

October 27, 2000

Stephan Brocoum, Assistant Manager  
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P.O. Box 30307  
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SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION/U.S. DEPARTMENT OF  
ENERGY TECHNICAL EXCHANGE AND MANAGEMENT MEETING ON  
SUBISSUES RELATED TO CRITICALITY (OCTOBER 23-24, 2000)

Dear Mr. Brocoum:

Enclosed are the meeting summary highlights agreed upon during the October 23-24, 2000, Technical Exchange and Management meeting between the staff of the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy. The main purpose of the meeting was to discuss subissues related to criticality (Container Life and Source Term Subissue 5, Radionuclide Transport Subissue 4, and Evolution of the Near-Field Environment Subissue 5). The meeting was held in Las Vegas, Nevada.

If you have any questions regarding this letter, please contact the technical lead for the criticality subissues, Mr. Meraj Rahimi or the Senior Project Manager for issue closure, Mr. James Andersen. Mr. Rahimi can be reached at (301) 415-6616 and Mr. Andersen at (301) 415-5717.

Sincerely,  
*/RA/*

Janet Schlueter, Acting Chief  
High-Level Waste Branch  
Division of Waste Management  
Office of Nuclear Material Safety  
and Safeguards

Enclosure: Summary Highlights of NRC/DOE Technical Exchange and Management Meeting  
on Subissues Related to Criticality

cc: See attached distribution list

Stephan Brocoun, Assistant Manager  
Office of Licensing and Regulatory Compliance  
U.S. Department of Energy  
Office of Civilian Radioactive Waste Management  
Yucca Mountain Site Characterization Office  
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Letter to S. Brocoun from J. Schlueter dated: October 27, 2000

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## **Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Subissues Related to Criticality**

October 23-24, 2000  
Las Vegas, Nevada

### Introduction and Objectives

This Technical Exchange and Management Meeting on subissues related to criticality (Container Life and Source Term (CLST Subissue 5), Radionuclide Transport (RT Subissue 4), and Evolution of the Near-Field Environment (ENFE Subissue 5)) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on preclicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during preclicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. Resolution at the staff level does not preclude an issue being raised and considered during the licensing proceedings, nor does it prejudice what the NRC staff evaluation of that issue will be after its licensing review. Issue resolution at the staff level, during preclicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues are "closed" if the DOE approach and available information acceptably address staff questions such that no information beyond what is currently available will likely be required for regulatory decision making at the time of any initial license application. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues are "open" if the NRC has identified questions regarding the DOE approach or information, and the DOE has not yet acceptably addressed the questions or agreed to provide the necessary additional information in a potential license application.

The objective of this meeting is to discuss and review the progress on resolving the subissues related to criticality (see Attachment 1 for list of subissues).

### Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that CLST Subissue 5, RT Subissue 4, and ENFE Subissue 5 were "closed-pending." Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

### Highlights

## **1) Opening Comments**

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the criticality subissues (see "Criticality - Summary of Status from a DOE Perspective" presentation given by Paige Russell). DOE stated that in the CLST Issue Resolution Status Report (IRSR), Rev. 02, RT IRSR, Rev. 02, and ENFE IRSR, Rev. 3, the NRC listed CLST Subissue 5 as "open" and RT Subissue 4 and ENFE Subissue 5 as "closed-pending." During this meeting, DOE stated that its presentation would focus on confirmatory and additional information, data, and analyses identified by the NRC in its Safety Evaluation Report (SER), the previously mentioned IRSRs, and subsequent discussions. DOE stated that it felt the presentations would identify future documents which can be used as the basis to go to "closed-pending."

