May 6, 2003

Mr. R. S. Lytton
Chair, Ice Condenser Utility Group
Duke Power Company
P. O. Box 1006
Charlotte, NC 28201-1006

SUBJECT: DRAFT SAFETY EVALUATION FOR ICE CONDENSER UTILITY GROUP TOPICAL REPORT NO. ICUG-001, REVISION 0: APPLICATION OF THE ACTIVE ICE MASS MANAGEMENT CONCEPT TO THE ICE CONDENSER ICE MASS TECHNICAL SPECIFICATION (TAC NO. MB3379)

Dear Mr. Lytton:

The Nuclear Regulatory Commission staff is continuing its review of the Ice Condenser Utility Group (ICUG) Topical Report No. ICUG-001, Revision 0, “Application of the Active Ice Mass Management Concept to the Ice Condenser Ice Mass Technical Specification,” submitted by the Duke Power Company (DPC) in a letter dated September 18, 2001, as supplemented by letters dated June 12, October 10, October 22 and November 26, 2002.

The enclosed Draft Safety Evaluation (SE) reflects the progress of the review conducted to date. There are several unresolved issues within the draft SE. We have planned with your staff to discuss these issues in a meeting in Rockville, Maryland in the near future. Therefore, to facilitate the resolution of issues in that meeting, we are providing the draft SE. The resolution of these issues may require an additional submittal of information and an updated revision of the topical report.

Should you have questions or comments, please contact Mr. Robert Martin of my staff at (301) 415-1493.

Sincerely,

/RA/

John A. Nakoski, Chief, Section 1
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-413, 50-414, 50-369, 50-370, 50-327, 50-328, 50-390, 50-315 and 50-316

Enclosure: As stated

cc w/encl: See next page

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DRAFT SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO TOPICAL REPORT ICUG-001, REVISION 0

APPLICATION OF THE ACTIVE ICE MASS MANAGEMENT CONCEPT TO THE ICE

CONDENSER ICE MASS TECHNICAL SPECIFICATIONS

ICE CONDENSER UTILITY GROUP

1.0 INTRODUCTION

By letter dated September 18, 2001, (Reference 1), as supplemented by letters dated June 12, October 10, October 22 and November 26, 2002 (References 2, 3, 4, and 5), the Ice Condenser Utility Group (ICUG), representing the Catawba and McGuire Nuclear Stations, the Sequoyah and Watts Bar Nuclear Plants and the Donald C. Cook Nuclear Plant, submitted for Nuclear Regulatory Commission (NRC) staff review and approval, the Topical Report: ICUG-001, Revision 0, "Application of the Active Ice Mass Management Concept to the Ice Condenser Ice Mass Technical Specification."

The topical report describes the basis and methodology to support an industry-proposed revision to the generic ice condenser containment (ICC) Technical Specification (TS) for the ICC ice bed. This issue is also addressed in parallel by the Technical Specification Task Force (TSTF) traveler number 429, Revision 0, dated January 27, 2002, (reference 6) that describes proposed revisions to the TS Surveillance Requirement (SR) for determining the mass of the ICC ice baskets.

The ice bed consists of over two million pounds of ice stored in 1,944 twelve foot long baskets within the ICC. Its primary purpose is to provide a large heat sink to absorb heat in the event of a design basis accident (DBA) in containment. The standard TS for the ICC ice bed is included in NUREG-1431, "Standard Technical Specifications for Westinghouse Plants." The Limiting Condition for Operation (LCO) for the ice bed requires that a sufficient amount of stored ice to maintain the containment air temperature and pressure within the DBA design bases limits be provided. The SR for the ice weighing program is intended to verify that the total weight of ice is adequate by taking a sample of the ice baskets to determine the weight of the entire ice bed. In addition, determining the weight of an appropriate sample of baskets ensures that no local zone of the ice bed is deficient in ice. Based on the operating experience of ice condenser plants, the ICUG proposed several changes to the current ice mass TS.

2.0 EVALUATION

The NRC staff's review of the topical report and TSTF-429 included the following areas: (1) Active Ice Mass Management (AIMM) and total ice mass requirement concepts, (2) the minimum ice mass requirement for individual ice baskets, (3) methodologies for determining ice basket mass to the degree supported by the generic topical report, (4) the concept of sampling from three radial zones in the ice bed and alternate basket sampling, and (5) the ice mass statistical sampling plan.

2.1 Active Ice Mass Management and Total Ice Mass Requirement

2.1.1 Technical Information in the Topical Report and TSTF-429

AIMM uses active monitoring of varying sublimation rates to support the process of replenishing the ice baskets to restore ice bed mass. The ice sublimation rates are different in different areas of the ice condenser. The plant-specific ice basket sublimation data can be obtained from operating experience and is trended using software such as ICEMAN (an ICE condenser MANAGEMENT program). Table A-1 of the topical report presents a set of composite historical sublimation data from Catawba, McGuire, Sequoyah, and Watts Bar plants. The data were compiled and normalized to reflect a typical ice condenser plant.

