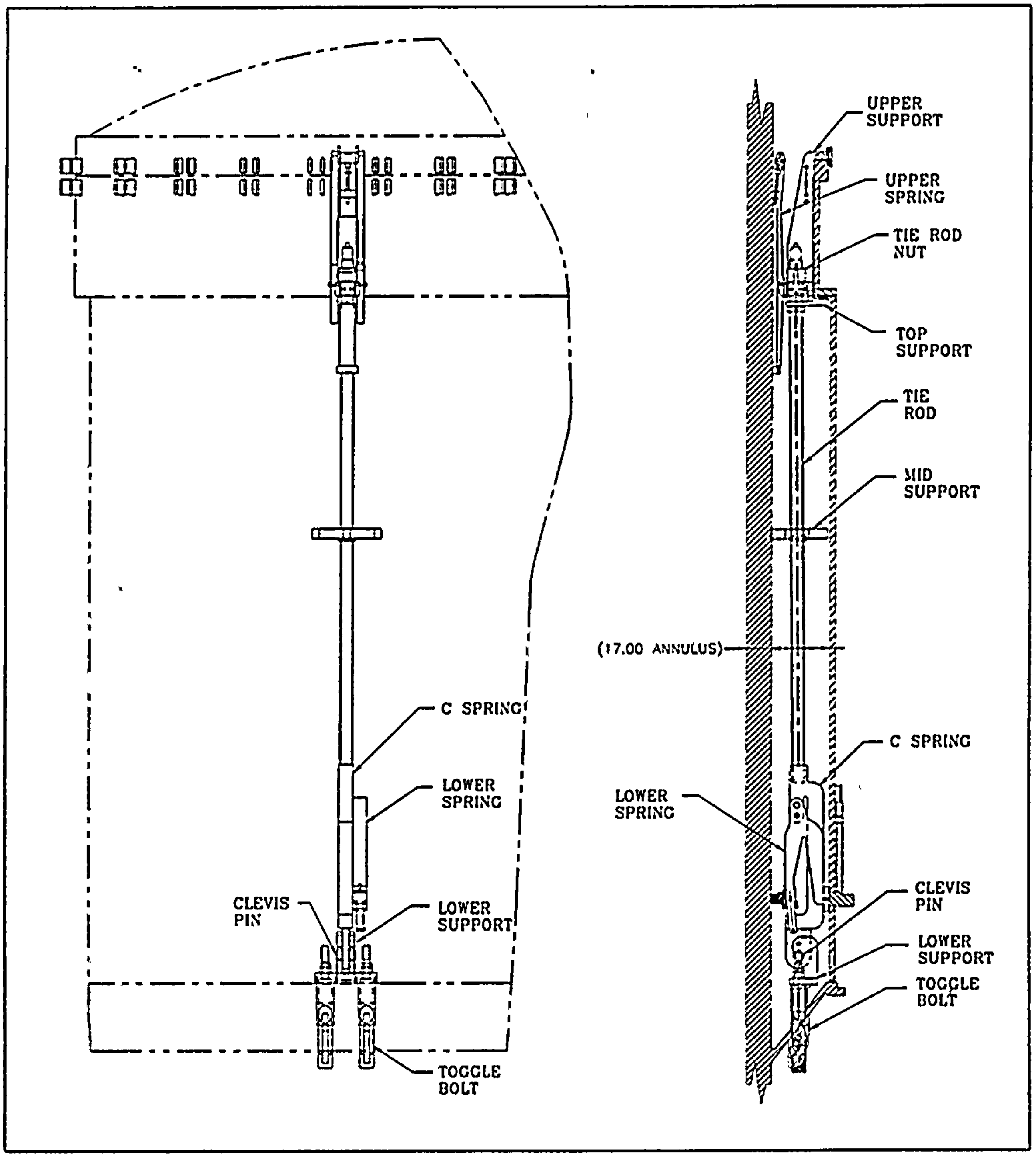

Figure 2 : Core Shroud Stabilizer