DOE stated that it has two documents that will contain the methodology for evaluating criticality: (1) the Disposal Criticality Analysis Methodology Topical Report (Topical Report) and (2) the Preclosure Criticality Analysis Process Report (Preclosure Report). DOE stated that the Preclosure Report would not be issued until Fiscal Year 2002 due to work prioritization. DOE stated that it plans to validate the models in a series of validation reports which will provide justification for the range over which the models are to be used. The NRC questioned when the validation reports will be issued and whether they will cover all the specific waste forms. DOE stated that the validation reports will be issued during the next two fiscal years and that it is in the process of gathering information on all the waste types. DOE noted that as information became available, it would provide it to the NRC. DOE also stated that it did not believe the current waste package design would be negatively impacted by the other waste types.

## **2) Discussion of Criticality Topical Report**

DOE presented an overview of the update to the criticality topical report (see "Disposal Criticality Topical Report Update" presentation given by Daniel Thomas). DOE stated that the objective of this presentation was to give a general description of Revision 1 to the Topical Report, briefly summarize the changes in Revision 1, and provide a cross-reference to the NRC SER open items, Revision 1 of the Topical Report, and the presentations for this technical exchange. DOE stated that the Topical Report was reorganized to be consistent with the NRC SER. DOE provided an overview of the methodology used in the Topical Report and the changes since Revision 0 to the Topical Report.

DOE stated that of the 28 SER open items, all except one are addressed in the CLST Subissue 5 presentations. The exception related to Open Item 1, the verification of the spent fuel burnup. DOE stated that this open item was unique in that it did not correspond to a KTI subissue and that it would be more appropriate to address it as part of the Topical Report/SER process. DOE stated that it was developing an approach for burnup verification and that it would be formally documented in the Preclosure Report. The NRC stated that, since this was a preclosure issue, that it would be more fully discussed during a future technical exchange addressing preclosure issues.

## **3) Technical Discussions - CLST Subissue #5, Effect of In-Package Criticality on Waste Package and Engineered Barrier System Performance**

A summary of the current status of resolution was presented in a number of presentations (see Container Life and Source Term Subissue 5, Acceptance Criterion presentations). There are a total of seven acceptance criteria for this subissue, all of which are considered to be “closed-pending” by the DOE. DOE then discussed each acceptance criterion (AC) and the information items identified in the CLST IRSR, Rev. 2 and in the NRC SER.

Under AC #1, DOE discussed the design criteria for components to mitigate potential effects of in-package criticality on repository performance. DOE addressed the actions or information needs identified by the NRC and stated that the consequence criterion has been removed from the Topical Report and that all probability/consequence pairs will be evaluated for inclusion in at least one Total System Performance Assessment (TSPA) sensitivity analysis. DOE further stated that only probability defined in the proposed 10 CFR 63.114(d) will be used for screening criticality events from TSPA. The NRC had questions related to the analysis done for TSPA. DOE stated that the sensitivity analysis related to criticality would be further discussed under AC #7.

Under AC #2, DOE discussed the features, events, and processes (FEPs) that may increase the reactivity of the system inside the waste package. DOE addressed the actions or information needs identified by the NRC and stated that the description of the methodology and modeling for igneous events is provided in the revision to the Topical Report and that an application of this methodology will be available in November 2000 (Probability of Criticality Before 10,000 years, CAL-EBS-NU-000014, Rev. 0). DOE also discussed the inclusion of seismicity and faulting in the in-package criticality scenario development. DOE stated that the description for seismicity has already been accepted by the NRC in the SER. DOE stated that faulting has been screened out based on low probability for damage. The NRC stated that providing the revision to the Disruptive Events FEPs AMR was an agreement reached in the Structural Deformation and Seismicity (SDS) KTI technical exchange and still needed to be reviewed prior to accepting DOE's conclusions. The NRC also stated that it needed to review the revision to the FEPs database.

The NRC questioned whether low-frequency, high-volume infiltration events were factored into the DOE analysis. The NRC questioned whether some FEPs conducive to criticality may be screened out since they may not affect the performance assessment. DOE stated that a wide range of seepage distributions were factored in and covered the full range of possible drip rates and that DOE does consider the potential differences in conservative approaches with respect to criticality and radionuclide release. DOE stated that the full range of credible parameters will be considered for criticality.