The current TS requires an "as-left" (post-maintenance) surveillance of the total ice mass and distribution. With this approach, an operational cycle is completed and during the following outage the ice baskets are replenished to meet the SR to ensure that sufficient ice will be provided for the following operational cycle. This requires that an assumed uniform sublimation (and weighing error) allowance be added to the ice mass required for the DBA analysis to meet the SR. In the current standard TS, the total "as-left" ice mass of [2,721,600] lbs is required for the coming operational cycle. (Note: The bracketed value would be adjusted to reflect plant-specific requirements.)

The proposed revision to the standard TS, as set forth in TSTF-429, uses an "as-found" (pre-maintenance) surveillance of the ice mass. The total ice mass of [2,346,408] lbs is specified in SR 3.6.15.2 of the proposed TS, and is the value used in the DBA analysis. This value is the minimum requirement for ice bed operability. The SR is conducted at the end of an operational cycle and it verifies that the "as-found" ice mass at the end of a cycle was adequate for that cycle's requirements. With the "as found" approach, the sublimation allowance and mass determination accuracy details are not included in the TS but will be maintained in accordance with procedures at each site. This allows the ice baskets to be serviced under plant maintenance procedures based on individual basket sublimation rates. The practice of managing individual baskets, based on sublimation experience, to maintain the ice bed is the foundation of the AIMM concept.

2.1.2 Staff Evaluation

The staff reviewed the proposed AIMM concept described in the topical report. This concept couples the plant-specific ice maintenance procedures to the TS SR for the total ice mass requirement. However, the topical report did not describe the procedures in sufficient detail. In requests for additional information (RAI) Nos. 1 and 2, the staff requested that the ICUG provide a copy of typical plant-specific procedures to support an improved understanding of how the ice maintenance procedures (i.e., AIMM methodology) can be used with the TS surveillance to establish the total ice mass requirement. The ICUG responded that the plant-specific procedures were not available. They would be developed after the approval of the topical report and TSTF. Therefore, the NRC staff will consider the need for submittal of these procedures during plant-specific reviews of proposed changes to plant TS. However, in response to the specific questions identified in the RAIs, the ICUG provided additional information about the plant-specific ice maintenance procedures.

The ICUG stated that the plant-specific ice bed maintenance procedures monitor sublimation rates and ice basket masses from operating cycle to operating cycle. The monitoring of the ice mass depletion rates is periodic, occurring each time the plants perform maintenance-related ice basket mass determination (weighing) procedures. Because the ice mass depletion rates tend to be linear and consistent with sufficient historical data, the mass of the ice in any basket can be predicted. The ICUG stated that if an anomaly occurred, it could be found from either control room indicators, ice bed temperature surveillance requirements, or frequent procedurally-mandated online ice condenser inspections. Any anomaly would be addressed by corrective action in accordance with the licensee's program for meeting the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix B, (Reference 7). If a condition should develop during operation such that it could result in the TS SRs being violated, the TS action statements require that the plant be brought to a safe mode of operation. In response to RAI No. 1, ICUG stated that under the proposed ice mass SRs, the formal documentation of the existing ice mass maintenance practices would be part of the plant-specific TS implementation. These practices satisfy the "as-found" (pre-maintenance) SRs and assure compliance with the LCO. The sublimation and error allowances, and associated methodology, will be formally documented at each plant. These procedures are maintained pursuant to the requirements of the Commission's regulations in 10 CFR Part 50, Appendix B, and 10 CFR 50.59.

The proposed total ice mass requirement has two elements: (1) the TS SR to specify the "as-found" total ice mass, and (2) the plant-specific ice maintenance procedures to manage sublimation and weighing errors. The combination of these two elements ensures a sufficient amount of total ice in the ice condenser for removing heat during DBAs and for meeting sublimation requirements during operating cycles. Also, as noted above, the plant-specific procedures are maintained in accordance with 10 CFR Part 50, Appendix B, and 10 CFR 50.59. Therefore, the NRC staff finds the AIMM concept and its application for the total ice mass requirement in TSTF-429 to be acceptable.

By letter dated November 26, 2002, (reference 5) the ICUG revised the bracketed value in the proposed TS for the total ice mass from [2,346,408] lbs to [2,200,000] lbs. The ICUG clarified that the value of [2,200,000] lbs corresponds to the "as-found" total ice mass in D. C. Cook UFSAR Section 14.3.4, and is an upper bound value representative of all ice condenser plants. The value of [2,346,408] does not correspond to any specific ice condenser plant. Each licensee will specify the value of this bracketed parameter based on their plant-specific safety analysis. The NRC staff finds the change of the bracketed value of [2,200,000] lbs in the proposed TS to be acceptable.

