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COMMENTS FROM TECHNICAL REVIEW OF THE NRC TECHNICAL
POSITION PAPER ON "STAFF TECHNICAL POSITION ON INVESTIGATION TO IDENTIFY
FAULT DISPLACEMENT AND SEISMIC HAZARDS AT A GEOLOGIC REPOSITORY"

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Technical review of the NRC document was conducted by

Renner B. Hofmann
Gerry L. Stirewalt
Stephen S. Young

This Document Assembled by

Renner B. Hofmann
Center for Nuclear Waste Regulatory Analyses
San Antonio, Texas

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Discussion of CNWRA comments:

Comments by reviewers of the STP on fault and seismic investigations (April 1991), have been grouped to the extent possible. The categories are:

- 1. Use of "fault size" rather than some specific measure of faulting.
- 2. Use of the word "deterministic" and "probabilistic" with "investigations".
- 3. Use of "displacement" and "seismicity" as hazards.
- 4. Definition of region boundaries.
- 5. Perceived wording problems and other comments.

Some of the comments are similar to comments CNWRA staff made on an earlier draft STP, "Methods of Investigating the Seismic Hazard at a Geologic Repository" (Revised Internal Review Draft Dated February, 1989) in a letter from John L. Russell (CNWRA) to Michael Blackford (NRC) dated April 24, 1990. Those areas of concern which remain in this version from the earlier one are:

- 1. Lack of a useful definition for "fault size".
- 2. An inadequate description of what is meant by "deterministic" and "probabilistic" investigations.
- 3. An unclear separation of faulting, as a hazard generator by itself, from faulting as a generator of earthquake related hazards. For example, see comments 10, 11, 13 and 17 of CNWRA's April 24, 1990 review.

CATEGORY 1 COMMENTS

COMMENT #1

Statement of Concern --- The use of "fault size" instead of fault length, trace length or other criteria which might include net slip, fault width, fault zone width, structural style or slip history, is thought to be insufficiently precise to be useful in a staff position.

Basis --- Reviewers commented on several parts of the STP in regard to the use of fault size. The term, "fault size" is used as a screening criteria for faults outside the GROA (pg 9, Step 2) and as criteria for determining the degree of hazard, e.g. page 10, Sect. 3.2. Different definitions may be appropriate. "Fault size" is not an accepted term with which to describe faults, e.g. see Bates and Jackson, 1980. Concern was expressed re.:

- pg 7, Sect 3.1.2, bullet 1 No length criteria is provided for faults within the controlled area. Time and funding resources may be limited compared to the number of faults or fractures present - many of which cannot create a hazard which will effect repository performance.

- pgs 7-9, Sect 3.1.2, pp 2
lines 1-4 Fault size does not adequately describe a fault. Net slip and other criteria should be added to 'Step No. 2'.

- pg 9, Step 2, lines 1,3,8,12 Fault size is used in 5 places but no measure or definition is discussed.

- pg 18, discussion of Step 2
pp 1, lines 4-6, 9 Fault size is apparently used as a substitute for fault or trace length in 3 places.

No criteria are given for assessing fault susceptibility for these two applications within the controlled area. If all faults must be investigated, their number becomes very large, such that their investigation could exceed time and funding resources. Only larger faults at some distance could have any effect on the repository by altering regional water tables or through earthquake shaking. Very small faults within the repository cannot create a hazard should they move. Criteria to eliminate faults which are not likely to affect repository performance should be provided to ensure that the public health and safety is protected by focussing investigations on those faults which can possibly affect the repository.

Recommendation --- Distinguish between the meaning of fault size as a screening criteria and as a criteria to determine hazard potential. Replace fault size with trace length as a screening criteria. A list of factors could be referenced for determining the degree to which a fault requiring investigation may affect repository performance. Distinguish, by definition, the difference between faults and fractures in a quantitative manner.

References --- Bates, R. L. and Jackson, J. A. (1980) Glossary of Geology, published by the American Geological Institute

CATEGORY 2 COMMENTS

COMMENT #2

Statement of Concern --- Reviewers understand the difference between deterministic and probabilistic analysis but do not believe that "deterministic approach to investigations" is in sufficiently general use that its intent is clear.

