

POLICY ISSUE NOTATION VOTE

May 23, 2003

SECY-03-0085

FOR: The Commissioners

FROM: William D. Travers
Executive Director for Operations

SUBJECT: DENIAL OF PETITIONS FOR RULEMAKING ON REVISING 10 CFR 50.46 AND APPENDIX K TO 10 CFR PART 50 TO REQUIRE LICENSEES TO ADDRESS THE IMPACT ON COOLANT FLOW OF RELEASE AND RESUSPENSION OF CRUD BUILDUP ON FUEL CLADDING DURING LOSS-OF-COOLANT ACCIDENT SCENARIOS AND DURING NORMAL OPERATIONS (PRM 50-73 AND PRM 50-73A)

PURPOSE:

To obtain Commission approval for denial of two related petitions for rulemaking on 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," and Appendix K to Part 50, "ECCS Evaluation Models."

BACKGROUND:

10 CFR 50.46 specifies the performance criteria against which the emergency core cooling system (ECCS) must be evaluated. Appendix K to Part 50 provides the required and acceptable features of ECCS evaluation models. The criteria include the peak cladding temperature that cannot be exceeded, the maximum cladding oxidation thickness, the maximum total hydrogen generation, and requirements to assure a core geometry that can be cooled and abundant long term cooling. The regulations also state that calculated cooling performance following postulated loss-of-coolant accidents (LOCAs) must be calculated in accordance with an acceptable evaluation model and that in applying the model, comparisons

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to applicable experimental data must be made. The petitioner contends that these sections of the Commission's regulations are inadequate because they do not address the effect of crud on the cooling of the reactor, both under the turbulent coolant flow conditions of a LOCA and during normal operations. Crud is a colloquial term for corrosion and wear products (rust particles, etc.) that become radioactive (i.e., activated) when exposed to neutron irradiation. The petitioner states that crud detachment and resuspension during a LOCA could lead to obstructed flow of coolant, inadequate cooling, and ultimately to meltdown. In addition, the petitioner contends that crud buildup during normal operations could result in severe fuel damage. The petitioner identified numerous elements of the specified ECCS evaluation procedures and the evaluation model that he believed need to include comparisons to applicable experimental data.

The petition for rulemaking (PRM) designated PRM-50-73 addressing potential crud interference with coolant flow during a fast-moving (large-break) LOCA was received by the NRC on September 4, 2001, and the notice of receipt of the petition and request for public comment was published in the *Federal Register* (FR) on October 12, 2001 (66 FR 52065). The public comment period ended on December 26, 2001. On November 5, 2001, the NRC received a second, supplemental petition, designated PRM-50-73A, from the same petitioner alleging crud interference with core cooling during normal operations. The staff determined that the two petitions should be addressed as one action. The notice of receipt of the second petition was published in the FR on January 29, 2002 (67 FR 4214). The public comment period ended on April 15, 2002. Five letters of public comment were received in response to PRM-50-73, and seven letters addressed PRM-50-73A.

DISCUSSION:

PRM-50-73

In PRM-50-73, the petitioner stated that §50.46 and Appendix K to Part 50 do not address the impact of crud on core cooling during a fast moving (large-break) LOCA. The petitioner noted that a licensed power reactor had operated with heavy crud deposits on many of the fuel rods. The petitioner stated that had a fast-moving (large-break) LOCA occurred before shutdown for refueling, extensive blockage of flow channels within the fuel bundles would have developed, leading to a degradation of core cooling and compromising defense in depth. The petitioner further stated that significant crud deposits could lead to extensive fuel failure during full-power operation and that the amount of failed fuel would then lead to a decision to shut down the reactor as the inventory of radioactive material in the reactor coolant reached the limits allowed by the technical specifications. However, the petitioner also stated that operating experience indicates that it is possible to continue to operate a reactor within technical specification limits with unusually heavy crud deposits present.

The petitioner requested that §50.46 and specific paragraphs in Appendix K to Part 50 be revised to include comparisons to applicable experimental data that address the impact of crud deposits on fuel rods.

Five letters of public comment were received on PRM-50-73, all opposed to the action requested in the petition. The commenters were Framatome ANP, Exelon Nuclear, Westinghouse Electric

Company LLC, General Electric Nuclear Energy, and the Nuclear Energy Institute (NEI). Two commenters stated that existing regulations and guidance are already adequate to address crud buildup and its potential impact on coolant flow during a LOCA. Three of the commenters stated that the postulated release of crud would not create flow blockage because the consistency of crud was powdery. Another commenter noted that in 30 years of monitoring fuel performance in numerous plants, only one plant ever experienced severe crud buildup, and in that case the buildup was quickly noticed and remediated. Subsequently crud deposits have been effectively controlled using Electric Power Research Institute (EPRI) Chemistry Guidelines.