2.2 <u>Minimum Ice Mass Requirement for Individual Ice Baskets</u>

2.2.1 Technical Information in the Topical Report and TSTF-429

The topical report, Revision 0, states that the original intent of the ice mass requirement for individual ice baskets was to prevent localized gross degradation of the ice bed from creating a "burn-through" scenario[1] during the blowdown phase of a large-break loss-of-coolant accident (LOCA). The ICUG established the requirement for the minimum ice mass for individual ice baskets to be the amount of ice required during the blowdown phase of a LOCA. The topical report refers to this minimum ice mass as the "blowdown ice mass." If a burn-through scenario occurred, it could cause a chimney effect in ice condenser bays, and provide a path for steam to bypass the ice bed and get into the upper compartment without being condensed.

The methodology used to implement the proposed TS SR 3.6.15.3 requires licensees to verify the minimum ice mass for individual ice baskets by ensuring that the ice mass of each basket sampled in SR 3.6.15.2 is no less than [400] lbs. The bracketed parameter allows plant-specific values to be specified for individual plants. In response to the NRC staff RAI No. 4 (Reference 2), the ICUG provided the plant-specific minimum blowdown ice mass to be 288 lbs/basket for McGuire and Catawba, 325 lbs/basket for Sequoyah, 313 lbs/basket for Watts Bar, and 334 lbs/basket for D.C. Cook.

2.2.2 Staff Evaluation

The current licensing bases (CLB) for the long-term containment integrity analysis for ice condenser plants is based on the assumption of a uniform flow distribution through the ice bed. A burn-through scenario in the ice bed during both the blowdown and post-blowdown phases of a LOCA would invalidate the assumption, and could change the results of a LOCA containment analysis and challenge the containment design pressure. The containment design pressure is the basis for compliance with General Design Criteria (GDC) 16, "Containment Design" and GDC 50, "Containment Design Basis." The current TS[2] addresses this concern in SR 3.6.15.2.a, by requiring the sampled ice basket to have more than [1400] lbs of ice. The [1400] lbs limit is the "as-left" average ice mass per basket, which is sufficient to prevent ice burn-through during both the blowdown and post-blowdown phases of a LOCA. If a single basket contains less than [1400] lbs, the current TS Bases for SR 3.6.15.2 specifies weighing 20 additional baskets from the same bay to confirm that there is no local ice deficiency. Because the proposed minimum blowdown ice mass in the topical report addresses the ice burn-through scenario during the blowdown phase only, the NRC staff found that this minimum ice mass was not sufficient to prevent ice burn-through during the post-blowdown phase of a LOCA or to maintain a uniform flow distribution as required by the CLB.

In RAI No. 5, the staff requested that the ICUG provide a quantitative analysis, or test data to demonstrate that the post-blowdown ice burn-through had no impact on the peak containment pressure. In its response in Reference 2, the ICUG stated that the post-blowdown ice burn-through would result in a <u>decrease</u> in the peak containment pressure. The statement was based on the results of an analysis, using the Westinghouse Long Term Ice Condenser (LOTIC) computer code, to show that for a non-uniform flow distribution with a flow maldistribution factor of 1.36, the peak containment pressure was lower than the pressure with uniform flow. The NRC staff reviewed the analysis and found that the single value

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[1] "Burn-through" is a term used by the ICUG to refer to melting of ice in the baskets sufficient to create a large local steam flow channel within the ice baskets. "Melt-through" could be a more accurate description of the actual physical process.

[2] An example of the current TS is provided in Appendix A of reference 1.

maldistribution factor (1.36) did not represent the post-blowdown ice burn-through phenomena associated with the condition of having an ice mass as low as the blowdown ice mass. Specifically, the staff concern was that once ice burn-through started at the end of blowdown (approximately 30 seconds), it could grow quickly and change the flow pattern significantly. After 6000 seconds of post-blowdown ice burn-through, there was no reason to believe that the maldistribution could be maintained as a constant or be limited to a value of 1.36. It appeared that the LOTIC analysis only provided qualitative information about the impact of a specific non-uniform flow distribution, and it could not be used to address the severe ice burn-through that might result from having a blowdown ice mass of [400] lbs per basket. The NRC staff determined that ICUG's LOTIC analysis was not adequate to justify the blowdown ice mass methodology, and communicated its concern to the ICUG in a telephone conference on October 1, 2002.