The NRC questioned whether DOE's approach in CAL-EBS-NU-000014, Rev. 0 was consistent with the NRC/DOE agreements made during the igneous activity technical exchange (e.g., discussions related to the probability of igneous activity at  $10^{-8}$ ). DOE stated that its approach was consistent. The NRC also questioned whether DOE's approach considered the potential for criticality within a tephra deposit following an extrusive volcanic event. DOE stated that processes equivalent to this scenario were considered in CAL-EBS-NU-000014, Rev. 0.

Under AC #3, DOE discussed the configuration classes that have potential for criticality. DOE addressed the actions or information needs identified by the NRC and stated that the acceptance of the methodology for identifying the configuration classes was discussed in the

NRC SER. The NRC stated that the SER just discusses the configuration classes and not specific configurations. The NRC stated that it needed examples of parameter values within specific configurations. DOE stated that it has issued a number of calculations which discuss the range of parameters which could be considered as examples in this area. The NRC stated that it would review these documents and provide DOE with any comments, if applicable.

The NRC and DOE also discussed tables listing the primary and secondary criticality FEPs. The NRC stated that it would review the tables and also the revised FEPs database when it becomes available.

The NRC raised a question regarding fuel misloads. DOE stated that fuel misloads are covered as a change in waste package inventory and not as a FEP or configuration class. DOE stated it considers all possible loadings of a particular waste form and that it is treated as a preclosure issue (verification of waste package loading).

Ms. Treichel (Nevada Nuclear Waste Task Force) asked whether it was safe to use the proposed 10 CFR Part 63 criteria (rather than Part 60). The NRC stated that the Commission has adopted a risk-informed, performance based approach for licensing and that this was more consistent with proposed Part 63 criteria. Therefore, the proposed Part 63 was more appropriate for discussions focused toward a potential license application. Mr. Frishman (State of Nevada) questioned how future changes to the proposed Part 63 would affect the agreements made at these KTI technical exchanges and the NRC's sufficiency review. The NRC stated that a change back to Part 60 would potentially change the agreements already made and sufficiency review comments.

Regarding AC #4, DOE discussed the method for assigning probability values. DOE addressed the actions or information needs identified by the NRC and stated that this AC should be closed pending confirmation by NRC review of cited examples. NRC questioned how the Monte Carlo calculations are implemented. DOE discussed the methodology and stated that the example calculations indicate the Monte Carlo technique can be applied with a moderately large number of simultaneous lookup and interpolation parameters without experiencing an unacceptably large running time. The NRC stated that it would review the calculations and provide DOE with any comments, if applicable.

Regarding AC #5, DOE discussed the computer models for calculating  $k_{\text{eff}}$ . DOE addressed the actions or information needs identified by the NRC (Open Items 4 through 19 of the NRC SER) and stated that the revision to the Topical Report addresses all of the SER open items related to this AC. DOE further stated that the details would be provided in specific validation reports. DOE stated that Open Items 4, 12, and 21 relating to pinhole effects would be discussed under AC #6.

In the discussions related to Open Item #5, DOE discussed criticality margin for regression analyses. DOE questioned the use of subcritical margin. DOE stated that using subcritical margin is inconsistent with proposed 10 CFR Part 63 and a risk-informed approach. DOE stated that ANSI/ANS 8.17 is intended for deterministic uses, not risk-informed approaches. DOE stated that it has accounted for all uncertainties and biases and, therefore, does not need to use an arbitrary margin.

In the discussions related to Open Item #7, DOE stated that the isotopic depletion model will account for multi-dimensional neutron spectral effects through comparisons to multi-dimensional codes. DOE further stated that the Isotopic Model Validation Reports will address the adequacy of the modeling used. In the discussions related to Open Item #8, DOE stated that it would demonstrate that the cross-section data at temperature used is conservative. In the discussions related to Open Item #10, DOE stated that no reactivity credit will be taken for neutron absorber in solution. In the discussions related to Open Item #13, DOE stated that it is following ANSI/ANS 8.17 guidelines for establishing biases and uncertainties. In the discussions related to Open Item #14, DOE stated that, if a single predictor is adequate to define a trend conservatively, it will not use multi-parameters.