One commenter noted that in the worst case crud release event that has occurred, River Bend, the core remained in a configuration that could be cooled and the licensee was able to maintain a substantial margin to the 2200° F peak cladding temperature criterion specified by 10 CFR 50.46. In addition, this commenter stated that fuel performance and coolant activity levels are monitored routinely to ensure that core evaluation models accurately reflect real conditions. Another commenter noted that existing regulations are not overly prescriptive in terms of specifying phenomena to be addressed in evaluating core cooling capability, which allows for advances in the technical database and updating of the evaluation procedures without the need for rulemaking. In addition, this commenter stated that the extensive data collected on crud deposits and their impact on coolant flow do not support the petitioner's contentions.

PRM-50-73A

In addition to the petition regarding the effect of crud on reactor cooling during a LOCA, the petitioner submitted a supplemental petition for rulemaking, PRM-50-73A. The supplemental petition stated that §50.46 and Appendix K to Part 50 do not address the impact of severe crud deposits on fuel bundle cooling during normal operations of a light-water-cooled reactor at (full) power. The petition stated that a licensed power reactor had operated with unusually heavy crud deposits, which, had they been allowed to build up, would likely have blocked flow channels, interfered with core cooling and led to significant damage to structural components of the core. The petitioner asked that §50.46 and Appendix K be revised to consider the impact of crud deposits on fuel bundles during normal operations.

Of the seven letters of public comment, two were submitted by the petitioner to provide additional information and related technical support for the assertions in PRM-50-73 and PRM-50-73A. The other five letters opposed the request for rulemaking as discussed in PRM-50-73A, and were submitted by Strategic Teaming and Resource Sharing (STARS), General Electric Nuclear Energy, Tennessee Valley Authority, Westinghouse Electric Company, and NEI. The comments included the observation that the NRC Standard Review Plan (SRP) specifies acceptance criteria that specifically address the impact of fuel crud deposits during normal operation. This commenter also pointed out that pressure drop monitoring for reactor coolant flow is required, implying that this monitoring would detect any interference with coolant flow resulting from crud deposition. Another commenter stated that the monitoring of coolant chemistry indicators and core power distribution measurements would provide indication of possible heavy crud deposition or movement. The same commenter stated that visual inspection of fuel assemblies during refueling outages has found no evidence of heavy crud deposits.

One commenter stated that the petitioner's postulated scenario leading to rapid core melt is not supported by any technical or scientific data. Another commenter asserted that the single high crud event at River Bend was the only event of this type in over 1,000 reactor-years of boiling water reactor operation and that, even with the unusual crud buildup in that case, the core would have remained in a configuration that could be cooled.

ANALYSIS OF REQUESTED ACTION:

The staff has evaluated the advantages and disadvantages of the rulemaking requested by the petitions with respect to the four NRC Strategic Performance Goals as follows:

1. Maintaining Safety: The NRC staff believes that the requested rulemaking would not make a significant contribution to maintaining safety because current regulations and regulatory guidance already address consideration of crud-related parameters for core cooling, because no existing data suggests that the crud normally present on reactor fuel can significantly interfere with coolant flow, and because the cause of the single event noted by the petitioner is known and has been corrected.
2. Enhancing Public Confidence: The proposed revisions would not enhance public confidence. First, the NRC staff has concluded that the petitioner's contentions lack an adequate technical basis. Second, current regulations and guidance already address the effects of crud on core cooling. The petitioner's request in effect would require that consideration be given to abnormally heavy crud deposits as a potential source of coolant flow obstruction, which is a condition that has never been observed. The staff does not believe that such unnecessary regulatory action, without technical justification, would enhance public confidence in the safety of nuclear power.
3. Improving Efficiency, Effectiveness, and Realism: The proposed revisions would decrease efficiency, effectiveness, and realism because licensees would be required to generate additional information as part of the development of their ECCS evaluation models and the NRC staff would need to evaluate the licensee's data and analysis. The NRC staff believes that this additional consideration is of marginal safety value because the petitioner's scenarios are not supported by a technical basis. The additional NRC staff and licensee effort would not improve efficiency or effectiveness. In addition, the NRC resources expended to promulgate the rule and supporting regulatory guidance would be significant with little return of value.
4. Reducing Unnecessary Regulatory Burden: The requested rule would increase licensee burden by requiring significant additional testing and analysis of ECCS effectiveness with little expected benefit.