In its response dated October 22, 2002, the ICUG performed a sensitivity analysis using the computer code GOTHIC with the McGuire containment. The McGuire containment has a design pressure of 15 psig. The results of the analysis are shown below:

	ice mass lbs/basket	peak containment pressure P, psig	ΔP, psi, increase from base case	margin (psi), from 15 psig	margin reduction, ΔP/ 1.56, %
Base Case	973 (all baskets)	13.44	0	1.56	0
Case 1	600 (75 baskets)	13.5	0.06	1.50	3.8
Case 2	400 (75 baskets)	13.73	0.29	1.27	19
Case 3	400 (225 baskets)	13.79	0.35	1.21	22
Blowdown Ice Mass	288	___	___	___	unanalyzed

For a range of reduced mass (973, 600, and 400 lbs/basket) in a group of ice baskets, the results show that the peak containment pressures <u>increase</u>, with decreased ice mass. This trend is contrary to ICUG's previous response to RAI No. 5, which would predict the peak pressures decreasing from the Base Case (13.44 psig). Further, it should be noted that the plant-specific blowdown ice mass for McGuire is 288 lbs/basket, which is much less than any of the amounts analyzed and would result in a more severe impact. As shown in the last column of the above table, the margin reduction resulting from a blowdown ice mass of 288 lbs/basket could be significantly more than 22 percent. Therefore, the NRC staff found that the GOTHIC analysis could not support the ICUG's methodology for the minimum blowdown ice mass.

The NRC staff discussed its concern with the ICUG in a telephone conference, on November 13, and in a meeting on November 14, 2002. During the meeting, the ICUG stated that the McGuire containment response is not significantly sensitive to ice mass maldistribution and that for the above ice mass sensitivity cases, there are no significant changes in the containment pressure response. The NRC staff disagreed with the ICUG. The base case of 973 lbs per basket corresponds to the "safety analysis mean" for individual baskets in the McGuire ice bed. Based on the sensitivity analysis, for a small ice reduction (from 973 lbs to 600 lbs per basket), the amount of localized ice burn-through would have a relatively insignificant impact on the peak containment pressure. For the intermediate cases, Cases 2 and 3, the pressure increases are 0.29 psi and 0.35 psi, respectively, corresponding to a margin reduction of 19 percent and 22 percent, respectively. For a severe reduction from the safety analysis mean to the blowdown ice mass (from 973 lbs to 288 lbs per basket for McGuire), the amount of localized ice burn-through could have a significant impact on the peak containment pressure, and could challenge the containment pressure design limit. Furthermore, it should be noted that the design margins are plant-specific values. The other ice condenser plants may have lower containment design pressures and smaller design margins compared to McGuire. These less favorable design parameters for other plants would result in more significant impacts on the peak containment pressure.

2.2.3 Revised Ice Mass Requirement for Individual Ice Basket

In its response dated November 26, 2002 (reference 5), the ICUG proposed a revised methodology and a revision to the topical report and to the TSTF to resolve the issue of specifying the minimum ice mass per basket. In the revised methodology, the ICUG committed to revise the topical report to require that ice basket mass be maintained at a level above the "safety analysis mean" under their AIMM practices. Accordingly, the Bases for SR 3.6.15.2 of the TSTF will be revised to state that the licensee's maintenance practices actively manage individual ice basket mass above the required safety analysis mean mass for each radial zone. Specifically, each basket is maintained to keep its ice mass above [1132] lbs for each radial zone. Nonconforming conditions will be addressed in the licensee's corrective action program. The bracketed value of [1132] lbs is a plant-specific example of the safety analysis mean from the D.C. Cook UFSAR, and is an upper bound for other ice condenser plants.

In the Reference 5 revision to TSTF-429, SR 3.6.15.2, the minimum ice mass per basket limit was changed to 600 lbs per basket. The previous value, as noted in the Reference 2 response to RAI No. 1, was [400 lbs] in brackets, which allowed for plant specific values to be specified. It is noted that the revised value of 600 lbs was proposed without a plant-specific variation (i.e., no bracket). Therefore, the value of 600 lbs is intended to be applicable to all ICC plants.

The NRC staff reviewed the revised method and determined that the safety analysis mean is the amount of ice for each basket that is sufficient to prevent local ice burn-through during a LOCA. Actively managing the ice mass of individual baskets to the safety analysis mean will prevent local ice burn-through that could result from the blowdown and post-blowdown phases. Allowing licensees to manage individual ice baskets is consistent with the AIMM concept, discussed in Section 2.1 above, where licensees are allowed to manage ice sublimation. The proposed TS limit of 600 lbs of ice mass per basket was evaluated in Section 2.2.2. Case 1 (600 lb) shows that the amount of localized ice burn-through has a relatively insignificant impact on containment pressure. Because the impact may vary from plant to plant, combining the TS limit (600 lbs) with active management (plant-specific safety analysis mean) provides reasonable assurance that the impact of local ice burn-through will be either insignificant or non-existant. The revised methodology for the requirement of ice mass per basket has two elements: (1) the plant-specific active ice management to "safety analysis mean" for individual baskets, and (2) a TS surveillance requirement of 600 lbs per basket. The NRC staff finds that the combination of these two elements, as specified in the revised TSTF-429, is acceptable. The discussion of these two elements should also be included in the topical report.

