January 25, 2001

Mr. James M. Kenny, Chairman
BWR Owners Group
PPL, Inc.
2 North Ninth Street M/C A6-1
Allentown, PA 18101

SUBJECT: BWR OWNERS GROUP - TOPICAL REPORT NEDC-32975(P), "REGULATORY RELAXATION FOR BWR LOOSE PARTS MONITORING SYSTEMS" (TAC NO. MA9643)

Dear Mr. Kenny:

The NRC staff has reviewed the Boiling Water Reactor Owners Group (BWROG) Topical Report NEDC-32975(P), "Regulatory Relaxation for BWR Loose Parts Monitoring Systems." The BWROG proposed to eliminate the requirements for loose parts monitoring (LPM) systems, stating that (1) the LPM system did not provide the safety benefits initially envisioned in the 1970s; (2) LPM systems' repair and maintenance entail high costs and high radiation exposures, and (3) the risk insights from several hundred years of plant experience indicate that there are no differential effects on core damage and/or early release fractions, whether the LPM systems are used or not.

The staff finds that the subject topical report is acceptable for referencing in licensing applications to the extent specified and under the limitations delineated in the report and in the associated NRC safety evaluation. The safety evaluation, which is enclosed, defines the basis for acceptance of the topical report.

The staff will not repeat its review of the matters described in the subject report, when the report appears as a reference in license applications, except to ensure that the material presented applies to the specific plant involved. In accordance with the procedures established in NUREG-0390, the NRC requests that the BWROG publish an accepted version of the report within 3 months of receipt of this letter. The accepted version shall incorporate (1) this letter and the enclosed safety evaluation between the title page and the abstract, (2) all requests for additional information from the staff and all associated responses, and (3) an "-A" (designating "accepted") following the report identification symbol.

If the NRC's criteria or regulations change so that its conclusions about the acceptability of the report are invalidated, BWROG or the applicant referencing the report, or both, will be expected to revise and resubmit its respective documentation, or submit justification for the continued effective applicability of the report without revision of the respective documentation.

Pursuant to 10 CFR 2.790, we have determined that the enclosed safety evaluation does not contain proprietary information. However, we will delay placing the safety evaluation in the public document room for a period of ten (10) working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. If you believe that any information in the enclosure is proprietary, please identify such information line by line and define the basis pursuant to the criteria of 10 CFR 2.790.

If you have any questions, please call Robert M. Pulsifer at (301) 415-3016.

Sincerely,

/RA/

Stuart A. Richards, Director
Project Directorate IV and Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 691

Enclosure: Safety Evaluation

cc w/encl: see next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO TOPICAL REPORT NEDC-32975P, "REGULATORY RELAXATION FOR BWR LOOSE PARTS MONITORING SYSTEMS"

BOILING WATER REACTOR OWNERS GROUP

PROJECT NO. 691

1.0 INTRODUCTION

On July 31, 2000, the Boiling Water Reactor Owners Group (BWROG) submitted a General Electric (GE) Topical Report NEDC-32975P, "Regulatory Relaxation for BWR Loose Parts Monitoring Systems." In its submittal, the BWROG discussed the effectiveness of the loose-parts monitoring systems (LPMS) installed in some BWR plants and proposed eliminating the LPMS requirements. The BWROG stated that (1) operating experience does not indicate any beneficial advantage for plants that installed the system as compared to the plants that did not; (2) LPMS do not have the sensitivity or the reliability to detect loose-parts; (3) LPMS incur high repair costs; and (4) the maintenance of the system leads to high radiation exposures.

In May 1981, NRC published Regulatory Guide (RG) 1.133, "Loose-Parts Detection Program for the Primary System of Light-Water-Cooled Reactors." This RG discussed the purpose of loose-part monitoring and specified the design features necessary for detection of loose-parts in the primary system, while minimizing radiation exposure and time expended by the station personnel. Most BWRs licensed after the issuance of the RG were required, as part of their licensing basis, to meet RG 1.133.