Basis --- Reviewers made comments regarding the use of the terms "deterministic approach to investigations" in this review and in the review of the prior version of this STP. Clearly the meaning of these terms is not understood and is easily confused with the commonly used terms "deterministic analysis " and "probabilistic analysis". Particular reference is made to:

- pg 1, Section 1.1, pp, lines 1-2
- pg iii, Abstract, pp 1, line 7
- pg 4, Sect 2.0, pp 3 and continuation on pg 5 - "due consideration" re. uncertainties implies a probabilistic approach.
- pg 5, Sect 3.0, pp 1, lines 1-3
- pg 7, Sect 7.1.3, bullet 2
- pg 14, PP 2 - also note that the reference, 45 FR 74697, is not included in the reference list in a recognizable manner. -

Recommendations --- Include definitions in the glossary for "deterministic approach to investigations" and "probabilistic approach to investigations". Include 45 FR 74697 in the reference list.

CATEGORY 3 COMMENTS

COMMENT #3

Statement of Concern (Re - pg 1, Sect 1.1, para 1, lines 6-7 and pg 1, title) --- The reference is made to "... faults ... thought to have the ability to generate displacements and earthquakes ...". Should not the concept be reinforced, that these are separate hazards (because displacements without seismic activity can occur as well as displacements with earthquakes), in the text that concerns fault displacement and seismic activity?

Basis --- To avoid potential confusion, perhaps readers of the STP should be made aware early in the document that fault displacement hazards are a separate concern from seismic hazards resulting from fault displacement.

Recommendation --- If this statement of concern is deemed important to clarify, consider a wording change such as "... ability to generate displacements and/or earthquakes ...". Consider slightly changing the title of this STP to "Investigations to Identify Hazards from Fault Displacement and Seismicity at a Geologic Repository".

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References --- None cited by CNWRA reviewers.

CATEGORY 4 COMMENTS

COMMENT #5

Statement of Concern (Re Section 1.0 INTRODUCTION) --- A more precise description of faulting may result in more effective guidance.

Basis --- The STP considers that "fault displacement" and "rates of fault displacement" are the important fault characteristics to be considered in the determination of hazards due to faulting. Displacement is a general term (e.g. see Bates and Jackson) that is typically used to describe apparent relative offset of stratigraphic markers that cross the fault of interest. Slip or net slip are more specific terms which mean total displacement and may convey the intent of the STP more precisely.

Recommendation --- Use the term 'slip' when referring to fault movement or rates of fault movement.

References --- Bates, R. L. and Jackson, J. A. (1980) "Glossary of Geology", American Geological Institute.

COMMENT #6

Statement of Concern (Re - pg 6, Sect 3.1.1, bullet 1) --- The statement is made that region boundaries should be determined "by the nature of the geologic setting", but no real information is provided about guidelines for identification of a region.

Basis --- Some information is needed to provide at least general guidance on definition of the region or regions to be investigated for analysis of hazards related to fault displacement and to seismicity. Determination of the region or regions to be investigated is an important first step in the analysis of these hazards.

Recommendation --- Consider at least cross-referencing Section 4.1.1, which provides general guidelines for identification of the region to be investigated for analysis of these two hazards. Also consider whether or not other guidelines should be provided. See for example the Natural Resources Options Report.

References --- CNWRA Natural Resources Options Report, 1991.

CATEGORY 5 COMMENTS

COMMENT #7

Statement of Concern (Re - pg 8, 1st three lines above Step No 1) --- The statement refers to "faults that meet the criteria ... and need to be characterized in detail and be considered as susceptible ...".

Basis --- A small point, perhaps - but the faults are to be classified as susceptible (by the steps outlined in the STP) and then characterized in detail, rather than the reverse sequence indicated in the referenced statement.

Recommendation --- Consider rewriting the referenced sentence as follows: "Only those faults that meet the criteria described in both Step 1 and Step 2, below, need to be considered as susceptible and characterized in detail."

References --- None cited by CNWRA reviewers.

COMMENT #8

Statement of Concern (Re - pg 11, Sect 3.2, paragraph labeled (2), lines 2-5) --- The direction is given that "if susceptible faults encountered in the underground facility cannot be correlated with surface expressions, then investigations should be performed in accordance with ...".

Basis --- As the referenced statement is written, it may be unclear how the investigations should be acceptably performed if a subsurface fault cannot be correlated with the surface expression of a fault which can be readily investigated. The wording change recommended below would eliminate this potential problem.

Recommendation --- Consider rewording the referenced sentence as follows: "If susceptible faults encountered in the underground facility cannot be correlated with surface expressions of faults which can be or have been analyzed, then investigation of those subsurface faults should be performed in the underground facility in accordance with Item (1) of Section 3.2."