However, the NRC staff noted some inconsistencies in the revised topical report. For example, on page O-3, "Summary of Significant Aspects:" ... to manage the ice mass in each basket above the required "technical specification mean,"... should read as "safety analysis mean." On page I-1, "Design Basis," the discussion in this section was to establish the basis for the "minimum blowdown ice mass" alone, which is inconsistent with the revised TSTF-429, Revision 1. It should be noted that the revised methodology is based on the combination of both an active ice management goal and a TS limit. The ICUG should ensure that the discussion of the revised methodology in the topical report treats both elements throughout the report consistently. The ICUG should incorporate the above comments into Revision 1 of the topical report.

2.3 Ice Basket Mass Determination Methodology

2.3.1 Technical Information in the Topical Report

As the ICUG notes in Section II of the topical report, historically, the determination of ice basket mass has been through manual lifting and weighing of the basket. Although other methods, discussed below, have been used to predict the number of ice baskets that would require replenishment during outages to meet the TS SR, the specific determination of ice basket mass to meet the SR has been by manual lifting and weighing of ice baskets. An individual ice basket weight is typically determined by lifting the basket with a lifting rig and an attached scale or load cell. The topical report (Section II) states that this method provides the most accurate determination of ice mass, and is the preferred method.

However, some baskets may become stuck, as a result of baskets freezing to the supporting lattice framework, thus preventing them from being physically lifted and weighed. The ICUG has proposed several alternate mass determination methods to address the issue of stuck baskets. These methods include: (a) estimating the basket weight based on previous measurements of basket weight and then trending that data using the ICEMAN (ICE MANAGEMENT) software program and, (b) estimating basket weight based on visual examinations. Concepts for several other methods were mentioned in the topical report but they were not extensively described.

The licensee states that ICEMAN is a software program that trends ice basket mass histories and can be used to project future ice basket mass based on valid individual sublimation rates and previous ice basket mass data. This alternate mass determination technique requires a significant amount of accurate ice mass data to generate projections. The data that were obtained by using less accurate methods are generally not used in ICEMAN projections, because the effect of larger measurement error will be compounded over time. Visual inspection method uses a camera inspection over the length of the ice basket to estimate the amount of mass missing from the column in the form of linear gaps, shaped voids, and annular shrink-back from the ice basket mesh. The total amount of missing mass is subtracted from the known mean mass of a full basket to obtain an estimate of the mass of that basket.

Table 2-1 of the topical report, "Mass Determination Method Errors (Reference Only)," shows a comparison of the relative accuracy for the manual lifting, ICEMAN projections, and visual inspection methods. The report states that data in the table is for illustrative purposes and that actual plant data will vary from the values in the table. The table listed systematic bias (mean difference from manual lifting measurement), standard deviation, and assumed method random error. The standard deviations and assumed method random errors for manual lifting, ICEMAN projection, and visual inspection are (15 lbs and ± 15 lbs), (69 lbs and ± 40 lbs), and (177 lbs and ± 300 lbs), respectively. The larger errors involved with the visual inspection method may necessitate larger (i.e., expanded) statistical samples in order to meet plant specific licensee maintenance objectives. The report states that as ice condenser plants accumulate more operating data into their individual ICEMAN and visual estimation database, the mean difference and standard deviation will decrease, and the resultant projection will become more precise. The random errors associated with different methods (Chapter II of the topical report) has to be incorporated with the statistical analysis (Chapter III of the topical report) to obtain the 95 percent confidence level specified in the proposed TS.

For any of the alternate mass determination methods, validation of the technique and training of personnel to perform the method will be addressed on a plant-specific basis. Details regarding the determination of ice basket mass (e.g., equipment, procedures, treatment of measurement error and systematic bias) are maintained in plant-specific procedures.

2.3.2 Staff Evaluation

Table 2-1 of the topical report shows that ICEMAN, on the average, underestimates the true weight (measured by lifting) by 13 lbs. This was statistically obtained from 9,470 projections by ICEMAN. Because underestimates are conservative in ice weighing surveillance, they are acceptable. In RAI No. 8, the NRC staff asked for a more refined error analysis in terms of radial rows, since different radial rows typically have different means and, perhaps, different standard deviations. In the response (reference 2), the ICUG re-analyzed the mean difference and standard deviation between ICEMAN and manual lifting determined by rows. Based on the analysis, the ICUG concluded that the mean difference between ICEMAN and manual lifting remains conservative over all the radial rows in the ice bed. The mean difference is less conservative in Rows 2-6, because in these rows the ICEMAN prediction is closer to the actual mass. The mean difference is larger toward the containment and crane wall (Rows 1 and 9, respectively). The standard deviation evaluated by rows shows a similar distribution; i.e., the standard deviation is closer to zero in the middle rows of the ice bed (Rows 2-6) because ICEMAN predicts the actual masses better, and the standard deviation increases as the rows move outward toward the containment and crane wall.