According to the BWROG, fifteen BWRs (40 percent) have loose-parts monitoring systems installed. Nineteen BWRs were licensed without LPMS requirements. Some licensees have relocated the LPMS requirements from their TS to a licensee controlled document under the purview of the 50.59 process. Since the RG 1.133 requirements are part of their licensing basis, however, even these licensees cannot delete the LPMS requirement or physically disable the system under the 50.59 process without prior NRC approval. The BWROG seeks generic approval of Topical Report NEDC-32975P in order to facilitate and expedite plant specific amendments requesting to remove the LPMS requirements.

2.0 BACKGROUND

In RG 1.133, the staff stated that the primary purpose of the loose-parts detection program is the early detection of loose metallic parts in order to avoid or mitigate damage to safety-related components. The staff pointed out that a loose (i.e., disengaged and drifting) part in the primary coolant system:

- can be indicative of a failed or weakening safety-related component. The detection of the loose parts will thus provide an early warning of a degraded safety condition;

- may have been inadvertently left in the primary system during construction, refueling or maintenance. The loose part (foreign object) can contribute to safety related component damage or wear by frequently impacting other parts of the system;
- may cause a blockage of the coolant flow through the fuel assemblies. Flow blockage could initiate departure from nucleate boiling and result in fuel cladding failure;
- might increase the potential for control rod jamming; and
- might increase the levels of radioactivity in the reactor coolant system through the accumulation of crud.

According to RG 1.133, 10 CFR Part 50, Appendix A, Criterion 1, "Quality Standards and Records," Criterion 13, "Instrumentation and Controls," and 10 CFR 50.36 apply to the detection of safety-related loose parts during normal operation. Criterion 13 in Appendix A requires, in part, that instrumentation be provided to monitor variables and systems during anticipated ranges for normal operation, anticipated operational occurrences and accident conditions to ensure adequate safety, including those variables and systems that can affect the fission process, the integrity of the core and the reactor coolant pressure boundary. The primary objective of the proposed loose-parts monitoring system is to detect loose metallic parts in the primary system early and thus avoid damage to, or malfunctions of, primary system components. The second purpose of the LPMS is to minimize radiation exposure to the station staff. Since the LPMS would indicate the general location of the abnormal structural condition, it would minimize the collection of wear-generated radioactive crud and allow the station staff to take timely remedial actions, thereby, reducing the need for extensive structural repair. Thus, a well implemented LPMS would prevent damage to the components in the reactor coolant pressure boundary, jamming of the control rod drives, blockage of flow through the fuel bundles, and accumulation of radioactive crud in the primary system.

If a loose part were to be detected, the RG recommended that the licensees develop diagnostic procedures, using supplemental station information (plant processing signals, inspection, and prior operating history). Licensees could evaluate both the short-term and long-term safety implications of the detected loose part, without taking any action on the plant operation solely based on the loose-part detection system. RG 1.133 recommended that licensees notify the NRC if the presence of loose parts is confirmed, in accordance with RG 1.16, "Reporting of Operating Information-Appendix A" of the technical specifications. Licensees' reports to the Commission are also required when defining the LPMS alert level or when the LPMS technical specification (TS) requirements are violated.

The RG also stated that loose parts traveling in the primary system should generally accumulate, at least for a time, in natural collection areas such as the plenums of the reactor vessel and the steam generators, while loose parts in straight pipes will pass through quickly. The design and layout of the system should minimize the personnel time in high radiation areas and facilitate the recognition, location, replacement, repair and adjustment of malfunctioning components.

In the RG, the staff stated that a well-designed loose-part detection system should be able to discriminate signals caused by the impact of a loose part from those signals attributed to normal hydraulic, mechanical and electrical background noise and large amplitude electrical transients. The potential damage of a loose part may not necessarily be proportional to the impact energy of the loose part. A small metallic plate imparts little impact energy, but could restrict local flow to the reactor core. However, there are technical difficulties in trying to distinguish a very-low-energy impact signal from the normal reactor acoustic background noise. The RG stated that the LPMS should be able to detect a loose part weighing from 0.25 lb (0.11 kg) to 30 lb (13.6 kg) and impacts with a kinetic energy of 0.5 lbf-ft (0.68 joules) on the surface of the reactor coolant pressure boundaries within 3 feet (0.91 meter) of the sensor. The staff selected the specified weight range as representative of the most common and significant class of loose parts. The RG stated that signals from metallic-objects within the recommended sensitivity range should be able to distinguished from the normal background noise levels and in some instances smaller impact energy with signals within the background noise can be distinguished by the manual audio monitoring mode.