Section 10 CFR 50.46 already requires a nuclear power plant applicant/licensee to address the impacts of the core geometry change on cooling in ECCS analyses and transient analyses. The staff does not believe that crud buildup to the levels postulated by the petitioner are reasonable. The petitioner's hypothetical discussion of fuel clad performance with severe levels of crud was

not supported by modeling, experimental results or operational data sufficient to demonstrate that fuel with high crud levels will actually behave in the manner postulated by the petitioner. The staff believes that there are other phenomena the petitioner failed to consider that would tend to reduce metal-water reactions and counteract autocatalytic reactions even if the extreme conditions postulated by the petitioner could be reached. The operating experience at several nuclear power plants that have experienced fuel failures shows that fuel degradation has progressed in a manner which is controllable. The one event (River Bend) identified by the petitioner as evidence of the likelihood of high crud levels occurred only once at that plant and has not been repeated there, or at any other plant in the United States. Finally, technical specifications for monitoring of reactor coolant activity and the requirements in 10 CFR Part 20 to maintain occupational exposures as low as reasonably achievable (ALARA) have resulted in licensee operational practices for early identification of coolant activity increase due to crud deposits before they build to the levels postulated by the petitioner. The staff does not believe that the petitioner's hypothetical discussion of a mechanism preventing early detection of abnormal activity levels is credible. For these reasons, the staff has determined that the petitioner's contentions have not been substantiated, and recommends that the subject petitions for rulemaking be denied.

COORDINATION:

The Office of the General Counsel has no legal objection to the denial of these petitions.

RECOMMENDATION:

That the Commission:

- (1) Approve denial of the subject petitions for rulemaking and publication of the *Federal Register* Notice (Attachment 1) of the denials.
- (2) Note that:
 - a. a letter is attached for the Secretary's signature (Attachment 2), informing the petitioner of the Commission's decision to deny his petitions.
 - b. the appropriate Congressional committees will be informed.

/RA William F. Kane Acting For/

William D. Travers
Executive Director
for Operations

Attachments: 1. Federal Register Notice
2. Letter to Petitioner

FEDERAL REGISTER NOTICE

NUCLEAR REGULATORY COMMISSION

10 CFR Part 50

[Docket Nos. PRM-50-73 and PRM-50-73A]

Mr. Robert H. Leyse; Denial of Petition for Rulemaking

AGENCY: Nuclear Regulatory Commission.

ACTION: Denial of petition for rulemaking.

SUMMARY: The Nuclear Regulatory Commission (NRC) is denying two related petitions for rulemaking submitted by Mr. Robert H. Leyse (PRM-50-73 and PRM-50-73A). The petitioner requested that the NRC revise its regulations at 10 CFR Part 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," and Appendix K to Part 50, "ECCS Evaluation models." The petitioner contends that these regulations are inadequate because they do not address the effect of crud on the cooling of the reactor core under the turbulent coolant flow conditions of a loss-of-coolant-accident (LOCA), and during normal operations. Crud is a colloquial term for corrosion and wear products (rust particles, etc.) that become radioactive (i.e., activated) when exposed to neutron irradiation. The petitioner states that crud buildup during normal operations and its detachment and resuspension during a LOCA could obstruct flow of coolant, resulting in inadequate cooling and ultimately leading to melt-down. In addition, the petitioner requested that the NRC amend its regulations to include comparisons to applicable experimental data that address the impact of crud deposits on the ability to cool fuel rods.

ADDRESSES: Copies of the petitions for rulemaking, the public comments received, and the NRC's letter of denial to the petitioner may be examined, and/or copied for a fee, at the NRC's Public Document Room, located at One White Flint North, 11555 Rockville Pike, Public File Area 01 F21, Rockville, Maryland. These documents are also available electronically at the NRC's Public Electronic Reading Room on the Internet at <http://www.nrc.gov/reading-rm/adams.html>. From this site, the public can gain entry into the NRC's Agencywide Document Access and Management System (ADAMS), which provides text and image files of NRC's public documents. For further information contact the PDR reference staff at 1-(800) 387-4209, (301) 415-4737 or by e-mail to pdr@nrc.gov.

FOR FURTHER INFORMATION CONTACT: Alan K. Roecklein, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, telephone (301) 415-3883, e-mail akr@nrc.gov.

SUPPLEMENTARY INFORMATION:

Background

Section 50.46 specifies the performance criteria against which the emergency core cooling system (ECCS) must be evaluated. Appendix K to Part 50 provides the required and acceptable features of ECCS evaluation models. The criteria are peak cladding temperature that cannot be exceeded, the maximum cladding oxidation thickness, the maximum total hydrogen generation, and requirements to assure a core geometry that can be cooled and abundant long term cooling. The regulations also state that assessments of cooling performance following postulated LOCAs must be calculated in accordance with an acceptable

evaluation model and that in applying the model, comparisons to applicable experimental data must be made.

The petitioner identified numerous elements of the specified ECCS evaluation procedures and the evaluation model that he believed need to include additional comparisons to applicable experimental data.

The Petitions

The petition for rulemaking designated PRM-50-73 addressing potential crud interference with coolant flow during a fast-moving (large-break) LOCA, was sent to the NRC September 4, 2001, and the notice of receipt of the petition and request for public comment was published in the *Federal Register* (FR) on October 12, 2001 (66 FR 52065). The public comment period ended on December 26, 2001. On November 5, 2001, the supplemental petition, designated PRM-50-73A, was sent by the same petitioner alleging crud interference with coolant flow during normal operations. The notice of receipt of the second petition was published on January 29, 2002 (67 FR 4214). The public comment period ended on April 15, 2002. Five letters of public comment were received on PRM-50-73 and seven letters were received on PRM-50-73A. The NRC staff determined that the two petitions should be addressed as one action.