In RAI No. 13, the NRC staff asked the ICUG to explain why the visual inspection method, that has a random error of 300 lbs, is a viable option. In the response, the ICUG explained that the assumed random error of [300] lbs is a general value based on little data. Additional use of this method may allow the error to be reduced. It is the intent of licensees to optimize the mass determination process for ice baskets, requiring that the standard deviations be adjusted for newly obtained data. The ICUG indicated in reference 2 that since the proposed TS required only the minimum blowdown ice mass (an extremely low limit) for an individual ice basket mass limit, the lower accuracy of the visual inspection method would not be a significant concern. It should be noted that the NRC staff reviewed the methodology of “minimum blowdown ice mass” in Section 2.2.2 and found that it is not acceptable. Therefore, when using the visual inspection method, the ICUG should rely on reducing the measurement error rather than rely on a low limit of “blowdown ice mass” for weighing individual ice baskets. Because the larger error involved with the visual inspection may necessitate larger statistical samples in order to meet the mass requirement, the process will encourage the improvement in error reduction.

The ICUG addresses industry challenges in its Overview section of the topical report, noting the maintenance challenges and introducing changes to the TS to respond to those challenges. In this instance the NRC staff is principally concerned with ensuring that revised SRs will continue to provide adequate assurance of a sufficient mass of ice in the ICC to meet design basis safety analysis requirements. In this regard, the NRC staff considers that the most significant aspect of the overall ICUG topical report is that the previous requirement to determine ice mass by weighing ice baskets would now be replaced by an SR that would allow determination by any combination of three methods: (a) weighing baskets, (b) estimating weights by ICEMAN, or (c) estimating weights by visual inspection.

The ICUG topical report has described the methods in conceptual form with information that is illustrative of the industry as a whole and has indicated that details regarding the method are contained in plant specific procedures. Therefore, the NRC staff will review the details regarding implementation in response to plant-specific license amendment applications. The direct weighing of baskets by scale or load cell is the most mature of the three methods and, thus, will require the least additional information. ICEMAN has been used extensively by one utility for maintenance purposes. The visual inspection method is the least mature method and will require proportionately more information to justify it on a plant-specific basis. For each of the methods to be applied on a plant-specific basis, the NRC staff will require the following categories of information:

a) A discussion of the accuracy and the precision of the method in terms of the physical devices used and their method of application. A plant-specific justification for the standard deviation and the assumed method random error to be used for specific operational cycles should be provided. Discuss plans for dealing with the following concerns:

    i) At present, there is no limit on how many times the two estimation methods may be used successively to estimate the weight of a given basket or radial zone.

    ii) The proposed TS do not require the weighing of any baskets. Table A-1 of the topical report indicates that estimation techniques will be used for over 80 percent of the baskets in row 9 and over 70 percent of the baskets in row 1, for example. Criteria will be requested for the proportion of plant-specific mass determination to be performed by each method.

    iii) The information supporting the bias and uncertainty values for the minimum basket weight of 600 lbs criterion will be reviewed on a plant-specific basis for each license amendment application referencing the topical report.

b) Provide correlations and data to demonstrate the adequacy of estimation methods in predicting ice weight.

c) Describe the processes that will ensure that once the adequacy of an estimation method is determined, it will continue to be maintained.

d) A discussion of the training and qualifications of the personnel that will perform the inspections or estimations.

e) Identify any areas where the plant-specific application differs from the ICUG topical report.

f) Provide a sample calculation showing how individual ice basket weight data, both measured and estimated, will be processed to determine compliance with the TS limit values.

g) Enclosure two to the November 26, 2002, letter (reference 5), states the following:

> If any basket is identified to be deficient with respect to [the individual zone safety analysis mean] values, this condition is to be addressed in the Licensee's corrective action program. This alone is not considered a significant condition adverse to quality as long as the ice mass requirements of SR 3.6.15.2 and SR 3.6.15.3 remain satisfied.

In at least one licensee's Quality Assurance Program description (reference 9), the corrective action program is associated with conditions that are adverse to quality. Please discuss the comparable processes and criteria in the Quality Assurance Program that will apply to treatment of this issue in the licensee's corrective action program if the condition is not considered to be adverse to quality.

2.4 Radial Zones in the Ice Bed and Alternate Basket Sampling

2.4.1 Technical Information in the Topical Report and TSTF-429

A top-down view of an ice bed is shown in Figure A-1 of the topical report. The ice bed consists of 1944 ice baskets in 24 bay sections arranged in approximately a 300 degree arc inside the containment. Each bay has 81 baskets in a 9 x 9 row-column arrangement.