The NRC and DOE then discussed the range of data needed. DOE stated that it was reviewing additional data from Three Mile Island and Quad Cities reactors. This additional data will extend the enrichment database and provide a valid basis for evaluation. DOE further stated that for DOE spent nuclear fuel, fresh-fuel assumptions would be used.

In the discussions related to Open Item #17, DOE stated that it will be using the procedures defined in ANSI/ANS 8.1 for extending trends. DOE concluded for AC #5 that all the issues relative to the SER open items have been addressed in the revision to the Topical Report and the validation report plans are presented therein.

Regarding AC #6, DOE discussed the computer models for criticality consequences. DOE addressed the actions or information needs identified by the NRC (Open Items 20 through 27 of the NRC SER) and stated that the revision to the Topical Report addresses all of the SER open items related to this AC.

In the discussions related to Open Item #20, DOE stated that the revision to the Topical Report will address other moderators (other than water), in particular silica. In the discussions related to Open Item #21, DOE stated that the revision to the Topical Report shows a comprehensive approach to evaluating the probability of neutron absorber loss through cladding defects. The NRC and DOE discussed the likelihood for pinholes to affect consequences since pinholes occur in a very small percentage of commercial spent nuclear fuel cladding. Mr. Frishman (State of Nevada) stated that older fuel may have a much higher percentage of pinholes and questioned its effect on the consequences if DOE does not blend the fuel. DOE stated that it would account for the probability of such an occurrence. NRC noted that discussions under this open item must be consistent with CLST Subissue #3.

In the discussions related to Open Item #22, DOE stated that it believed that the revision to the Topical Report shows a comprehensive approach to evaluating the enhanced corrosion rate of the waste package barriers from the prolonged elevated temperature resulting from a steady-state criticality. The NRC raised a question regarding how the increase in the radiation fields due to the criticality event affects the consequence evaluation because of the possibility of increased radiolysis inside the waste package and at the surfaces of nearby waste packages. DOE stated that they will conduct the appropriate calculations and include such coupled processes.

In the discussions related to Open Item #23, DOE stated that the modeling for external steady-state criticality consequences is sufficiently similar to those for internal steady-state criticality



that it should be accepted on the same basis. DOE further stated that as an additional validation of the external model, that it would check for consistency with the most authoritative analyses of the Oklo natural reactor. DOE stated that it is currently identifying external configurations and that it will soon do new calculations using Topical Report approach, applied to high-enriched DOE spent nuclear fuel.

In the discussions related to Open Item #25, DOE stated that spent nuclear fuel inside the waste package is sufficiently similar to in-reactor configurations that RELAP5/MOD3.2 code is applicable. In the discussions related to Open Item #27, DOE stated that the revision to the Topical Report adequately describes the validation approach for the transient criticality consequence model. In particular, eight candidate comparison experiments have been identified and evaluated as having parameters similar to those that could occur in the repository. DOE concluded for AC #6 that all the issues relative to the SER open items will be addressed in the revision to the Topical Report and the model validation reports.

Regarding AC #7, DOE discussed the risk contribution from the in-package criticality to the total repository system performance. DOE addressed the actions or information needs identified by the NRC and stated that the process for evaluating criticality results is addressed in the revision to the Topical Report. DOE stated that in-package criticality has been screened out of the TSPA-SR on the basis of low probability during the regulatory period. NRC asked whether criticality was considered in the human intrusion analysis required in both the proposed NRC and Environmental Protection Agency (EPA) rules. DOE stated that criticality was not included in the human intrusion analysis because unlikely disruptive events are not required in the human intrusion analysis in the proposed EPA standard. DOE stated that all probability/consequence pairs will be evaluated for inclusion in at least one TSPA sensitivity analysis. DOE stated that the TSPA-SR document does not include a post 10,000 year criticality, but these would be considered in a post 10,000 year TSPA, called sensitivity analysis. NRC questioned the scope and screening processes for these sensitivity analyses. DOE stated that the scope of these sensitivity analyses had not been determined to date. DOE also discussed a "what-if" analysis to evaluate the impact of criticality assuming an early waste package failure. The scope and assumptions used for this "what-if" analyses were discussed and DOE stated that the assumptions used would be consistent with other early-failure sensitivity studies.