References --- None cited by CNWRA reviewers.

COMMENT #9

Statement of Concern (Re - pg 14, last sentence on page) --- The sentence refers to the "list of technical positions given in Section 3.0".

Basis --- Section 3.0 has a series of headings which this section also follows, and the reference to paralleling a "list of technical positions" seems inaccurate.

Recommendation --- Consider rewording the referenced sentence as follows: "The following discussion parallels the organizational headings used in Section 3.0."

References --- None cited by CNWRA reviewers.

COMMENT #10

Statement of Concern (Re. pg 8, third paragraph from the bottom "(c)") --- Almost any fault orientation, except one in which a fault strike is exactly parallel to the predominant stresses can be argued to cause a fault to be "subject to displacement". Therefore, this criterion is too broad to be used as a screening criterion and is ineffective in reducing the number of faults to be investigated.

Recommendation --- Suggest using wording like that in the first paragraph of page 18 or of Step 1 in figure 2, or establishing a numerical criteria for orientation as is implied by the reference to Rogers and others (1987) in the 1st pp of pg 18.

References --- None cited by CNWRA reviewers.

COMMENT #11

Statement of Concern (Re - pg 1, Sect 1.0, para 1, last line and pg 3, Sect 1.2, para 2, lines 1-4) As currently worded, only design (preclosure) and performance (postclosure) are specified as being potentially directly affected by hazards from fault displacement and vibratory ground motion. Should potential direct effects on design, construction and operations parts of the preclosure period, also be considered?

Basis --- It should be considered whether hazards from fault displacement and seismicity could potentially affect design, construction and operation approaches, methods, or schedules enough to warrant inclusion of "design, construction and operation" in the referenced sentences.

Recommendation --- Consider rewriting the second sentence as follows, and incorporating this one-sentence paragraph into paragraph 1 of the section: "The objective of providing guidance ... to identify ... hazards is to determine, at an early time, the potential for significant future design, construction, operations and/or performance problems so they can be avoided." Rewrite the first sentence to include "design, construction, operations and performance".

References --- None cited by CNWRA reviewers.

COMMENT #12

Statement of Concern (pg 11 and on, Section 3.3) --- There is no requirement for acquiring earthquake data over a large enough area to permit adequate calculation of earthquake recurrence, as is required for shorter lived nuclear power plants, for which a deterministic analysis is required.

Basis --- It is the opinion of this reviewer that an adequate deterministic or probabilistic analysis cannot be made without a regional evaluation of earthquake recurrence. In a broad sense, section 4.1.1 can be considered to cover this topic but, if so, little guidance is given by the STP in this regard.

Recommendation --- Insert --- "The occurrence of instrumentally recorded earthquakes and those which may otherwise be reported in literature, shall be studied and documented in detail within the radius of a circle large enough that an accurate earthquake recurrence can be estimated for the site.

References --- None cited by CNWRA reviewers

COMMENT #13

Statement of Concern (Re - pg 2, Sect 1.1, para 4, lines 1-5) --- Likely there will be general agreement that the guidance in the STP is most applicable for a western site rather than an eastern site. These lines also at least partially explain why this idea is thought to be true. However, there may be some question about the reference to " ... similar activity in areas east ..." based on the logic outlined below.

Basis --- Potential questions, which could arise related to use of the expression "similar activity in areas east", are: Does use of "similar activity" imply that the seismic hazard is similar in the east and west? Does it imply that there is a similar intensity of seismic activity in the east and west? A simple wording modification, presented below, may help avoid such questions.

Recommendation --- Consider changing the expression "... than can similar activity in areas east ..." to "... than can seismic activity in areas east ..." to avoid misconceptions about what is being addressed and any implied comparisons of the east and west regarding similarity of seismic hazards or seismic intensities.

References --- None cited by CNWRA reviewers.

COMMENT #14

Statement of Concern (Re - Figure 2, heading and legend) --- The figure is titled "Hierarchy of ..." and a definition of "geologic setting" is given.

Note: CNWRA has been given two versions of this STP with the same title and date. One version does not have this figure. If the final version does not have this figure, ignore this comment.

Basis --- The figure, simply speaking, presents the components of the geologic setting. Some question may arise concerning whether the definition given for "geologic setting" is the accepted and standard one for the NRC. The second tier of boxes uses the word setting in each box. It appears to imply more than the Part 60 definition intends.

Recommendation --- Consider retitling the figure as follows: "Components of the Geologic Setting".