Three radial zones are defined as follows: Zone A contains Rows 7, 8, and 9 (innermost rows next to the crane wall); Zone B contains Rows 4, 5, and 6, and Zone C contains Rows 1, 2, and 3. For statistical purposes, each zone has a similar expected as-found mean mass and a reasonable standard deviation. Taking random samples in each radial zone to estimate the total mass of that zone to be [782,136] lbs, as described in the topical report and TSTF-429, is a change from the current TS for taking a limited azimuthal row-group sampling. The random sample will include at least 30 baskets from each of these defined radial zones. The value of [782,136] lbs is one-third of the total ice mass in the ice bed. By letter, dated November 26, 2002, the ICUG revised the value to [733,400] lbs as a result of a change of the bracketed value in the total ice mass (see Section 2.1.2 for evaluation)

In case of a physical obstruction or surface ice accumulation, an alternate sample basket from the vicinity of the initial sample will need to be selected. The alternate selection criteria have been designed using the radial zone concept, in which baskets in the same radial zone generally have similar mass. Alternate selections are representative of initial selections as long as they have the same probability of being selected as an initial selection and can be expected to have similar characteristics as an initial selection. The representative alternate must be from the same bay and same radial zone as the original selection. In addition, the use of alternate selections is restricted to preventing repeated use of the same alternate basket from affecting statistical confidence.

2.4.2 Staff Evaluation

In reviewing Table 1-1 and Figure 1-2 of the topical report, the staff noted that significant differences in sublimation rates appeared among Rows 7, 8, 9 and that more frozen ice baskets exist in Row 9 than in Rows 7 or 8. In RAI No. 3, the NRC staff asked ICUG to explain how the differences and the frozen baskets would affect the accuracy of the weight measurement by using the radial zone concept.

In the response, the ICUG explained that the probability of an ice basket being initially selected for the sample analysis is based on a blind, random sampling strategy that includes all rows of the ice bed. Therefore, regardless of the sublimation rates, each basket in the radial zone has the same probability of being initially selected as any other basket in the zone. The radial zone grouping concept considers that baskets in the same radial zone will sublimate through their operating "lives" to approximately the same mean mass. Because of the noted sublimation differences between rows, baskets in Radial Zone A are actively managed to the design basis limit such that every basket in the zone inherently contains a generally similar mass at the end of the operating cycle. This is done by different replenishment frequencies, a process which has the effect of covering the mean basket mass in a given zone. Because the baskets in Row 9 are characteristically the most likely to be frozen and have higher sublimation than baskets in other rows, the beginning-of-cycle mass of stored ice in Row 9 is typically higher than in Row 7 or Row 8. Therefore, it is likely that an alternate selection of another sample basket from Row 7 or Row 8 would contain the same, or conservatively less, stored ice than that of a Row 9 basket in the as-found condition.

Alternate selection of another ice basket as a statistical replacement would typically indicate that the original selection is obstructed and its mass cannot be determined for the purpose of the surveillance. The alternate selection criteria were developed on the need to preserve the random sampling of local areas. The alternate selection is limited not only to the same radial zone as the original selection, but also to the same bay. It prohibits the repeat use of an ice basket that was analyzed as an alternate in any of the previous three most recent surveillances. This restriction, coupled with the potential of multiple statistical sample selections from a single Bay-Zone, ultimately requires that the plants have access to as many baskets as possible for the determination of mass. The combination of this alternate selection criteria and active management of the ice bed ensures a 95 percent confidence level in the total mass of ice in any radial zone.

The above ICUG's clarification resolved the staff's concern that was identified in the RAI. Therefore, the staff finds the proposed radial zone concept and alternate basket sampling method to be acceptable.

2.5 Ice Mass Statistical Sampling Plan

The surveillance to determine the mass of ice in the ice bed consists of three activities: (a) the random selection of the sample group of 30 or more ice baskets for each radial zone, (b) selection of the mass determination method, whether by direct weighing or estimation, and (c) for weighing attempts that encounter stuck baskets either selection of an alternate basket or use of an estimation technique to determine the weight.

The ice mass statistical sampling plan is discussed in Chapter III of the topical report. As stated in the topical report, the sampling plan calls for a stratification of the population by radial zones, where Zone A comprises the first three rows next to the crane wall, Zone B includes the three middle rows of the ice bed, and Zone C includes the three outer rows next to the containment wall. A random sample of at least 30 baskets from each stratum (zone) is selected for a total of at least 90 baskets for the entire ice bed. The distinct advantage of the stratified sampling is that it minimizes the risk that the sample will contain a disproportionate number of a minority group. The selection of the sample size (at least 30 per zone for a total of at least 90 baskets) is adequately explained in Chapter III of the topical report and is acceptable to the NRC staff. The sampling plan is acceptable to the staff.

Weight measurements of each basket in the sample are corrected for systematic bias before using such measurements in any statistical calculations. Measurements uncertainties are given in two forms (Equation 3.1 and Equation 3.2 in the topical report), of which the latter is more conservative. Licensees will be requested to identify whether they utilize one or both methods and to describe the implementation of the method(s) on a plant-specific basis.