Since an earthquake could dislodge or lift loose parts from the natural collection sites or generate loose parts, the staff recommended that the LPMS be designed to function following all seismic events that do not require plant shutdown.

3.0 DISCUSSIONS AND EVALUATION

RG 1.133 recommended installation of an LPMS in light-water reactors. Most plants licensed about 1980 have an LPMS installed as part of their licensing basis to meet RG 1.133. In Topical Report NEDC-32975P, the BWROG proposed removing the LPMS requirements and disabling of the loose part detection systems for BWRs. The topical report discusses the bases for the proposed changes and provides: (1) an analysis of the consequence of loose metallic parts in the reactor vessel, (2) a review of the operating experience with a survey of 12 BWR plants that have an LPMS installed, and (3) discussion of the annual cost burden of maintaining or updating the LPMS.

3.1 Justification for Eliminating the Loose Parts Monitoring System

3.1.1 BWROG Position

The BWROG stated that the operating experience of domestic BWRs indicates that an LPMS does not provide safety significant benefits, and cited the following observation for its position.

1. The detrimental effects identified in RG 1.133 did not occur in any of the 15 domestic BWRs with LPMS or in the 19 domestic BWRs which have been licensed without requirements for LPMS.

2. Although loose parts have been detected on a few occasions, the BWROG had not identified any case where a BWR was shutdown to investigate an LPMS alarm signal. The system also has not detected a failed or weakened safety-related component.

3. Small metallic filings or debris could, and have, contributed to fuel cladding damage, but this class of debris cannot be detected by an LPMS. The industry has also recently incorporated debris filters to fuel support pieces to protect against fuel cladding damage due to debris.

4. BWRs typically employ aggressive foreign material exclusion (FME) programs and underwater camera inspections during refueling outages to assure that loose parts are not allowed to accumulate in the reactor vessel.

5. Experience has shown that components inadvertently left in the reactor (or transported to the reactor system) are retained in low flow regions of the reactor vessel.

The BWROG also stated that EPRI Topical Report EPRI TR-105707, "BWR Vessel and Internals Project, Safety Assessment of BWR Reactor Internals (BWRVIP-06)," supports their position that loose-part monitoring systems have no safety benefit and can, therefore, be removed.

The EPRI topical report evaluated the consequences of loose parts generated in the reactor vessel or transported to the reactor vessel. The report stated that loose parts represent a safety concern if they result in: (a) the potential for flow blockage and consequence fuel damage; (b) the potential for interference with control rod operation; or (c) the potential for corrosion and chemical reaction with other reactor internals.

EPRI did not consider it credible that generated multiple loose parts could arrange themselves in a manner that could cause unacceptable conditions. The report considered fretting wear of fuel cladding by debris to be an operational concern because a fuel cladding leak would be detected by the offgas system. Appropriate action can then be taken to maintain the offsite radiation release within the acceptable plant specific limits.

The report also stated that transport of loose parts or debris in the reactor vessel would be gravity-dominated, flow-dominated or a combination of both. Depending on their relative weights and sizes, transport of large loose parts (generated by cracking of reactor vessel internals) into the reactor vessel will be gravity-dominated. Because the flow clearances between the reactor vessel regions are small, large parts would likely remain in the regions in which they are generated. Because the flow clearances between these regions are on the same order of magnitude as the loose parts, certain small parts or debris could be transported away from the location in which they were generated.