References --- None cited by CNWRA reviewers.

COMMENT #15

Statement of Concern (Re - pg 6, Sect 3.1.2, section heading; pg 28, Appendix A, glossary) --- This section introduces the concept of "candidate faults" and discusses general criteria for their identification. However, the specific expression "candidate faults" is not used until the first line of Section 3.1.3. Also, the term is not included in the glossary although "susceptible fault" is.

Basis --- The specific expression "candidate faults" should be properly introduced before it is coined in Section 3.1.3, and properly defined in the glossary.

Recommendation --- In parallel with early introduction of the expression "susceptible faults" under Section 3.1.3, consider including the following at the end of the section title: (i.e. - "candidate" faults). Also consider including "candidate fault" in the glossary of Appendix A.

References --- None cited by CNWRA reviewers.

COMMENT #16

Statement of Concern (Re - pg 10, Sect 3.1.4, 1st para, lines 2-4) --- The statement is made that faults eliminated from further consideration early in the evaluations should "periodically be reconsidered" based on results of subsequent activities.

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Basis --- As written, the referenced statement could be construed to indicate that no fault will ever be completely eliminated from concern. This is also implied by the figure entitled "Staff Technical Position 3.1.3: Detail to the "Approach ---". Is this the impression that is meant to be conveyed?

Recommendation --- Consider whether or not this statement might imply an open-ended assessment of which faults may be considered as susceptible, and whether this implication is an acceptable one to the NRC.

References --- None cited by CNWRA reviewers.

COMMENT #17

Statement of Concern (Re - pg 10, Sect 3.2, bullet 1) --- Bullet 1 (Items a through e) outlines an acceptable approach for investigating fault displacement hazards for susceptible faults. There is no statement that addresses what would be considered an acceptable approach if data could not be acquired to adequately analyze all the factors in the listed items.

Basis --- If data were not available to allow certain of the factors to be determined, concerns may arise regarding what acceptable alternatives would exist for analyzing the potential hazards from displacement of a susceptible fault. Would it be possible to set up a worst-case scenario for analyzing hazards from fault displacement?

Recommendation --- Consider what alternative approach would be acceptable for analyzing fault-displacement hazards if adequate data were not available for addressing the factors specified, and provide a statement about this alternative approach, (e.g. the use of analogs) if deemed appropriate.

References --- None cited by CNWRA reviewers.

COMMENT #18

Statement of Concern (pg 17, third paragraph and text continued on page 18) --- Reference to public comments on the draft 10 CFR Part 60. --- The staff interprets Dr. Allen's comments to imply that the entire Quaternary period must be investigated or an investigation has no merit in determining the susceptibility of a fault. Dr. Allen's 1975 comments could be otherwise interpreted as meaning that processes occurring in the Quaternary are much more important in evaluating seismicity (current or during a time period short compared to the Quaternary) than processes occurring in older geologic times.

Basis --- If tectonic processes in the Quaternary changed such that sediments were deposited for only a portion of the Quaternary, those processes should be considered. If Quaternary

sediments are present and are undisturbed, they are indicative that faulting was not active in the Quaternary following their deposition and, therefore, are indicative of Quaternary processes, or the lack of them. Suggest that the staff leave open for their consideration, the use of undisturbed sediments whose age includes most of the Quaternary, but not the entire Quaternary time, as determined from worldwide geologic investigations. If only very early undisturbed Quaternary sediments (not available in the vicinity of Yucca Mountain) are allowed as criteria for non susceptibility, all faults in the vicinity of Yucca Mountain and virtually all of the Basin and Range province, are, by definition, susceptible. Therefore, the use of the term, susceptible, provides no guidance to DOE.

Recommendation --- Replace the sentence with the following --- If the entire Quaternary record is available and undisturbed over a fault, the fault will be considered inactive. If most of the Quaternary record is present and undisturbed over a fault, the NRC staff, may consider this with other evidence, as indicating that the fault is inactive. If pre-Quaternary deposits are undisturbed over a fault, criteria for lack of fault activity will be deemed adequately established under the precepts of this STP.

References --- NRC NUREG-0804 "Staff Analysis of Public Comments on Proposed Rule 10 CFR Part 60. 'Disposal of High-Level Radioactive Wastes in Geologic Repositories' 1983

Allen, C. R. (1975) "Geological Criteria for Evaluating Seismicity", Geological Society of America Bulletin, V. 86, pgs 1041-1057.2