PRM-50-73

The petitioner stated that §50.46 and Appendix K to Part 50 do not address the impact of crud on core cooling during a fast-moving (large-break) LOCA. The petitioner noted that a licensed power reactor had operated with heavy crud deposits on many of the fuel rods. The petitioner stated that had a fast-moving (large-break) LOCA occurred before shutdown for

refueling, extensive blockage of flow channels within the fuel bundles would have developed, leading to a degradation of core cooling and compromising defense in depth. The petitioner further stated that significant crud deposits could lead to an extensive fuel failure during full-power operation and that the amount of failed fuel would then lead to a decision to shut down the reactor as the inventory of radioactive material in the reactor coolant reached the limits allowed by the technical specifications.

PRM-50-73A

The petitioner stated that §50.46 and Appendix K to Part 50 do not address the impact of severe crud deposits on fuel bundle cooling during normal operations of a light water cooled reactor at power. The petitioner stated that a licensed power reactor had operated with unusually heavy crud deposits which, had they been allowed to build, would likely have blocked flow channels, interfered with core cooling and led to significant damage to structural components of the core. The petitioner requested that §50.46 and Appendix K be revised to include consideration of the impact of crud deposits on fuel bundles during normal operations.

Public Comments on the Petitions

PRM-50-73

The five letters of public comment received were opposed to this petition. Framatome ANP did not agree that crud would collect within the core as the petitioner suggested, nor that it would pose blockage problems. Framatome discussed the effects of crud for the sections of the regulations addressed by the petition, and stated that for each section, the effects of crud are adequately addressed. In Framatome's experience, typical crud formed on the surface of fuel

cladding does not have the consistency to create coolant flow blockage during either normal operation or blowdown (i.e., a LOCA). Framatome ANP stated that thermal transients in the cladding and movement resulting from strain might promote crud breakoff from the cladding but would produce small pieces that would be further broken down by the turbulence and velocity of the blowdown flow rates.

Exelon Nuclear stated that the petitioner's requested action was not necessary because 10 CFR 50.46 already requires that the cooling performance of the ECCS following postulated LOCAs meet certain acceptance criteria. Exelon stated that NRC regulatory guidance and approved ECCS evaluation models already address crud and other phenomena that could potentially impact performance relative to the acceptance criteria. Furthermore, Exelon Nuclear stated that it and its predecessors have over 30 years of experience in monitoring fuel performance in numerous nuclear power plants (NPPs) and that they have identified only one cycle, in one unit, with crud induced failures. Exelon further stated that corrective actions taken after those observed failures have resulted in no further failures due to crud at this or any other Exelon unit. In Exelon's experience, crud is powdery, and its characteristics, in terms of size or strength, indicate that it would not block the coolant flow channels and lead to fuel failures.

In general, Exelon asserted, industry experience related to significant crud deposits has been that they are isolated cases, and that after extensive root cause evaluations, effective corrective actions have prevented recurrence. Exelon also stated that crud deposits are effectively controlled through the use of the Electric Power Research Institute (EPRI) Chemistry Guidelines.

Westinghouse Electric Company, LLC, opposed the petition based on its extensive poolside and laboratory examinations of crud deposits on fuel rods used in pressurized-water reactors (PWRs), including cases in which abnormally high levels of crud could be detected during normal operation. Its results showed that it would be virtually impossible for any significant amount of the crud to contribute to flow blockage in the event of a large-break LOCA. Westinghouse also stated that most of any crud released would become suspended particles that would not affect core coolant flow. In one cited case, a water chemistry change resulted in a sudden release of all the accumulated crud in the core. A very small change in reactor coolant flow was observed as a result of this release.

GE Nuclear Energy opposed the proposed change on the basis that the event described in the petition was a unique event, not typical of crud buildup in boiling water reactors (BWRs). Even with that unusual buildup the core remained in a configuration that could be cooled throughout the cycle and would have remained in a configuration that could be cooled in the event of a LOCA. GE also stated that the safety evaluation concerning this event showed that, even with crud deposition, there would be substantial margin to the 2200 °F peak cladding temperature acceptance criterion specified by 10 CFR 50.46.

The Nuclear Energy Institute (NEI), an industry group representing all U.S. commercial nuclear power plants, plant designers, architect/engineering firms, and fuel cycle facilities, opposed the petition. NEI stated that existing NRC regulations establish performance criteria for maintaining core cooling and specify realistic ECCS evaluation models that address potential impacts on these performance measures. NEI stated that numerous thermal-hydraulic phenomena are addressed in the technical evaluation models. However, the regulations are not

overly prescriptive in terms of phenomena to be addressed, which allows for advances in the technical database and updating of the evaluation procedures without the need for rulemaking. Fuel performance and other performance measures are monitored routinely to ensure that core evaluation models accurately reflect real conditions.

