UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 2 1982

MEMORANDUM FOR: F. R. Cook, WMHL/NMSS

FROM: Michael B. McNeil, WM/DHSWM/RES

SUBJECT: BWIP CANSITER CORROSION RESEARCH PLANS AS REFLECTED IN THE SITE CHARACTERIZATION REPORT (SCR)

Thank you for providing me with a copy of the part of the SCR which outlines the research program which DOE contractors hope will supply answers to prove that the BWIP site and waste package will satisfy the requirements of 10 CFR Part 60.

Prediction of most corrosion phenomena over a period of 1000 years cannot be done with the certainty with which (for example) astronomical phenomena can be predicted, because our physical understanding of corrosion processes is deficient (the one exception being where the metal is electrochemically immune under all plausible conditions, which is irrelevant to the HLW container problem). Further, we have very few sources of corrosion data over 100 + year periods, so it is probably not feasible to reproduce conditions under which a sample is known to have survied. We must also bear in mind that both containers (as a result of variations in manufacturing and handling histories) and local conditions (as a result of the inhomogeneity of the site, and possible future drift) must be expected to show considerable scatter. It is thus important that a container not only be reliable under projected conditions, but also that reasonable deviations from these conditions not eliminate the reliability.

In order to justify a claim that a specified container manufactured and sealed by specified techniques will survive 1000 years without radionuclide release, must first of all determine the plausible range of water flow and water chemistry to which the container will be exposed.

There seems to be some disagreement about the water flow situations. Verbal statements have been made that hardly any water is expected at the canister; the test protocol (last paragraph of page 15.3-20, first paragraph of page 15.3-21) envisions the corrosion taking place in stagnant groundwater saturated with corrosion products; and yet discussions of mining techniques and pumping

facilities with NRC staff who are interested in the actual mining suggest that there may be considerable water flow in the repository. Chapter 5 did not settle this issue, at least in my mind.

In order to make a sound and defensible determination that an iron or steel canister can survive 1000 years in the BWIP repository, it is absolutely essential that a very convincing analysis of the water situation be provided, together with a projection of container temperature. In order to judge claims concerning corrosion of canisters, I would expect to have access to a quite detailed projection of the hydrological conditions and temperature at the canister over the 1000 year period, including analysis of how often the water is renewed (presumably this renewal rate will change with time as temperature gradients change). Great care should be taken to minimize the uncertainties in these analyses. Chapter 5 contains very extensive water flow analyses, but I cannot deduce from them answers to questions relating to water at the container.

Another important issue is water chemistry. In order for an applicant to demonstrate that corrosion test results submitted as part of an application have relevance to the issue of container survival, he must demonstrate that they cover (or can plausibly be intepreted to cover) the entire range of probable water chemistry at the container. This issue is addressed in Chapters 5 and 15 of the SCR, but not in great detail. Eh measurements in particular seem not to be given the attention they deserve; the comment on page 5.1-91 on the 1960 results is not helpful. The argument for reducing conditions on page 5.1-118 is not convincing as far as it applies to groundwater.

1. The waste is physically hot at first, so it is reasonable to assume that the first water to come near the waste will evaporate and leave behind any dissolved salts, so that the water which actually contacts the container may have higher concentrations of some ions (e.g., chloride) than the nominal groundwater composition. This issue needs careful analysis, especially since a high chloride concentration is particularly likely to lead to localized corrosion of irons and steels.

2. While the SCR proposed (page 15.3-3) to "determine the extent of Eh-pH and groundwater compositional control," this proposal seems to miss part of the point. The control on groundwater composition may not be by fresh rock surface but by the surfaces of old cracks and cavities which may be quite different chemically. I agree with the SCR that the investigation must be undertaken and feel that it must give NRC a detailed projection of the chemistry of the water at the canister, in which he must have considerable confidence, as otherwise corrosion test results cannot be used to establish that the proposed containers will satisfy the 1000 year criterion. However, I feel that this is a subtler issue than it seems, and that a great deal of attention needs to be paid to <u>how</u> the water chemistry is controlled. The experiments discribed in Chapter 5 relate to fresh surface and thus prejudge this issue.