NRC stated that DOE had provided it with a large amount of documents and calculations which the NRC has not had a chance to review. Therefore, based on these additional reviews, the agreements listed in Attachment 1 may not be a complete list. However, based on the information provided during this technical exchange, NRC and DOE reached seven agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #5 could be listed as "closed-pending."

#### **4) Technical Discussion - RT Subissue #4, "Nuclear Criticality in the Far Field" and ENFE Subissue #5, "Effects of Coupled Thermal-Hydrologic-Chemical Processes on Potential Nuclear Criticality in the Near Field"**

A summary of the current status of resolution was presented (see "Evolution of the Near Field Environment Subissue 5 and Radionuclide Transport Subissue 4" presentation given by Daniel Thomas). DOE provided a general overview of the near and far field issues. DOE stated that

much of the discussion on external criticality took place under the CLST subissue and that DOE would address the five issues pertaining to external criticality in Revision 1 to the Topical Report. NRC questioned where the actual analysis and data for external criticality would be documented. DOE stated that it would be documented in a similar fashion as in-package criticality. DOE stated that the validation reports would contain some of the information and that there are two documents that have previously been issued that would provide an example of the type of data and analysis that would be provided in a license application.

NRC stated that DOE had provided it with a large amount of documents and calculations which the NRC has not had a chance to review. Therefore, based on these additional reviews, the agreements listed in Attachment 1 may not be a complete list. However, based on the information provided during this technical exchange, NRC and DOE reached 3 agreements (see Attachment 1) for both the ENFE and RT subissues. With these agreements, the NRC stated that both RT Subissue #4 and ENFE Subissue #5 could be listed as "closed-pending."

## **7) Public Comments**

Mr. Frishman (State of Nevada) stated that if the NRC is considering "closed-pending" based on the revision of the Topical Report it was entering "new territory." He further stated that this would be the first time the NRC based "closed-pending" on it taking actions rather than DOE taking actions. The NRC noted his comments and stated that it too was discussing whether the information DOE discussed was adequate to list CLST Subissue #5 as "closed-pending."

Mr. Bullen (Nuclear Waste Technical Review Board) requested that (1) DOE discuss moderator exclusion, and (2) NRC discuss what kind of data does the NRC need to take credit for cladding. Regarding (1), DOE stated that it has looked at the issue and addressed it in several design process documents (which are available on the internet). Although moderator exclusion did show some advantages with respect to criticality, several system level issues, including high heat generation and cladding damage, precluded it from further consideration. Regarding (2), the NRC stated that it was looking at this issue under CLST Subissue #3.

C. William Reamer  
Acting Deputy Director  
Division of Waste Management  
Nuclear Regulatory Commission

Dennis R. Williams  
Deputy Assistant Manager  
Office of Licensing & Regulatory Compliance  
Department of Energy

## Summary of the Resolution of the Key Technical Issue on Subissues Related to Criticality

<u>Subissue #</u>	<u>Subissue Title</u>	<u>Status</u>	<u>NRC/DOE Agreements</u>
CLST Subissue 5	Effect of In-Package Criticality on Waste Package and Engineered Barrier System Performance	Closed-Pending	<p>1) Provide Revision 1 to the Topical Report. DOE stated that it will provide the Disposal Criticality Analysis Methodology Topical Report, Revision 01, to NRC during January 2001.</p> <p>2) Provide the Disruptive Events FEPs AMR, the FEPs database, and the Analyses to Support Screening of System-Level Features, Events, and Processes for the Yucca Mountain Total System Performance Assessment-Site Recommendation. DOE stated that it will provide the FEPs AMRs, the Analyses to Support Screening of System-Level Features, Events, and Processes for the Yucca Mountain Total System Performance Assessment-Site Recommendation AMR, and the FEPs database to NRC during January 2001.</p> <p>3) Provide the "Probability of Criticality Before 10,000 years" calculation. DOE stated that it will provide the calculation to NRC by November 1, 2000.</p>