NEI stated that considerable data has been accumulated on crud deposits and their impact on coolant flow properties. The data do not support the postulated existence of characteristics that might lead to a substantial blockage of flow. NEI believes that the provisions of 10 CFR 50.46 and Appendix K provide an adequate mechanism for ensuring that coolant flow and fuel performance are thoroughly monitored and maintained.

PRM 50-73A

In addition to his petition (PRM-50-73) regarding the effect of crud on reactor cooling during a LOCA, the petitioner submitted a supplemental petition for rulemaking, PRM-50-73A. The supplemental petition stated that §50.46 and Appendix K to Part 50 do not address the impact of severe crud deposits on fuel bundle cooling during normal operations of a light-water-cooled reactor at power. The petitioner stated that a licensed power reactor had operated with unusually heavy crud deposits, which, had they been allowed to build, would likely have blocked flow channels, interfered with core cooling, and led to significant damage to structural components of the core. The petitioner requested that §50.46 and Appendix K be revised to consider the impact of crud deposits on fuel bundles during normal operations.

Of the seven letters of public comment received in response to PRM-50-73A, two were submitted by the petitioner, and provided additional information and related technical support for

his assertions in PRM-50-73 and PRM-50-73A. The other five letters opposed the request for rulemaking as discussed in PRM-50-73A.

NEI noted that it had commented on the initial PRM-50-73 and provided a copy of the initial NEI comment letter. With respect to the changes to the regulations for normal operating conditions requested in this supplemental petition, NEI stated that the changes are not needed. In NEI's view the NRC Standard Review Plan (SRP) specifies a comprehensive set of acceptance criteria that specifically address the impact of fuel crud deposits and ensure that fuel design limits are not exceeded during any conditions of normal operation, including the effects of anticipated operational occurrences. NEI stated that any accumulation of crud that interfered with coolant flow would be detected quickly by pressure drop monitoring throughout the reactor cooling system.

A consortium of nuclear power plants, Strategic Teaming and Resource Sharing (STARS), supported the arguments against the petition presented by NEI and also stated that STARS opposed the subject petition. STARS stated that chemistry controls and core design constraints are in place to reduce susceptibility to heavy crud deposition and that during operation, chemistry indicators and core power measurements are evaluated continuously for evidence of heavy crud deposition or movement. STARS also stated that visual inspections of fuel assemblies during refueling have found no evidence of heavy crud deposits. STARS does not believe that nuclear safety will be enhanced by adopting the requested rulemaking.

GE Nuclear Energy stated that the supplemental petition for rulemaking held no technical merit. GE stated that the requested revision of the ECCS evaluation basis and criteria is based

on a single event that occurred at one plant during one cycle of operation; that the unique condition of heavy crud buildup has occurred only once in over 1,000 reactor years of BWR operation, and the postulated scenario (rapid and uncontrollable fuel and core melt) is not a credible scenario as shown by the damage characteristics observed for the cited event; and that the postulated inability to effectively detect and mitigate the occurrence of a heavy-crud-induced fuel damage condition during normal operation is invalid, as was adequately shown by the responsible and effective actions taken by the affected plant.

Tennessee Valley Authority (TVA) stated that the requested revisions in the supplemental petition are unnecessary because current regulations adequately address the impact of fuel crud deposits on the cooling of nuclear fuel during normal reactor operations. In addition, TVA supported the comments submitted by NEI.

Westinghouse Electric Company had opposed the initial petition for rulemaking PRM-50-73, and also opposed the action requested in this supplemental petition for rulemaking. Westinghouse stated that the postulated scenario leading to rapid core melting is completely speculative and is not supported by any technical or scientific data. Westinghouse also noted that the regulations recommended for modification in PRM-50-73A are not related to normal operating conditions, but rather apply to LOCAs.

NRC Technical Evaluation

The NRC reviewed each of the petitioner's claims and provides the following analysis.

1. The petitioner stated that a licensed power reactor operated with unusually heavy crud deposits on many of the fuel rods, which could lead to restricted coolant flow and ultimate core meltdown.

The event referred to by the petitioner occurred at the River Bend Station in 1999. A coolant chemistry excursion occurred with relatively high iron and copper levels, leading to excessive crud deposition. As the licensee event report (LER 50-458/99-016-00) indicated, the occurrence of this event was unusual and only happened once during the previous eight cycles for this specific plant. The NRC staff has not found any other nuclear power plants that experienced this unusually heavy crud formation. Although a thin oxidation layer appears in almost every operating reactor, the staff considers heavy crud build up to be extremely rare. Therefore, the probability of a large break LOCA occurring while some of the high power bundles have severe crud deposition is lower than that of a design basis accident.

2. The petitioner contended that if a fast moving LOCA had occurred with severe crud deposited on some high power bundles, extensive blockage of the flow channels within the fuel bundles would likely have developed. In addition, he argued that during a blowdown, the redistribution of crud into any or all of several restricted channels would result in substantial flow blockage. The petitioner postulated that the crud would break off during a LOCA to form a blockage at the down stream grid locations.