3. Sandia staff (working for DOE) at the MRS Boston meeting expressed the view that, if the water surrounding projected BWIP containers is stagnant, radiolysis will shift its chemistry to quite an oxidizing region. The SCR should contain an analyses of the projected effect of radiolysis on Eh.

The SCR correctly indicates that uniform corrosion testing is the best screening mechanism. However, the analysis of what is needed in the advanced testing program, as described on page 15.3-4, is a bit vague. The point that does not emerge clearly is that it is practically impossible to predict corrosion rates with any exactness and the best that can be done is to try to bound them. Pitting corrosion is a special problem because it tends to show an incubation time, so projection of long-term rates depends on mechanistic knowledge. [Work at Battelle Columbus Laboratory has shown the difficulty of projecting pitting corrosion data. Work at Brookhaven National Laboratory has revealed fundamental flaws in the former DOE crevice corrosion analysis.] It is not clear from the SCR how this knowledge is to be acquired; I think that something more than collections of test data will be needed in order to make reliable projections, and it is the development of interepretations, not the collection of data, that appears to be omitted from the plans.

I have no complaint about the plans for corrosion research, as far as they go, but more detail would permit the reader to form a clearer picture of what is proposed and to develop a greater degree of confidence in the completeness of the ultimate DOE submission. [The proposed RFP for research on manufacturing high-level waste containers will permit us to evaluate the aspects of the ultimate DOE submission relating to manufacturing technology to corrosion properties.] I believe that in preparing a revised plan for research DOE could profit from examination of the NRC/RES research plan (copy attached).

M B McNeil

Michael B. McNeil
Waste Management Branch
Division of Health, Siting,
and Waste Management, RES

Enclosure: As stated

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C11000 (1)	A) Uniform Corrosion B) Water chemistry and flux,temperature and temperature distribution C) Dissolution of all or part of canister Corrected 12 oct 82 Comments otherwise unattributed are due to M B McNeil, NRC/RES	A) Mean time to canister penetration and minimum likely time to canister penetration. B) A model which projects mean time failure and some measure of scatter in time to failure from accessible data	A) Uniform corrosion rates for cast or wrought steel non-self-shielded containers in tuff, basalt, and salt environments. Data must be collected in a way that ensures that uniform corrosion is the dominant corrosion mechanism and not, for example,pitting corrosion. Data should cover extraclean steels (e.g., from ESR) as well as commercial grades. B) Archaeological data in pure irons (which will not, of course, always be under pure-uniform-corrosion conditions) and short-time corrosion data on cast steels.	Extensive data available on wrought steels, not on cast.Wrought steels being considered by BWIP on a basis of minimizing uniform corrosion will have to be re-examined because of welding problems (conversation with Dr. E. Moore, BWIP). Uniform corrosion is probably not crucial for any reasonable choice of container design and repository.	A) Archaeological data are being assembled under B6467(BCL) and will be correlated with experimental data collected in the same program and with existing NBS data. Uniform corrosion is probably a fairly minor problem in any reasonably designed repository. B)
	A) (Electroslag remelting is referred to in the text as ESR) B) C)	A) B)	A) Uniform corrosion rate data for self-shielded cast steel containers in tuff, basalt, and salt environments. Data must be collected in such a way that uniform corrosion and not (e.g.) pitting corrosion is the dominant corrosion mechanism. Data should include measurements on ultraclean steels	Regarded by DOE as prime choice for salt and basalt environments and for tuff repositories above water table. Uniform corrosion is probably not going to be a very serious problem in these environments.?	A) Covered under B6467(BCL) and B7278(TBD). ? B) Unattributed statements of fact and opinion are due to M.B. McNeil, NRC/RES, who should be consulted for details.