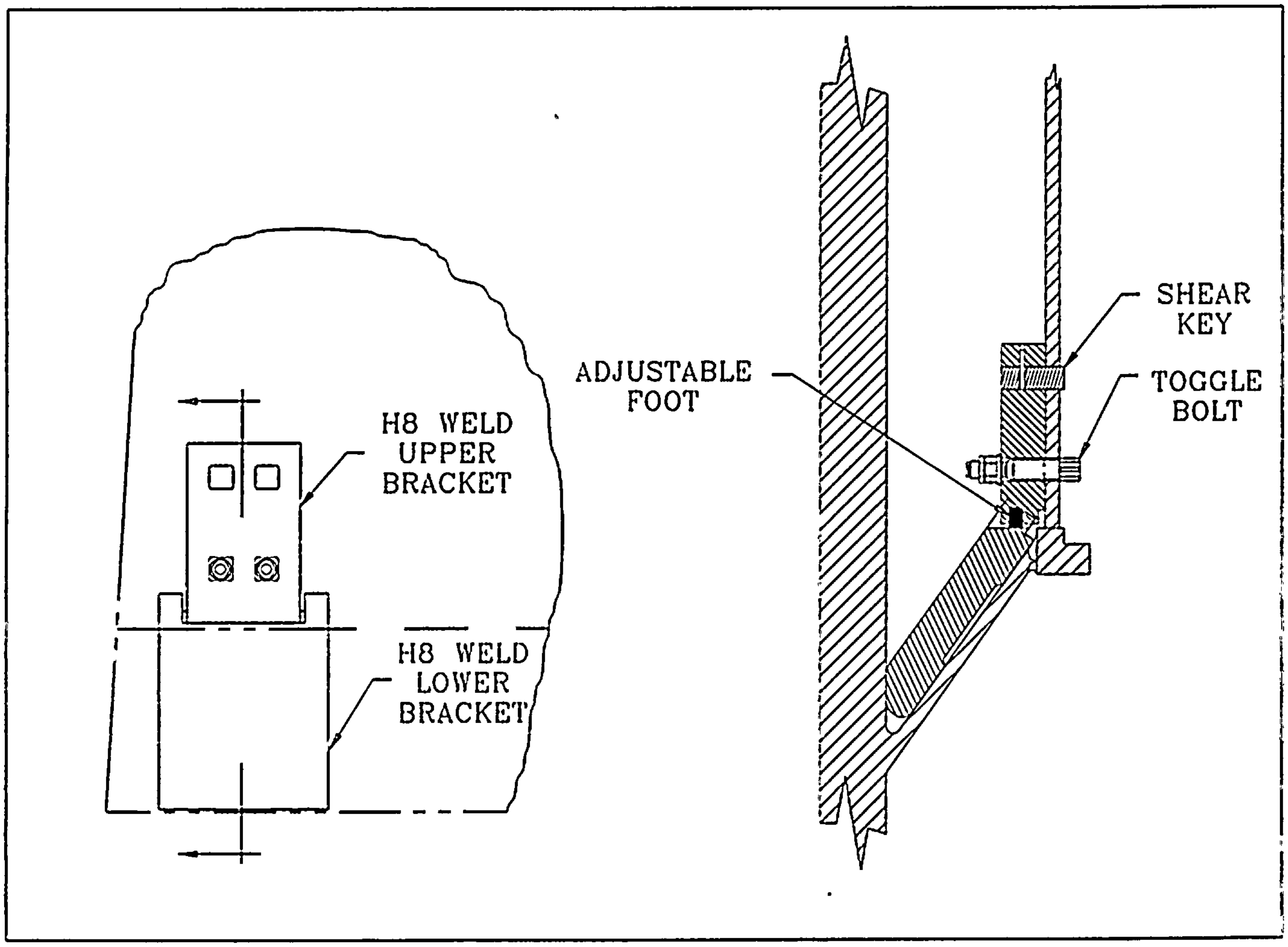

Figure 3 : H8 Weld Bracket

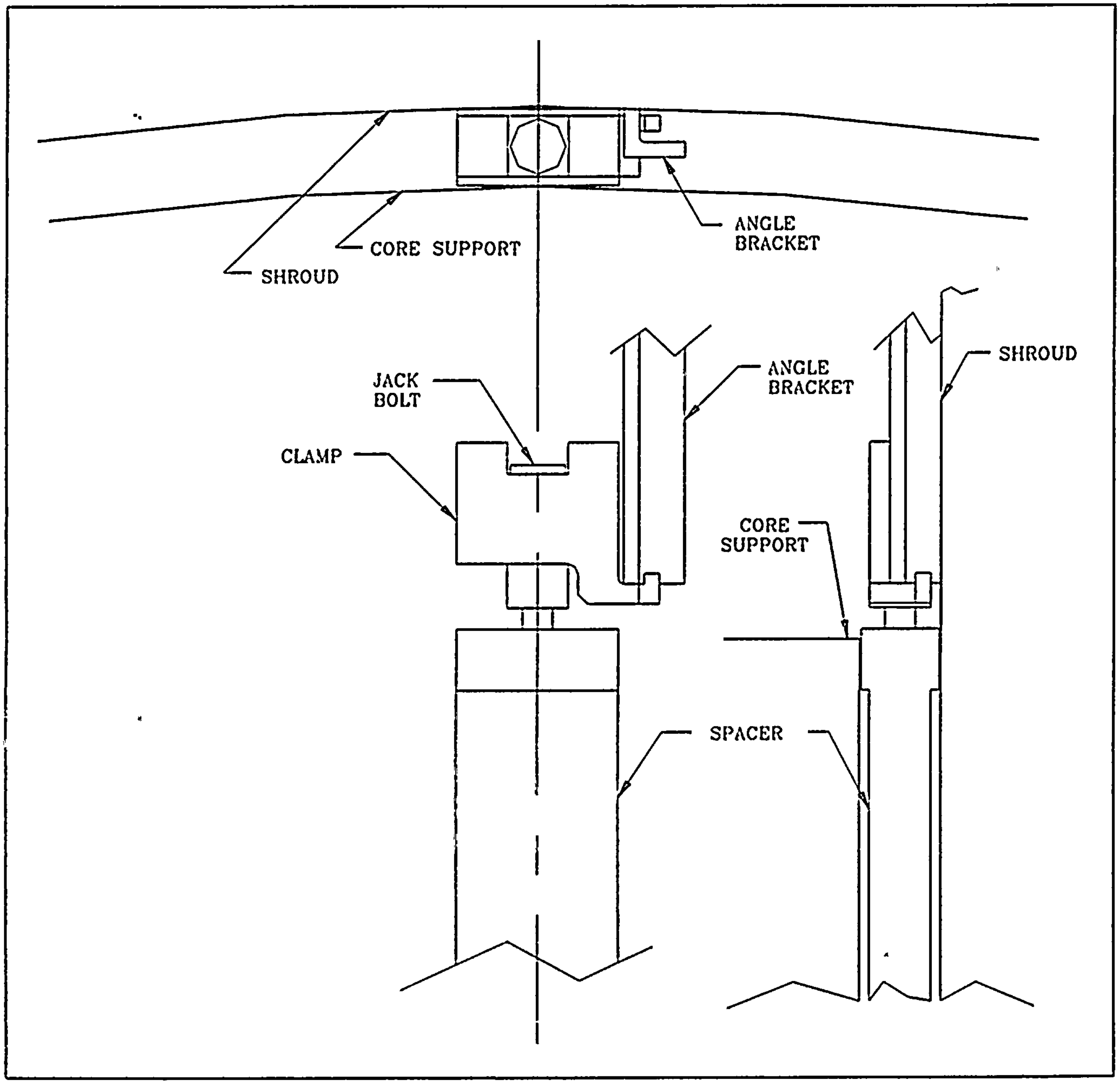

Figure 4 : Core Plate Wedge

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