Loose parts generated in the upper plenum could potentially cause fuel damage, but the off-gas monitor could detect the fuel failures and it is not considered a safety concern. Loose parts generated by component failures in the downcomer or transported to the downcomer from the upper plenum bypass would be drawn downwards by gravity or flow. The parts could settle on the core shroud support ring, on the jet pump assembly, or they might be drawn to the recirculation pump suction. If the jet pump or the recirculation pump suction becomes blocked, core flow would be affected and it would be detected during the routine operator surveillance, and operator action could be expected to bring the plant to safe shutdown.

Flow blockage of individual fuel channels can result in local overheating and, consequently, fuel damage in that region, but the entire core will not be affected. While individual fuel channel blockage may not be detected during normal operation, however, any fuel damage caused by the flow blockage will be detected by the offgas system or the main steam line radiation monitors.

EPRI claimed that the vertical velocity component in the lower plenum during normal operation is less than 10 ft/sec and therefore, the vertical component of the velocity should be insufficient to cause large loose parts to be lifted upwards with the core flow. Consequently, large loose parts which have been generated from the lower plenum components would settle to the bottom head region of the vessel. Large loose parts that accumulate in the lower head region will not be a safety concern in fuel channel blockage. In addition, the radial component of the flow velocities range from 7ft/sec. at the periphery to 1 ft/sec. at the center and would tend to move the large loose parts or debris to the reactor vessel centerline. The inward movement of large loose parts would be restricted by the "forest" of control rod guide tubes in the lower plenum.

Small loose parts generated in the lower plenum components or which have been transported to the lower plenum from the downcomer could be lifted by the flow and carried to the fuel bundle inlet orifice. The clearances between the control rod guide tubes (about 1 - 6 inches) are large enough to allow a small part to pass between them, even though the probability of a loose part navigating through the "forest" of control rod guide tubes and finding its way to a fuel bundle orifice is considered small. Nevertheless, the vertical component of the velocities in the lower plenum is sufficiently large that it could carry loose parts of certain weight and size towards a fuel support inlet orifice. The fuel support orifices range in size from about 1.2 to 2.4 inches in diameter, depending on the location and specific plant design. Partial blockage of a fuel support orifice can lead to the initiation of boiling transition or possibly channel instabilities. Due to the higher lift velocities and smaller orifice sizes in the periphery fuel bundles, small loose parts are more likely to block fuel channels in the periphery bundles than the central ones. Channel instability is less of a concern in this region due to the lower power distribution.

Smaller parts or debris that are able to pass through the inlet orifice could be stopped in the fuel bundle at the lower tie plate or fuel rod spacer which have smaller clearances than the orifices. Newer BWR fuel assemblies have debris filters that are specifically designed to prevent this type of debris from entering the fuel channel. Because a blockage of any of these filter openings is smaller than that required to initiate boiling transition, there is no safety significance.

The EPRI report also stated that loose parts do not, in general, affect CRD operation, because of the tortuous path required for loose parts to enter the CRD guide tube. From the upper plenum, the clearance between the fuel channel and the top of the guide tube is small and movement of any loose parts would be counter to the core flow. From the lower plenum, access to the CRD guide tube by metallic parts is effectively prevented by the integrity of the guide tube and the core flow patterns which exist in the fuel bundle and bypass regions. Any debris which enters a CRD guide tube is unlikely to have sufficient mechanical strength to interfere with the operation of the CRD.

EPRI concluded that safe reactor operation and shutdown capability are not compromised for most categories of postulated part sizes. While it is possible to generate loose parts which may have the specific critical geometry and weights to compromise fuel performance, it is extremely unlikely that such loose parts would result from failure of internal component welds. In addition, loose parts are made of materials approved for in-reactor use. Therefore, there is no safety concern for corrosion and chemical reaction with other materials in the reactor.

3.1.2 Staff Evaluation

The EPRI report cited by the BWROG evaluated the consequence of loose parts generated in, or transported to, the reactor vessel. The staff performed independent confirmatory calculations to evaluate the potential for fuel bundle flow blockage in the lower plenum. The velocity profiles (see Appendix A) that the staff calculated in the lower plenum support the EPRI report's conclusions that heavy loose parts will settle in the lower plenum and that small loose parts could be transported to the fuel support inlet orifice. In the staff calculations the lift velocities in the centerline are slightly higher than the velocities in the periphery of the core with the "forest" of the control rod guide tubes modeled but are ,otherwise, consistent with the EPRI results.