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C11000 (2)			(for example, ESR or VAR steels) as well as more commercial grades.? B) Archaeological data on pure irons and short-term uniform corrosion data on cast steels. Data can not be used directly but must be analyzed in light of probable radiolytic effects.?		
	A) (Vacuum arc remelting is referred to in the text as VAR) B) C)	A) B)	A) Uniform corrosion rate data on spheroidized (nodular) cast iron self-shielded containers in tuff, basalt, and salt environments. Data should be taken in such a way as to ensure that uniform corrosion, not (e.g.) pitting corrosion, is the dominant corrosion mechanism. Data should include measurements on low sulfur irons.? B) Archaeological data will have to be used in connection with short-term experimental data. Analyses of European experience with cast iron as a structural material should be used.?	Regarded by DOE as potential backup, though enthusiasm for self-shielded designs as shown in Westinghouse reports to DOE seems not to be shared by DOE staff. Cheapest self-shielded design. Cast iron offers few fabrication problems, but does present welding problems; closure must be considered carefully.?	A) Will be considered under B6467(BCL) and B7278(TBD). Data probably available from NBS, and probably not significantly different from those for cast steels. 'Graphitization' because of graphite nodules may be a problem.. B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C11000 (3)	A) (Stainless steel referred to as SS) B) C)	A) B)	A) Uniform corrosion rate data on titanium and TiCode 12 in non-self-shielded containers in salt, basalt, and tuff environments. Measurements under radiolytic conditions are important.? B) Short term corrosion data and an understanding of the fundamental electrochemistry, to permit extrapolation.	Regarded by DOE as most promising alternative for tuff below water table. Uniform corrosion is a non-problem for these materials in these environments in absence of radiolytic effects. This conclusion is based on the work of Molecke (Sandia) and others.	A) A3237(BNL) offers coverage. Work may be done under B6467(BCL). Probably a relatively minor worry, per work of Molecke. B)
	A) B) C)	A) B)	A) Uniform corrosion rate data on stainless steel non-self-shielded containers in tuff,basalt, and salt environments. Data must be collected in such a way that uniform corrosion (not, e.g., pitting corrosion) is the dominant mechanism. B) Short-term corrosion data and an understanding of the basic electrochemistry to permit extrapolation over long times.	Stainless steel canisters in titanium overpacks are DOE's first choice for storage in basalt.	A) Uniform corrosion is probably insignificant compared to grain corrosion boundary ~~containers~~ for these containers, which will probably be in a sensitized state because of filling and closing. Stainless steel is anodic with respect to titanium/in most environments, so work on galvanic effects may be required. B)
	A) B)	A) B)	A) Uniform corrosion rate data on 90% Cu 10% Ni non-self-	BWIP staff are convinced that corrosion rates are infinitesimal and regard	A) None B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C11000 (4)	C)		shielded containers. Data must be collected under conditions where uniform corrosion, not (e.g.) pitting corrosion, is the dominant mode. Data need only be collected in environments resembling basalt repositories. B) Geological data on copper (native) in contact with ground waters resembling those in basalt repositories, and short-term tests on alloys.	this as a potential backup to carbon steel non-self-shielded containers in basalt. They are probably correct as far as uniform corrosion is concerned.	

