

Hanford Vitrified Low Activity Waste (VLAW) Draft WIR Evaluation 9/16/2021 DOE-NRC Teleconference Summary

By letter dated November 6, 2020 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML20311A546), the Nuclear Regulatory Commission (NRC) issued a Request for Additional Information (RAI) to the Department of Energy (DOE) regarding its Draft Waste Incidental to Reprocessing (WIR) Evaluation for Vitrified Low-Activity Waste Disposed Onsite at the Hanford Site, Washington. The DOE provided its responses to these RAIs by letter dated June 21, 2021 and July 29, 2021 (ADAMS Accession No. ML21194A032 and ML21194A033).

On August 26, 2021 the DOE held a virtual public meeting with its contractors and the NRC to discuss its responses to the NRC RAI. During this meeting, the NRC identified RAI responses that would need further discussion, and as a result, the DOE established multiple public teleconferences to continue these discussions. The teleconference described below was the third of those teleconferences. Call-in information was posted on the DOE Hanford VLAW webpage (<https://www.hanford.gov/page.cfm/VitrifiedLowActivityWaste>) prior to the call.

The following attendance was observed for the teleconference:

- NRC Attendees: David Esh, Karen Pinkston, Maurice Heath
- DOE Attendees: Sherri Ross, Ingrid Milton, Gary Pyles, , Laura Cree, Kearn Lee, Buddy Cunningham, Dana Gribble, Jennifer Colborn, Rodney Skeen, Grace Chen, Randy Arthur, Rainer Senger, Robert Hanson, Dave Swanberg, Robert Andrews, Sean Reaksecker, John Fleming, Jacob Reynolds,
- Public Attendees: R.J. Lyons (Department of Ecology, State of Washington), Dan McDonald (Department of Ecology, State of Washington), Dan Solitz, Marissa Merker, Matthew Campbell, Mason Murphy

Discussion

The RAI responses discussed during this call were 2-6, 2-7, 2-9, and 2-10. These topics were associated with the proposed vitrified glass wasteform. NRC and DOE also discussed a follow-up item from the first call: documentation of the basis for the fraction of ⁹⁹Tc and ¹²⁹I that will be retained in the glass wasteform. A summary of the key points of the discussion is provided below.

Retention of ⁹⁹Tc and ¹²⁹I in glass

The NRC asked a follow-up question with respect to the first teleconference on September 9, 2021 as to when DOE expected to get back to NRC with respect to what documents will be provided for the ¹²⁹I and ⁹⁹Tc single pass retention values as well as the TopSIM generated 96% and 98% recycled retention values. DOE indicated that Laura Cree was working on this item and would follow-up with NRC as soon as practical.

RAI 2-6, Glass Wasteform and Volatile Species Distribution

NRC stated the RAI response indicated that the glass was homogeneous over the length of the pour but did not provide information about the radial dimension or address deposition on the walls or headspace. NRC also requested the reference VSL-11R2260-1.

- DOE indicated that the term “length of the pour” referred to the time of the pour, not the geometry of the glass. DOE stated that in their melter tests, glass is discharged into small containers periodically at a rate of approximately 2 kg/hr, not into full-scale canisters. Therefore, these tests do not provide information about the distribution of volatile species within the glass at production-scale. DOE indicated that the Vitreous State Laboratory (VSL) report referenced is the same as a different report with a River Protection Project (RPP) number that the NRC already has.

NRC referenced the language from the VSL report quoted in the DOE’s RAI response that used the term “majority” twice at the end of the quoted text about the ^{99m}Tc concentrations (e.g., “in the majority of the tests, the concentration of the ^{99m}Tc in the discharged glass increased...”). NRC asked what happened in the other tests that were not in the majority.

- DOE indicated that results from 11 different tests/melter runs were reported. In some cases, the glass pool started out with no Tc present, and the Tc then rose to steady state as a Tc spike in feed was added. In other cases, there was initially some residual Tc in the melt pool, the concentration then increased with a step change as feed spiked with Tc was added, and the concentration then reached steady state. The language about the “majority of the tests” was meant to address how the concentrations approached steady state. NRC asked a follow up question about whether DOE observed buildup in all cases and DOE indicated that they did. DOE said that all of the datasets are in the referenced report.

NRC asked about the statement in the response: “The container is maintained under active ventilation as it is being filled and for several hours after filling”. NRC asked where the gas and volatile materials go and what this ventilation is connected to.

- DOE indicated that the gas goes to the primary off-gas system. In response to a follow-up question, DOE indicated they were not sure of the details of the off-gas routing and the differential pressure in the system, but the off-gas system has a sealed connection to the container, and it pulls continuous suction on the head space. DOE said that the details are provided in a Duratek report that has been cleared for public release and would be provided to the NRC.