The EPRI report stated that the higher lift velocities and smaller inlet orifices of the periphery bundles make it more likely that potential flow blockage would occur in the periphery bundles rather than the central bundles where the channel instability is less of a concern. The staff asked the BWROG whether the radial power distribution may be designed more uniformly for facilities licensed with extended power uprate. The BWROG responded that, while the radial power distribution may be more uniform, the periphery bundles will continue to have lower power levels. Therefore, channel instability should remain less of a concern for flow blockage in the periphery bundles.

A loose part evaluation Licensee Event Report (LER) for Monticello (LER # 94-89-21-02) provides further insights on partial flow blockage that could initiate transitional boiling. The licensee (Northern States Power) analyzed the possibility that a jet pump riser brace directly above the recirculation loop suction nozzle fails and generates loose parts that could be carried into the lower plenum by the flow through the jet pump. The LER stated that the jet pump nozzle for Monticello was 3 inches in diameter and any part less than 3 inches in one dimension could be transported to the lower plenum. The licensee pointed out that any part less than 2.4 inches could be lifted by the flow and carried to the core region. Parts within this dimensional range, or smaller could move into the fuel support inlet orifice, but would be trapped at the lower tie plate grid. To cause boiling transition in the fuel bundle, the loose part would have to cause a fuel bundle flow blockage of 59 percent, which corresponds to 86 percent blockage of the lower tie plate. This level of flow blockage of the lower tie plate will require at least 4 pieces, 2.4 X 2.4 inches in size, migrating to the same fuel bundles out of 484 bundles for Monticello. The licensee stated that the probability for such an event occurring is 9.0E-9 and is therefore considered negligible.

While this was a loose part evaluation for a plant-specific condition, the analysis depicts the aggregate of small loose parts that must flow to a single fuel bundle to cause flow blockage. The possibility of loose parts of 1.2 to 2.4 inches in size blocking the fuel support inlet still exists, but such loose parts would still have to navigate through the guide tubes. Also, review of the operating history supports the contention that the probability of a loose part causing partial bundle flow blockage is not high and the operating history database does not show a higher incidence or occurrence of partial bundle flow blockages in the facilities which do not have an LPMS installed.

Small debris that passes though the inlet orifice could cause fuel cladding damage. However, such small metallic fillings or debris cannot be detected by an LPMS. Also, some of the new fuel designs have debris filters in the lower tie plates in order to reduce debris fretting fuel failures. As pointed out in the EPRI report, the effect of fuel failures would be detected by the offgas system.

The staff also agrees with most of EPRI's analysis of loose parts transport and consequences in the annulus region, upper plenum and the lower vessel region. In the upper plenum evaluation, the EPRI report pointed out that a large loose part would be gravity-dominated and would most likely fall into the core region. Fuel bundle flow blockage could occur if a loose part falls on the core top guide assembly or on a fuel bundle upper tie plate grid. If core flow is affected because a sufficient number of fuel bundle flows are blocked, a power reduction would be observed and the plant would be brought to safe shutdown. If the impact on core flow or power cannot be observed, some fuel damage could occur which would be detectable by the offgas system. In addition, because the LPMS sensors are located on the exterior surfaces of the vessel, the system may not have the sensitivity to detect the impact of loose parts in the upper plenum and in the core. The staff accepts the EPRI report's assessment of the impact of loose parts in the upper plenum.

The staff also agrees with the EPRI report's evaluation that small loose parts or debris from the lower plenum will probably not impede CRD operation due to the difficult flow path. Small loose parts and debris could enter the CRD during refueling, but the LPMS will not likely detect this class of debris.