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C12000 (1)	A) Pitting Corrosion B) Water chemistry and flux, temperature, structure and heat treatment of container metal. Presence of inclusions is especially important. C) Penetration of container by pits	A) Determination of whether container is vulnerable to pitting corrosion under projected service conditions. B) Pitting corrosion rate data, critical pitting potential data, other data from which a microscopic understanding of pitting processes can be developed.	A) Pitting corrosion rate data, including scratch tests,a on low carbon cast or wrought steel self-shielded containers in tuff, basalt, and salt environments. Measurements must be made on very clean steels (ESR or VAR) as well as commercial steels. B) Very extensive polarization resistance, pit propagation rate(PPR),and other experimental data must be collected and correlated with archaeological data to obtain predictive models.	DOE is considering this type of container for BWIP. Extensive data exist on wrought steels, but essentially none on cast steels	A) Some work will be done under B6467(BCL) and B7278(TBD). B6467 is looking at a loosely specified inexpensive low carbon cast steel. B) (Pit propagation rate is referred to as PPR)
	A) B) C)	A) B)	A) Pitting corrosion data, including scratch tests, on non-self-shielded cast or wrought low-carbon steel containers in tuff, basalt, and salt environments. Performance data must be collected under radiolytic conditions and an very clean (ESR or VAR) steels. B) PPR, polarization resistance, and other data on self-shielded cast steel	DOE is considering this for containers in salt, basalt, and in tuff above the water table. Unfortunately, practically no experimental data seem to be available on cast steel, though data exist on wrought.	A) Top priority in B6467(BCL) and B7278(TBD). B6467 is considering a loosely specified inexpensive cast steel. B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C12000 (2)			containers (above) must be reinterpreted in connection with radiolytic data to develop models.		
	A) B) C)	A) B)	A) Pitting corrosion rate data, including scratch test data, on spheroidized cast iron self-shielded containers in tuff, basalt, and salt environments. Data should include information on low-sulfur irons. B) PPR, polarization resistance, and other data on spheroidized cast iron. Nature and adherence of oxide films is important.	Potential backup for DOE in all types of repositories. Cheapest self-shielded design and offers minimum casting problems, though welding is a problem. Considerable data probably available.	A) Can be covered under B6467(BCL) and B7278(TBD), but not top priority. Probably little will be done unless DOE priorities change. B)
	A) B) C)	A) B)	A) Pitting corrosion rate data, including scratch test data, on Ti and TiCode 12 non-self-shielded containers in tuff, basalt, and salt environments. Radiolytic conditions are important. B) PPR,polarization resistance, and other measurements must be used to understand pitting kinetics. Radiolytic effects may be important.	DOE/ONWI have been active. Presently the prime candidate for storage in tuff below the water table, so more DOE research can be expected.Ti alloys are supposed to be very resistant to pitting corrosion. Extensive work has been done by Molecke (Sandia) and is planned by Westerman(PNL).	A) Being treated under A3237(BNL). Work may also be done under B6467(BCL). B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C12000 (3)	A) B) C)	A) B)	A) Pitting corrosion data on stainless steel non-self-shielded container-sin tuff repor-sitories. B) Unclear.	May be used in basalt environments in conjunction with Ti overpacks. Indications are the SS containers will be sensitized as placed in repositories and will be almost immediately destroyed by localized corrosion following contact with groundwater. This is reflected by DOE's claiming no protective value for them	A) To be considered under B6467(BCL) B)
	A) B) C)	A) B)	A) Pitting corrosion data on non-self shielded 90% Cu 10% Ni containers in basalt environment. B) Understanding of mechanisms of pitting corrosion in 90% Co 10% Ni alloys in basalt groundwaters.	Backup design for basalt repositories.	A) None B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C13000 (1)	A) Crevice Corrosion B) Water chemistry and flux, temperature C) Penetration of canister	A) Determination of whether canister is vulnerable to crevice corrosion given expected conditions. B) Crevice corrosion potential data and information on mechanisms of crevice corrosion.	A) Crevice corrosion data on low carbon steel cast self-shielded containers in tuff, basalt, and rock salt environments. Data should include measurements on ultraclean (ESR or VAR) steels as well as more conventional grades. B) Archaeological data on pure irons and short-term data on cast steels,especially such data as reveal the chemistry of crevice corrosion.	DOE regards as expensive backup for non-self-shielded cast steel containers.	A) Data on cast steels are not readily available. B6467(BCL) and especially B7278(TBD) will address. B)
	A) B) C)	A) B)	A) Crevice corrosion data on non-self-shielded cast or wrought steel containers in tuff, basalt, and salt environments. Data must include radiolytic effects and include data on extraclean (ESR, VAR) steels as well as more conventional grades. B) Electrochemical measurements on kinetics of crevice corrosion in non-self-shielded cast steel containers, including radiolytic effects.	This is the prime DOE choice for HLW containment in basalt and salt environments, and in tuff environments above the water table. Nonetheless, very few data appear to be available on cast steel containers, though there are data on wrought steels.	A) Top priority under B6467(BCL) and B7278(TBD). B6467 is looking at a loosely defined, inexpensive cast low carbon steel. B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C13000 (2)	A) B) C)	A) B)	A) Crevice corrosion data on nodular (spheroidized) cast iron self-shielded containers in tuff, basalt, and salt environments. Performance data should include information on effect of low sulfur spec. B) Electrochemical data from which the crevice corrosion of spheroidized cast irons can be understood.	At present a backup to DOE's more favored designs. Extensive literature data probably exist.	A) Can be covered under B6467(BCL) and B7278(TBD) B)
	A) B) C)	A) B)	A) Crevice corrosion data on titanium and TiCode 12 non-self-shielded containers for use in tuff, basalt, and salt environments. Measurements under radiolytic conditions are important. B) Electrochemical measurements revealing the chemistry of crevice corrosion in titanium and TiCode 12 and the effects of radiolytic effects on this.	Prime choice for tuff repositories below the water table. Major effort has been undertaken by Molecke at Sandia. Some work may be done in Westerman's group at PNL.	A) Work is proceeding in brines under A3237(BNL), which will also address tuff groundwaters. Coverage also offered under B6467 (BCL). B)
	A) B) C)	A) B)	A) Crevice corrosion data on stainless-steel non-self-shielded containers in basalt repositories, including galvanic ef-	DOE propose to use stainless steel canisters with titanium overpacks in basalt environments. Status of data unknown.	A) B 6467(BCL) will address in particular case of 304L stainless. This seems to be highest priority stainless, but it is not obvious why work need be done. Will be further considered.