The ICUG has recognized that where estimation methods are used that have relatively large uncertainties, this must be accounted for in the statistical calculation called the error of the mean. The topical report’s method for accomplishing this is derived from the statistical methodology described in Section 8.3.1.1 of Reference 8 and is described by equation 3.2 of the report. The NRC staff has reviewed the formulation of equation 3.2 for consistency with the methods in Reference 8 and finds it to be acceptable.

The main statistics involved in the total ice mass determination are the average and the standard deviation from which a 95 percent lower confidence limit (LCL) is constructed. Thus we are 95 percent sure that the total ice weight is not below the calculated LCL. The calculations of the main statistics (including the finite population correction for the standard deviation) and the LCL are acceptable to the NRC staff.

In addition to the requirement for an acceptable estimate of the total ice mass, a minimum weight criterion of 600 lbs is set for each of the baskets selected for the sample. The measured minimum weight, accounting for bias and measurement uncertainty, must not fall short of the minimum weight criterion. The information supporting these bias and uncertainty values will be reviewed on a plant-specific basis for each license amendment application referencing the topical report.

3.0 Conclusion

The NRC staff has reviewed Topical Report ICUG-1, Revision 0, “Application of the Active Ice Mass Management Concept to the Ice Condenser Ice Mass Technical Specification.” The NRC staff finds, based on the evaluation provide above, that the following concepts and methodology are acceptable: the AIMM concept and total ice mass requirement, the radial zone concept for sampling and alternate basket selection and the ice mass statistical sampling plan. The ice mass determination methods will be evaluated on a plant-specific basis. However, the NRC staff found that specifying the minimum individual basket ice mass to be “blowdown ice mass” and the bracketed value of 400 lbs is not acceptable (see evaluation in Section 2.2.2). The NRC staff finds the revised ice mass requirement for individual ice baskets of 600 lbs, as discussed in Section 2.2.3, to be acceptable. However, the NRC staff noted some inconsistencies between the revised TSTF-429 and the revised topical report and provided comments in Section 2.2.3 of this SER. The ICUG should incorporate the above comments into Revision 1 of the topical report.

4.0 REFERENCES

1. Letter from R. S. Lytton, Chair, Ice Condenser Utility Group, Duke Power Company, to US Nuclear Regulatory Commission, “Ice Condenser Utility Group Topical Report No. ICUG-001: Application of the Active Ice Mass Management Concept to the Ice Condenser Ice Mass Technical Specification.” (TAC No. MB3369), September 18, 2001.

2. Letter from R. S. Lytton, Chair, Ice Condenser Utility Group, Duke Power Company, to US Nuclear Regulatory Commission, “Responses to Questions on Ice Condenser Utility Group Topical Report No. ICUG-001, Rev. 0: Application of the Active Ice Mass Management Concept to the Ice Condenser Ice Mass Technical Specification,” and TSTF-429, Rev. 0 (TAC Nos. MB3369 and MB3938),” June 12, 2002.

3. Letter from R. S. Lytton, Chair, Ice Condenser Utility Group, Duke Power Company, to US Nuclear Regulatory Commission, “Responses to Follow-up Questions on Ice Condenser Utility Group Topical Report No. ICUG-001, Rev. 0: Application of the Active Ice Mass Management Concept to the Ice Condenser Ice Mass Technical Specification,” and TSTF-429, Rev. 0 (TAC Nos. MB3369 and MB3938),” October 10, 2002.

4. Letter from R. S. Lytton, Chair, Ice Condenser Utility Group, Duke Power Company, to US Nuclear Regulatory Commission, “Responses to Follow-up Questions on Ice Condenser Utility Group Topical Report No. ICUG-001, Rev. 0: Application of the Active Ice Mass Management Concept to the Ice Condenser Ice Mass Technical Specification,” and TSTF-429, Rev. 0 (TAC Nos. MB3369 and MB3938),” October 22, 2002.

5. Letter from R. S. Lytton, Chair, Ice Condenser Utility Group, Duke Power Company, to US Nuclear Regulatory Commission, “Responses to Follow-up Questions on Ice Condenser Utility Group Topical Report No. ICUG-001, Rev. 0: Application of the Active Ice Mass Management Concept to the Ice Condenser Ice Mass Technical Specification,” and TSTF-429, Rev. 0 (TAC Nos. MB3369 and MB3938),” November 26, 2002.

6. Technical Specification Task Force (TSTF) traveler number 429, Revision 0, dated January 27, 2002.

7. Appendix B to Part 50 - Quality Assurance Criteria for Nuclear Power Plants and Fuel Processing Plants.

8. NUREG/CR-4604, Statistical Methods for Nuclear Material Management, December 1988.

9. Letter, M. S. Tuckman, Duke Power Company to NRC, “Nuclear Quality Assurance Program, Amendment 32,” dated December 18, 2002.

10. Letter, B. B. Desai, NRC, to Duke Energy Corporation, “Catawba Nuclear Station - NRC Inspection Report 50-413/02-02, 50-414/02-02,” dated July 17, 2002.

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