The operating experience relative to significant crud deposits has been that the observed crud is powdery or fluffy. During a large-break LOCA, even if the pressure wave breaks off

some of the crud, only small solid particles are expected to be carried downstream. No data was provided in the petition to support the petitioner's argument for crud blockage. The NRC also reviewed records of licensee event reports and found no test data or documents supporting the assumption that, in a LWR, the crud might break off and form a flow blockage. Therefore, the NRC does not believe that the petitioner's concerns about the flow blockage due to crud are supported by technical or scientific data.

3. The petitioner argued that with the degradation of core cooling due to the crud, there would likely have been a rapid deterioration of defense in depth. The petitioner argued that if severe crud existed within the fuel bundles, the crud could lead to a loss of cooling with consequent overheating of zirconium and rapid autocatalytic zirconium-water reactions of the fuel cladding.

The NRC agrees that heavy crud could cause higher-than-normal fuel cladding temperatures due to the additional heat transfer resistance during normal operation and postulated accidents. In particular, the porous form of crud could function as an additional heat conduction barrier between the zirconium cladding and the coolant. But the NRC does not believe that the petitioner's concern about the possibility of autocatalytic zirconium-water reactions is valid. However, if the metal-water reaction is assumed to occur, the NRC believes that this additional layer of material would also form a shield between the coolant and the cladding material that would reduce the metal-water reaction rate. Should the metal-water reaction occur, the steam from the coolant stream would need to overcome the additional mass transfer resistance of the crud layer in order to reach the cladding, and the resulting hydrogen generated at the cladding surface would need to diffuse outward through the crud. Therefore,

compared to a bare metal surface at the same temperature, a fuel rod with a layer of crud would be expected to have a reduced metal-water reaction rate, thus reducing the additional heat generated by the metal-water reaction. It would be inappropriate to consider only the additional heat transfer resistance and assume zero reduction of the metal-water reaction rate. Some locations where the crud has cracks would not see the reduction of the metal-water reaction. However, at these locations, it is expected that the steam would directly cool the bare metal surface and form a colder surface region before the temperature rose high enough to trigger the metal-water reaction.

4. The petitioner asserted that 10 CFR 50.46 does not address the impact of crud on core cooling during the large-break LOCA.

Section 50.46 (b)(4), however, provides a requirement regarding the cooling of the core. This section states: "Calculated changes in core geometry shall be such that the core remains amenable to cooling". In addition, Section I.C.3 of Appendix K to Part 50 states: "The following effects shall be taken into account in the conservation of momentum equation:...(3) area change momentum flux...(6) pressure loss resulting from area change...". Many phenomena and mechanisms may cause a change in core geometry (e.g, the rod ballooning effect, thermal expansion, crud buildup). The NRC does not believe that it is necessary for the regulation to explicitly include all the possible mechanisms causing a change in core geometry.

Although the scenario of a large break LOCA coinciding with heavy crud formation is considered a low probability event, NRC's Standard Review Plan (SRP) for ECCS has already defined detailed requirements to monitor the effect of crud deposits. The SRP outlines a

comprehensive set of acceptance criteria that serve to demonstrate compliance with regulatory requirements. Three acceptance criteria that specifically address the impact of fuel crud deposits are provided below:

SRP Section 4.2 Fuel System Design, Acceptance Criterion II.A.1.(d)

“Oxidation, hydriding, and the buildup of corrosion products (crud) should be limited. Allowable oxidation, hydriding, and crud levels should be discussed in the Safety Analysis Report and shown to be acceptable. These levels should be presumed to exist in paragraphs (a) and (b) above.”

SRP Section 4.4 Thermal And Hydraulic Design (II. Acceptance Criteria)

“8. The effects of crud should be accounted for in the thermal-hydraulic design by including it in the CHF calculations in the core or in the pressure drop throughout the RCS. Process monitoring provisions should assure the capability for detection of a three percent drop in the reactor coolant flow. The flow should be monitored every 24 hours.”

SRP Section 4.4 Thermal And Hydraulic Design (III. Review Procedures)

“The reviewer ensures that adequate account is taken of the effect of crud in the primary coolant system, such as in the calculation of CHF in the core, heat transfer in the steam generators, and pressure drop throughout the RCS.”

The NRC staff believes that these guidelines adequately address the impacts of fuel crud on normal reactor operation and ECCS performance during a large break LOCA.

In addition, the NRC believes that the nuclear industry has strong incentives to control crud buildup. Excessive crud formation could lead to operation at reduced power levels or even shutdown if coolant activity levels (suspended activated corrosion products) were to exceed technical specifications. Reduced grid power is costly. Activated crud deposition throughout plant systems increases dose-rate levels that would result in costly increases in worker radiation doses. The industry is required to demonstrate efforts to maintain occupational doses as low as is reasonably achievable (ALARA). The NRC believes that incentives for optimizing power output and minimizing occupational doses are strong. The NRC is aware that the EPRI water chemistry guidelines that the industry follows provide effective methods to control crud formation and buildup. Occupational doses over the past fifteen years have declined, and sustained power output levels have increased, suggesting that crud control incentives and methods are effective.