INDEX NO.	A) PROCESS B) CONDITIONS AF- FECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMA- TION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSIS- TANCE
1C13000 (3)			fect of stainless steel being in con- tact with titanium while undergoing corrosion. B) Electrochemical experiments giving information on the kinetics of crevice corrosion in stain- less steels. Ex- periments under anodic conditions are relevant, since if SS canisters con- tact groundwater they will be acting as sacrificial anodes for the already-failed Ti overpacks.However, grain boundary at- tack may make all others mechanisms of corrosion negligible in comparison.		B)
	A) B) C)	A) B)	A) Crevice corrosion rate data on non- self-shielded 90%Cu 10% Ni containers in basalt environments, especially with regard to radiolytic effects. B) Electrochemical data indicating mechanisms of crevice corrosion of Cu 90% Ni 10% in basalt environments, and data on effects of radiolysis.	DOE regards as useful backup in basalt. Data on crevice corrosion in absence of radiation probably exist for this or similar alloys.	A) None B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C14000 (1)	A) Stress Corrosion Cracking B) Stress state of canister, alloy structure and heat treatment, water chemistry and flux, temperature. C) Fractures container	A) Whether container is vulnerable to stress corrosion cracking under projected conditions. B) Kc/V curves, slow strain rate data, and an understanding of the basic metallurgy of scc. Kc/V curves depend on exposure time and extensive extrapolations will be necessary.	A) Kc/V curves and slow-strain data for self-shielded cast steel containers in basalt, tuff, and salt environments. Data should be collected on extraclean steels (ESR, VAR) as well as more commercial grades. B) Kc/V curves and slow strain data in appropriate environments.	DOE regards this as a backup. BCL is analyzing availability of data.Steels are believed to be vulnerable in alkali ground waters.	A) B6467(BCL) and B7278(TBD) will cover. B)
	A) B) C)	A) B)	A) Stress corrosion cracking data on cast or wrought steel non-self-shielded containers in basalt, tuff, and salt environments. Data must cover extraclean (ESR,VAR) steels as well as more conventional grades, and take into account radiolytic effects. B) Dependence of Kc on V, slow strain rate data. Some understanding of the metallurgy of scc is crucial since the Kc/V curves must be extrapolated over several orders of magnitude in time.	These containers are DOE's present top choice for basalt and salt environments, as well as for tuff above the water table. Nonetheless, experimental data seem sparse on cast steels, though there are some on wrought steels. Westerman (PNL) is doing extensive work on some wrought alloy steels. A useful model was developed by Henthorne and Parkins (Corrosion Science v6 p357).	A) Top priority under B6467(BCL) and B7278(TBD) B)
	A)	A)	A) Stress corrosion cracking data on	Viewed by DOE as potential backup system. No	A) Could be covered under B6467(BCL). Be-