3.2 Operating Experience

3.2.1 <u>BWROG Position</u>

The BWROG stated that over 500 reactor years of operating experience have shown that loose parts detected by the LPMS and by visual inspection did not have the potential to significantly (1) cause damage to or malfunction of the primary system components; (2) pose a serious threat of partial flow blockage leading to fuel cladding failure; (3) cause control rod jamming; or (4) increase accumulation of radioactive crud in the primary system. The BWROG added that the detrimental effects described in RG 1.133 did not occur in 15 BWRs with LPMS and 19 BWRs which have been licensed domestically without loose parts detection and monitoring systems.

Section 4 of Topical Report NEDC-32975 described the results of a survey of the facilities with LPMS installed. The survey specified the type of LPMS installed, method used in filtering out background noise, and the loose part detection experience of each facility. Out of the eleven licensees that responded to the survey, six licensees stated that the system had never detected loose parts. Five licensees reported that the LPMS system did detect:

- a nut or bolt (less than 0.25 lbm) that prevented the correct operation of a supporting valve;
- a scaffolding knuckle inadvertently left in the feedwater (FW) piping system. The loose part migrated to, and became lodged in, the FW spargers and was removed during a refueling outage;
- a feedwater corrosion probe (14 ½"). The part broke off and traveled to the FW spargers, where it rattled and created a through-wall hole. The part was removed during the subsequent refueling outage;
- debris caught in the jet pump housing; and

- a dropped wear ring in the reactor recirculation pump.

The BWROG pointed out that although the LPMS did detect a few loose parts, they had not been able to identify any case where a BWR was shutdown to investigate a LPMS alarm signal. In addition, no LPMS detected a failed or weakened safety related component.

The EPRI topical report (BWRVIP-06) tabulated (see Table 4.1-1 from the BWRVIP report shown below) some of the loose metallic parts lost in the reactor vessel that plant-specific metallic loose part evaluations have demonstrated to have no adverse consequences.

BWRVIP - 06 Table 4.1-1 "Loose Part Evaluation Examples"

Description	**Location Lost**	**Size**
Ball Bearing	Annulus	2.5 mm balls
Jet Pump Beam	Annulus	250 x 100 x mm
Bolt	Annulus	200 x 50 mm
Plate	Annulus	80 x 80 x mm
Pin	Annulus	15 mm x 10 mm
Wire	Annulus	15 x1.5 x mm
Riser Brace	Annulus	16 x 4 x .2 inch
Sensing Line	Annulus	Long Tube
Latch	Bottom Head	17 x 32 x mm
Tip	Core	4 x mm
Pin	Core	25 x mm
Dry Tube Pieces	Core	1/3 x 2 x .9 inches
Screw	Core Plate	10 x 5 mm
C-Ring	CRD Tube	6 mm OD
Ring	Lower Plenum	15 mm OD
Core Spray Sparger Piece	Over Core	5 x 1 x 1 inch

3.2.2 Staff Evaluation

The objective of the current evaluation is to determine if the safety benefit of the loose part detection system detailed in RG 1.133 remains valid and outweighs the regulatory burden outlined by the BWROG. Since some of the facilities that are not licensed to comply with

RG 1.133 also submit loose part evaluation reports, the staff reviewed some of the available data from these plants. A review of some of the licensee event reports indicate that BWRs (with and without LPMS installed) have:

- scrammed due to loose parts (slugger wrench and other loose parts used during maintenance) migrating to the high pressure turbine;

- had failed valve components released into the reactor vessel as loose parts (trim ring alignment pins and bosses);

- had a jet pump mixer and a ram's head propelled out of the diffuser;

- found pieces of wire lodged in the feedwater sparger nozzles.

These experiences show that the presence of a loose part could indicate a failed or weakened component. In addition, a loose part that is generated or left inadvertently in the primary system could cause damage through fretting, and LPMS have alerted operators of potential malfunction of components (banging of valve disk, etc.) in the reactor coolant systems.

However, abnormal plant conditions caused by loose parts could also be identified by the plant process and monitoring systems and operators can take appropriate action. Loose parts could also be detected through visual inspections and component malfunction or degradation can be identified through surveillance. Finally, review of the reported operating history does not indicate significant differences in the impact or consequence of loose parts in the reactor coolant pressure boundary between plants with a LPMS and those without.