CLST Subissue 5	Effect of In-Package Criticality on Waste Package and Engineered Barrier System Performance (Cont.)		<p>4) Provide the list of validation reports and their schedules. DOE stated that the geochemical model validation reports for "Geochemistry Model Validation Report: Degradation and Release" and "Geochemistry Model Validation Report: Material Accumulation" are expected to be available during 2001. The remainder of the reports are expected to be available during FY2002 subject to the results of detailed planning and scheduling. DOE understands that these reports are required to be provided prior to LA. A list of model validation reports was provided during the technical exchange and is included as an attachment to the meeting summary.</p> <p>5) Provide information on how the increase in the radiation fields due to the criticality event affects the consequence evaluation because of increased radiolysis inside the waste package and at the surfaces of nearby waste packages or demonstrate that the current corrosion and dissolution models encompass the range of chemical conditions and corrosion potentials that would result from this increase in radiolysis. DOE stated that the preliminary assessment (calculation) of radiolysis effects from a criticality event will be available to NRC during February 2001. The final assessment of these conditions will be available to NRC prior to LA.</p> <p>6) Provide a "what-if" analysis to evaluate the impact of an early criticality assuming a waste package failure. DOE stated that it would provide the requested analyses prior to LA. Actual schedule to be provided pending DOE planning process.</p>
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CLST Subissue 5	Effect of In-Package Criticality on Waste Package and Engineered Barrier System Performance (Cont.)		7) Provide sensitivity analyses that will include the most significant probability/consequence criticality scenarios. DOE stated that it would provide the requested analyses prior to LA. Actual schedule to be provided pending DOE planning process.
RT Subissue 4	Nuclear Criticality in the Far Field	Closed-Pending	<p>1) Provide Revision 1 to the Topical Report. DOE will provide the Disposal Criticality Analysis Methodology Topical Report, Revision 01, to NRC during January 2001.</p> <p>2) Provide the updated FEPs database. DOE stated that it would provide the FEPs AMRs and the FEPs database to NRC during January 2001.</p> <p>3) Provide the applicable list of validation reports and their schedules for external criticality. DOE stated that the geochemical model validation reports for "Geochemistry Model Validation Report: Degradation and Release" and "Geochemistry Model Validation Report: Material Accumulation" are expected to be available during 2001. The remainder of the reports are expected to be available during FY2002 subject to the results of detailed planning and scheduling. DOE understands that these reports are required to be provided prior to LA. A list of model validation reports was provided during the technical exchange and is included as an attachment to the meeting summary.</p>

ENFE Subissue 5	Effects of Coupled Thermal-Hydrologic-Chemical Processes on Potential Nuclear Criticality in the Near Field	Closed-Pending	<p>1) Provide Revision 1 to the Topical Report. DOE will provide the Disposal Criticality Analysis Methodology Topical Report, Revision 01, to NRC during January 2001.</p> <p>2) Provide the updated FEPs database. DOE stated that it would provide the FEPs AMRs and the FEPs database to NRC during January 2001.</p> <p>3) Provide the applicable list of validation reports and their schedules for external criticality. DOE stated that the geochemical model validation reports for "Geochemistry Model Validation Report: Degradation and Release" and "Geochemistry Model Validation Report: Material Accumulation" are expected to be available during 2001. The remainder of the reports are expected to be available during FY2002 subject to the results of detailed planning and scheduling. DOE understands that these reports are required to be provided prior to LA. A list of model validation reports was provided during the technical exchange and is included as an attachment to the meeting summary.</p>
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