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C14000 (2)	B) C)	B)	nodular (spheroidized) cast iron self shielded containers in tuff, basalt, and salt environments. B) Kc/V and slow strain rate curves.	known DOE work.	cause of length and cost of experiments, probably little will be done unless DOE priorities change. B)
	A) B) C)	A) B)	A) Stress corrosion cracking data on titanium and TiCode 12 non-self-shielded containers in tuff, basalt, and salt environments. B) Radiolytic effects on Kc/V and slow strain rate effects and on the kinetics reflected in these effects.	Ti alloys are not usually very vulnerable to SCC. Work is ongoing at Sandia (Molecke) and PNL (Westerman).	A) Can be covered under A3237(BNL). Not supposed to be a problem, but radiolysis can cause surprises. B)
	A) B) C)	A) B)	A) Stress corrosion cracking data on 90% Cu 10% Ni alloys in basalt environments. B) An understanding of the basic metallurgy must be derived, especially using Kc/V and slow strain rate data, and used to project scc vulnerability into the remote future. Radiolytic effects must be taken into consideration.	Unknown. DOE regards this as a potential backup for basalt.	A) None B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C15000 (1)	A) Hydrogen Embrittlement B) Structure and heat treatment of alloys, solubility of hydrogen, tendency to form hydrides, radiation field, stress state of canister, water chemistry (especially pH and Eh) C) Fracture of container	A) Whether canister is vulnerable to hydrogen embrittlement. B) Kc, crack growth mechanisms, and strain rate sensitivity. Required extrapolations are great and must be based on an understanding of the mechanisms of SCC.	A) Hydrogen embrittlement data on cast steel self-shielded containers in basalt, salt, and tuff environments. B) Kc, crack growth mechanisms, strain rate sensitivity.	Logan and Yolken (Proc. 2d Intl. Conf. on Metallic Corrosion, NACE, Houston, 1966) reported preliminary investigations. Some work is believed to have been done since in the UK, but all indications are that existing data are all on wrought structures.	A) Will be treated as special case of non-self shielded cast steel containers(below) B)
	A) B) C)	A) B)	A) Hydrogen embrittlement data on non-self-shielded cast and wrought steel containers in tuff, basalt, and salt environments. Not only must conventional radiolytic effects be taken into account, but also the likelihood that (at least in salt) intense gamma fields will cause chemical changes in the environment of the container (specifically, by decomposing NaCl into Cl2 and Na). B) Kc,crack growth kinetics, strain rate sensitivity, and effect of various radiolytic reactions on these.	This type of container is DOE's top choice for salt and basalt, and for tuff above the watertable. Dr. Levy at BNL, under ONWI sponsorship, is looking into radiolytic effects in salt, but in general research on hydrogen embrittlement in cast steels seems fairly limited. Westerman (PNL) is doing relevant work on wrought steels.	A) Top priority under B6467(BCL) and B7278(TBD). Unfortunately, ESR steels seem more than normally vulnerable; use of VAR may be necessary. Totally inadequate data base at present. B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C15000 (2)	A) B) C)	A) B)	A) Hydrogen embrittlement data on nodular (spheroidized) self-shielded cast iron containers in salt, basalt, and tuff environments. B) Kc, crack growth kinetics, strain rate sensitivity	This type of container is a backup for DOE.	A) Can be covered under B6467(BCL) and B7278(TBD). Presently not high priority. B)
	A) B) C)	A) B)	A) Hydrogen embrittlement data in titanium and TiCode 12 non-self-shielded containers in tuff, basalt, and salt environments. Performance data must include the effects of radiolysis not only upon the groundwater, but also (especially in salt) on the backfill. B) Kc, crack growth kinetics, strain rate sensitivity.	Presently top choice by DOE for tuff below the water table. Work is ongoing in the laboratories of Oriani (U Minnesota), Westerman (PNL), Molecke (Sandia).	A) Work is going on under A3237(BNL). B6467(BCL) will also cover. Hydrogen embrittlement is a "killer" in many potential Ti applications, and the combination of Ti and radiolysis over long periods of time is worrisome. B)
	A) B) C)	A) B)	A) Hydrogen embrittlement data on stainless steel non-self-shielded containers in tuff, basalt, and salt environments. B) Kc,crack growth kinetics, strain rate sensitivity.	A likely candidate in basalt, but presence of Ti overpacks will keep stainless steel anodic and interfere with hydrogen pickup.	A) 304L may be examined under B6467(BCL). SS is not usually very vulnerable to hydrogen embrittlement.Hydrogen embrittlement is probably irrelevant compared to grain boundary attack. B)
	A)	A)	A) Hydrogen	DOE regards this as a	A) None. If DOE uses