The staff asked the BWROG if the LPMS might be more useful for licensees planning to apply for license renewal. The BWROG responded that the LPM system is not part of the systems credited in the aging management program. In addition, if the aging management program is successfully implemented, the conditions of safety-related components should not deteriorate. The staff concurs with this evaluation.

3.3 Probabilistic Risk Assessments

The BWROG considered what effect, if any, removing the LPMS would have from a safety risk prospective. The topical report stated that none of the BWR probabilistic risk assessments (PRAs) rely upon or address LPMS, and there are no quantitative risk assessment data to support retaining the LPMS. The BWROG stated that the risk insights based on several hundred years of plant experience indicate that the existence or non-existence of LPMS has had no effect on core damage or large early release frequency (LERF). The staff agrees that currently available risk assessments do not evaluate the risk impact of loose parts in the reactor coolant pressure boundary.

3.4 LPMS Annual Cost Burden

The BWROG stated that LPMS requires high cost maintenance and the systems would have to be completely replaced in the near future since replacement components will not be available. The BWROG gave the following estimated surveillance costs for a typical domestic BWR.

- The typical annual surveillance burden is approximately 380 man-hours based on 18 month refueling cycles (20 minutes daily, 40 man-hours quarterly and 150 man-hours for 12 to 18 months). At $50/hour labor rates this amounts to approximately $20,000 annually.

- The typical maintenance outage requires replacement of two hardline cables ($10,000) and accelerometers and the median radiation exposure is greater than 1 man-rem. One BWR licensee anticipates replacement of the associated computer and laser printer within the next few years . The resulting annual cost of maintenance is estimated at approximately $25,000 which includes $10,000 for dose exposure.

- One BWR licensee is planning a $40,000 design change that will introduce a 2 second time delay to preclude alarms during CRD testing.

- Other BWRs have LPMS that are not supported by the original vendors and they are unable to obtain the required spare parts. Replacement of these systems will require an expenditure of $500,000 or more per plant.

4.0 CONCLUSION

In Topical Report NEDC-32975P, "Regulatory Relaxation for BWR Loose Parts Monitoring Systems," the BWROG reported on the effectiveness of the LPMS installed in some BWR plants and proposed eliminating the LPMS requirements. The BWROG stated that although loose parts have been detected on a few occasions: (1) the BWROG did not identify any BWR that was shutdown due to the impact of loose parts, (2) no LPMS detected a failed or weakened safety-related component, (3) licensees employ an aggressive foreign material exclusion program, and underwater inspection during refueling outages to ensure loose parts do not accumulate in the reactor vessel, (4) experience also shows that components left in the reactor system are retained in low flow regions, which do not pose as a safety problem, and (5) small metallic filings and other similar debris could contribute to fuel cladding damage, but the LPMS would not detect this class of debris and the industry has installed debris filters into the fuel support pieces which may reduce fuel cladding damage due to fretting.

The staff finds that operating history does indicate that LPMS did detect weakened or degraded safety related components as well as damage to components due to loose parts inadvertently left during maintenance or refueling. However, the LPMS in use are not reliable or sensitive enough to provide the safety benefits envisioned by RG 1.133. Loose parts can be detected by the normal plant process and monitoring systems and also through visual inspections. Also, operating history does not show a higher incidence or occurrence of damage to safety-related components in plants that have no LPMS installed. The staff concurs that the safety benefits of the LPMS do not appear to be commensurate with the cost of maintenance and the associated radiation exposure for the plant personnel.

Therefore, the staff finds that Topical Report NEDC-32975P is acceptable for referencing in licensing applications to the extent specified and under the limitations delineated in this safety evaluation. The staff will not repeat its review of the matters described in the subject report, when the report appears as a reference in license applications, except to ensure that the material presented applies to the specific plant involved.

If the NRC’s criteria or regulations change so that its conclusions about the acceptability of the report are invalidated, the BWROG or the applicant referencing the report, or both, will be expected to revise and resubmit its respective documentation, or submit justification for the continued effective applicability of the report without revision of the respective documentation.