5. In PRM-50-73A, the petitioner contended that if the deposits continued to build during normal reactor operation, a severe crud buildup might form. Blockage of the flow within the fuel bundles would likely develop and overheating of the cladding would trigger an autocatalytic zirconium-water reaction. Subsequently, the petitioner stated that buildup could initiate substantial and rapid localized core melting while the LWR is at (full) power. Further, the petitioner contended that a LWR may be operated within its licensing basis and the technical specifications during the transition from unusually heavy crud to severe crud. The petitioner made a hypothesis that the increase of the off-gas system activity would not be regarded as an indicator of a possible heavy crud deposition and, therefore, the

plant would continue to operate until the transition from heavy crud deposition to a severe level occurs.

Crud build-up is generally a very slow process. With tight water chemistry control, the transition time from heavy crud to severe crud deposition will be on the order of weeks. Even before the formation of a heavy crud layer, the elevated cladding temperature due to crud can cause crud-assisted corrosion which usually results in pin-hole type fuel cladding damage. The longer the rod experiences the elevated temperature caused by the crud, the more damage to the fuel rod cladding would occur. With only a few fuel rods damaged, the off-gas activity would increase. Abnormally high activity readings in the off-gas system require operators to take action to mitigate fuel cladding damage. In several cases at different operating reactors, the operators were able to adjust the control rod pattern to lower the local power peaking factor around the damaged fuel bundles after the high off-gas system activity reading was observed even though the activity levels were below the technical specifications limit. Therefore, observed practice shows that fuel cladding damage due to excess crud formation is readily detectable during normal operation, and effective mitigation measures have been taken by operators.

Under conditions where heavy crud deposition occurs, fuel damage could eventually lead to cladding cracks or ballooning effects. The crud layer may then break off and fuel pellets will be cooled directly by the water, thus lowering the cladding temperature. Although the elevated cladding temperature could theoretically trigger a metal-water reaction in a very limited area of the fuel cladding, the crud also shields the cladding from the water and causes significant resistance to the metal-water reaction. The NRC does not believe that the petitioner's concern about the possibility of autocatalytic zirconium-water reactions is valid.

Furthermore, the NRC has not found any evidence to support the petitioner's view that the off-gas activity would stay below the technical specification limit while the heavy crud deposition continues. Operating experience has shown that if a reactor operates continuously under heavy crud conditions, the cladding damage will result in higher off-gas activity readings that are quickly noted by the plant operators. It is highly unlikely that the off-gas activity would remain undetected by plant operators. Recent operating experience at plants with leaking fuel demonstrates that plant operators quickly take action to suppress fuel leaks, and in many cases, shut down the reactor to inspect and replace leaking fuel.

Finally, crud formation is one of many items which are required to be considered for both LOCA and transient safety analyses, and existing regulations and the NRC Standard Review Plan already provide adequate guidance on addressing the impact of crud on plant safety. The NRC believes that the requested regulatory change is of marginal safety value and will cause additional and unnecessary NRC and licensee resource expenditure. NRC resources required to issue the rule would be significant with little return of value.

NRC Strategic Performance Goals

The NRC has evaluated the advantages and disadvantages of the rulemaking requested by the petitioner with respect to the four NRC Strategic Performance Goals as follows:

1. Maintaining Safety: The NRC believes that the requested rulemaking would not make a significant contribution to maintaining safety because current regulations and regulatory guidance already address the effect of crud-related parameters on core cooling, because no existing data suggests that the amount of crud normally deposited on reactor fuel can significantly interfere with coolant flow, and because the probable cause of the single event at River Bend Station noted by the petitioner, namely a transient coolant chemistry excursion with

high iron and copper levels, is known and has been corrected. The NRC believes that existing regulations, guidance and practices provide for monitoring, detecting and correcting any possible crud effects on core cooling before any significant safety problems could occur.

2. Enhancing Public Confidence: The proposed revisions would not enhance public confidence. First, the NRC has concluded that the petitioner's contentions lack an adequate technical basis. Second, current regulations and guidance already address the effects of normal crud accumulation on core cooling. The petitioner's request in effect would require that substantial, additional consideration be given to abnormally heavy accumulations of crud as a potential source of coolant flow obstruction, which is a condition that has never been observed. The NRC does not believe that such unnecessary and costly regulatory action to address a non-safety significant issue, without technical justification, would enhance public confidence in the safety of nuclear power.