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C15000 (3)	B) C)	B)	embrittlement of 90% Cu 10% Ni non-self-shielded containers in basalt environments. B) Kc, crack growth kinetics, strain rate sensitivity.	backup for basalt. Cu alloys are not usually thought of as vulnerable to hydrogen embrittlement, but radiolysis might be a factor.	this at least some confirmatory checks will be required. B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C16000 (1)	A) Grain Boundary Corrosion B) Alloy composition and structure, state of stress, water chemistry, temperature. C) Destroys mechanical integrity and leads to rupture of container.	A) Whether containers are subject to grain boundary corrosion under projected conditions. B) Basic metallurgical and electrochemical information on grain boundary corrosion.	A) Grain boundary corrosion rate data on self-shielded cast steel containers in basalt, tuff, and salt environments. B) Not determined	Some work in the UK.	A) BCL is undertaking a review of whaty can be learned from archaeology. B)
	A) B) C)	A) B)	A) Grain boundary corrosion data in cast or wrought steel non-self-shielded containers in basalt, tuff, and salt environments. Data should include work on extraclean (ESR,VAR) steels and under radiative conditions. B) Not known	Some work believed to have been done in the UK. Probably very few data exist for cast (as opposed to wrought) steels.	A) BCL's review of archaeological data may be useful. B)
	A) B) C)	A) B) Grain boundary corrosion data on nodular (spheroidized) cast irons in salt, basalt, and tuff environments in self-shielded container designs.	A) Unknown B) None known	Some data may come from BCL archaeological study.	A) B)
	A) B) C)	A) B) Grain boundary corrosion data on non-self-shielded	A) Unknown B) None known. Probably not a problem, unless Ti metal	None	A) B)

INDEX NO.	A) PROCESS B) CONDITIONS AFFECTING PROCESS RATE C) EFFECT ON SYSTEM PERFORMANCE	A) GENERIC INFORMATION NEEDS FOR LICENSING B) MODELING NEEDS FOR LICENSING	A) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR LICENSING B) SITE AND DESIGN SPECIFIC INFORMATION NEEDS FOR MODELING	STATUS OF DOE, FOREIGN, AND OTHER EFFORTS	A) PRIORITY AND DESCRIPTION OF PROJECTS ADDRESSING ISSUES FOR RESEARCH B) FOR TECHNICAL ASSISTANCE
1C16000 (2)		titanium and TiCode 12 containers in basalt, tuff, and rock salt.	oxidizes its own grain boundaries during hot stage.		
	A) B) C)	A) B) Grain boundary corrosion data on stainless steel non-self-shielded containers in tuff, basalt, and salt environments.	A) Unknown B) Stated DOE intention is to use 304L SS after treatment that should leave it in a sensitized condition. Grain boundary attack on sensitized stainless steels is usually catastrophic in a very short time.	None	A) Literature indicates vulnerability of sensitised SS B)
	A) B) C)	A) B) Grain boundary corrosion in 90% Cu 10% Ni non-self-shielded containers.	A) Unknown. Cahn-Balluffi diffusion may be a factor. B) None known.	If need justifies, may be covered under B6467(BCL)	A) B)