Attachment: Appendix A

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APPENDIX A

FLUENT EVALUATION OF LOWER VELOCITY DISTRIBUTION

1.0 INTRODUCTION

In support of the review of the BWROG submittal requesting removal of the licensing requirements of the loose parts monitoring system (LPMS) the staff performed an evaluation of the velocity distribution of the lower plenum during full power operations. This analysis was performed because part of the basis of the request from the BWROG was that the axial velocity profiles were such that only particles of a certain size will be lifted into the fuel. Furthermore, the BWROG stated that the velocity field was such that particles would preferentially go into the peripheral channels.

FLUENT is a code developed and maintained by FLUENT, Inc. located in Lebanon, New Hampshire. The code solves the Reynold's Averaged Navier-Stokes equations and equations for the conservation of mass and energy in three dimensions. FLUENT has many models for turbulence up to and including modeling the Reynold's stresses themselves. For this simulation, the RNG k-ε model with standard wall functions was used. Boundary layers around the guide tubes were evaluated by adding more detail near the walls than in the free-stream.

1.1 Satement of the Problem and Description of the Model

The simuation is intended to provide the staff with the following information: (1) resolve velocity field in the lower plenum during normal operation; and (2) the mass and size of particles expected to be carried along with the bulk flow. Since we are interested in the details of the velocity field we need to be assured that we have enough resolution around the guide tubes. The resolved velocity field will then be used to estimate the size and mass of particles which are expected to be carried along with the bulk flow.

The model consisted of a one-eighth slice of the plenum with symmetry boundary conditions representing the rest of the plenum. A pressure outlet boundary condition modeled the entrance to the lower tie plate and mass flow rate boundary conditions were used at the jet pump diffuser outlets. The boundary conditions were set using a TRAC-BF1 simulation of a BWR/4. The model consisted of 1011462 hexahedral and tetrahedral nodes. An image of the model is shown in Figure 1.

1.2 Discussion of Results

The results are presented in Figures 2 to 4. These figures are intended to show how the fluid flows in the lower plenum and the magnitude of the velocity. Figure 2 is a contour plot of the vertical velocity at the elevation of the lower tie plate. Figure 3 presents the same information as an x-y plot along a line running from the center of the lower tie plate to its outer radius. As one can see, the velocity varies from 3.5 to 2.5 m/s below the core entrance. Figure 4 shows the path-lines of the flow from the jet pump diffuser into the lower plenum. A path line is the path that a massless particle would travel if injected into the flow field at the jet pump diffuser. As expected, the primary flow path follows a trajectory from the jet pump diffuser which leads to the lower tie plate.

Several observations can be made upon examination of the results. First, the velocities quoted by the BWROG in their submittal compare very well with the FLUENT results. The BWROG stated that the maximum expected vertical velocity will be 3.1 m/s and the FLUENT predicted value is 3.4 m/s (refer to Figures 2 and 3). Second, the path lines in Figure 4 show that the primary flow path leads to the lower tie plate. However, this is not to say that all loose parts will make their way to the fuel inlet. Loose parts would have to make their way through the maze of guide tubes shown in Figure 1 with sufficient momentum to continue flowing upward. It is difficult to make generic statements about size and composition of loose parts which will be carried by the bulk flow. However, given the fact that the geometry is restricted and the velocity at the bottom of the lower plenum shown in Figure 4 where most particles would pass is small, it is difficult to conceive that loose parts of sufficient size to block a fuel channel would be lifted out of the bottom of the lower plenum.

Attachments:
1. Figure 1 - One-eighth Slice of BWR/4 Lower Plenum
2. Figure 2 - Contours of Vertical Velocity Looking Down from the Core into the Lower Plenum
3. Figure 3 - Plot of Vertical Velocity Along Two Lines at Different Elevations from the Centerline to the Outer Radius of the Lower Shroud
4. Figure 4 - Pathlines of Mass-less Particles Flowing from Jet Pump Diffuser into Lower Plenum