3. Improving Efficiency, Effectiveness, and Realism: The proposed revisions would decrease efficiency, effectiveness, and realism because licensees would be required to generate additional information as part of the development of their ECCS evaluation models and the NRC would need to evaluate the licensee's data and analysis. The NRC staff believes that this additional consideration is of marginal safety value because the petitioner's scenarios are not supported by a technical basis. The additional NRC staff and licensee effort would not improve efficiency or effectiveness. In addition, the NRC resources expended to promulgate the rule and supporting regulatory guidance would be significant with little return of value.

4. Reducing Unnecessary Regulatory Burden: The requested rule would increase licensee burden by requiring significant additional testing and analysis of ECCS effectiveness with little expected benefit.

Reasons for Denial

The Commission is denying the petitions for rulemaking. Section 10 CFR 50.46 already requires a nuclear power plant applicant/licensee to address the impacts of the core geometry change on cooling in ECCS analyses. The detailed interpretation of this requirement has been documented in the Commission's Standard Review Plan, which specifically addresses the potential buildup of crud and its effects for ECCS analyses and transient analyses. The Commission does not believe that crud buildup to the levels postulated by the petitioner are reasonable. The petitioner's hypothetical discussion of fuel clad performance with severe levels of crud buildup was not supported by modeling, experimental results or operational data sufficient to demonstrate that fuel with high crud levels will actually behave in the manner postulated by the petitioner. The NRC believes that there are other phenomena the petitioner failed to consider that would tend to reduce metal-water reactions and counteract autocatalytic reactions even if the extreme conditions postulated by the petitioner could be reached. The operating experience at several nuclear power plants that have experienced fuel failures shows that fuel degradation has progressed in a manner which is controllable. The event (River Bend) identified by the petitioner as evidence of the likelihood of high crud levels occurred only once at that plant and has not been repeated there, or at any other plant in the United States. Finally, technical specifications for monitoring of reactor coolant activity and the requirements in 10 CFR Part 20 to maintain occupational exposures as low as reasonably achievable (ALARA) have resulted in licensee operational practices for early identification of coolant activity increase due to crud deposits before they build to the levels postulated by the petitioner. The Commission does not believe that the petitioner's hypothetical discussion of a mechanism preventing early detection of abnormal activity levels is credible. For these reasons, the Commission has determined that the petitioner's contentions have not been substantiated.

For these reasons, the Commission denies PRM-50-73 and PRM-50-73A.

Dated at Rockville, Maryland, this _____ day of _____, 2003.

FOR THE NUCLEAR REGULATORY COMMISSION

Annette Vietti-Cook
Secretary of the Commission

Mr. Robert H. Leyse
P.O. Box 2850
Sun Valley, ID 83353

SUBJECT: PETITIONS FOR RULEMAKING PRM-50-73 AND PRM-50-73A: IMPACT OF
CRUD BUILDUP ON ECCS CAPABILITY

Dear Mr. Leyse:

I am responding to your letters of September 4, 2001, and November 5, 2001, which submitted petitions for rulemaking that asked for amendments to 10 CFR 50.46 and Appendix K of Part 50. Your letters contend that these regulations, and associated guidance, are inadequate because they do not address the effects of crud buildup during normal operations and the effects of crud detachment and resuspension during a loss-of-coolant accident (LOCA) on the capability of the emergency core cooling system (ECCS). You further state that these inadequacies could result in overheating of the core, leading to meltdown both during a large break LOCA and during normal operations.

The NRC published notices of receipt of PRM-50-73 on October 12, 2001, and PRM-50-73A on January 29, 2002. Five letters of public comment were received on PRM-50-73, and seven letters on PRM-50-73A. All of the letters of public comment, except two that you provided on PRM-50-73A, opposed the proposed actions. The commenters argued that existing rules require the ECCS to meet stringent performance criteria by, among other procedures, controlling buildup of crud; that only one cycle in one plant ever had a significant crud buildup, which was quickly observed and remediated; that concern for controlling dose rates from crud buildup and a desire to operate a plant at full power provide strong industry incentives to control crud; and that all safety analyses have shown that crud has not had any impact on required thermal safety margins.

The Commission is denying your two petitions for the following reasons. There is no apparent safety problem. The NRC found no reports or data indicating that heavy crud buildup had ever threatened the capability of the ECCS to manage a LOCA or that heavy crud buildup could significantly interfere with coolant flow during normal operations. The NRC believes that the ECCS performance criteria, along with three specific references to crud control in the Standard Review Plan, assure that licensees will continue to address crud buildup in their analyses of ECCS performance. The NRC believes that specifying that crud buildup be addressed specifically in the rules would provide little benefit and would not contribute to performance based regulation.

Mr. Robert H. Leyse

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Expending resources on rulemaking on a non-safety significant issue would not contribute to enhanced public confidence in the agency. Further details are discussed in the enclosed notice of Denial of Petition for Rulemaking, which will be published in the Federal Register.

Sincerely,

Annette Vietti-Cook
Secretary of the Commission

Enclosure: Federal Register Notice of Denial of
Petition for Rulemaking