NRC asked about deposition of volatile species on walls. NRC indicated that the Soret effect, diffusion under a temperature gradient, may result in migration of volatile species during cooling. NRC asked if DOE ever sampled the walls or measured the radial distribution of a volatile contaminant in a full-scale glass canister. NRC also asked about text at the bottom of page 69 of the RAI response that implied that the walls should be hotter than the centerline, which conflicted with the text on page 70 that indicated the centerline temperature would be much higher. Traditional heat transfer should dictate a higher centerline temperature than wall temperature.

- DOE indicated that some of this work has been done for Defense Waste Processing Facility (DWPF) glass and they were not sure if West Valley had also done similar work. DOE said they would provide the DWPF report(s) to the NRC. DOE stated that some work was also done at DWPF on the deposition of volatile salts on the container wall, but this research was done under different enough conditions that DOE did not consider it to be useful to address the NRC's question. DOE indicated that research on the deposition of Tc had not been done because there is no good surrogate for Tc volatility. DOE noted that the usual surrogate for Tc, rhenium, does not represent its volatility well. DOE also said that running tests with ⁹⁹Tc is too difficult and too expensive.
- DOE indicated the statements in the RAI response were intended to be more qualitative than quantitative. DOE said that they know that the walls will be hot, and that while they may not be as hot as the centerline temperature, the walls are still not a cold surface. DOE said that they expect that the walls will be at a warm enough temperature where it is unexpected for there to be condensation. DOE stated it is their expectation that there is a low probability that volatile contaminants would plate out on wall given the expected temperature and the presence of the ventilation system. DOE indicated that wall temperatures have been measured during testing of the glass pour process and that this information would be in the previously mentioned Duratek report. DOE noted that a variety of uncertainties impact DOE's understanding, including the presence of active ventilation and a lack of information on the Tc species present and their volatility.
- DOE took an action to send the NRC the DWPF report numbers.

NRC indicated they have many questions on this RAI response, not because of the quality of the response, but because it could be highly risk significant. NRC said that even if only 1% of the volatile radionuclides end up on the walls or in the headspace, this would still represent a lot of material that is available for release when canister corrodes. NRC noted that DOE's nominal fractional release rates are on the order of 1×10^{-7} to 1×10^{-8} . NRC further noted that the cooling process of glass will have possibly competing processes that might affect the performance in different directions. For example, if the glass is cooled quickly it cracks, whereas if it is cooled slowly it can crystallize. The cooling process may also impact the distribution of volatile species.

NRC asked if the data in Figure 2-6-1 of the RAI response were measurements taken for molten glass.

- DOE indicated that the glass samples were solid samples from glass discharged from the melter and that the dip samples were from molten glass.

NRC commented about the experimental result where glass was heated to represent a fire scenario and cesium volatilized into the head space of the canister. In the RAI response, DOE had indicated the fractional release was only 1×10^{-6} , which NRC noted could be up to 100 times larger than the calculated fractional release rates. NRC also asked about language on page 71 of the RAI response document which mentioned the retention of less volatile forms of Tc in glass and asked whether the retention of the less volatile forms is due to recycle or due to its form.

- DOE indicated that the observed retention is due to both the use of recycle and the form of the technetium. DOE said that they estimate the amount of reductant to add to the feed and have observed numerous instances where the amount of reductant, and resulting change to the chemical composition, has a very strong relationship with the amount of Tc that gets incorporated in glass. DOE said that the form of Tc has not been characterized in glass, but the fact that it gets incorporated indicates that it is not volatile.

NRC discussed the text on page 73 of the RAI response that indicated that the addition of a reductant reduces volatilization and increases the single pass efficiency. NRC asked about the extent of the increase in the efficiency and asked to confirm that the increase in efficiency is on the order of approximately 30% to a value of around 60% and not an increase from <50% to >90%.

- DOE indicated that is correct.

NRC asked a variety of questions about the potential for formation of sulfate phases on top of the glass melt. NRC noted that DOE's strategy was to implement controls to avoid formation of the sulfate phases, but in report RPP-54130 the unexpected formation of sulfate phases in some tests was described. NRC asked why the assumed performance of an engineered control would take precedence over an actual observation.

- DOE responded that in at least one of the runs, the higher-than-expected sulfate was related to a synergistic effect with chloride that was not previously understood. DOE said that their understanding of sulfate solubility and volatilization has evolved and that their engineering controls now account for chloride having an effect. DOE said that when predicting the incorporation of sulfate into glass, they first estimate the volatility and the amount that will be recycling through the system. If more sulfate goes through the recycling and comes back into the feed, the concentration of sulfate in the feed will increase, which could cause the sulfate to hit the solubility limit. If the concentration of sulfate in the feed increases, engineering controls may need to be adjusted to ensure that the sulfate remains below its solubility limit. DOE indicated that sulfate will be measured in the feed vessel and in the concentrate from the evaporator to check for unexpected build up. DOE said that when developing process correlations, researchers at the VSL at Catholic University used simulated waste feed to identify sulfate solubility limits.

NRC asked how well the sulfate concentrations are known throughout the tank farms and what the variability in its concentration is.

- DOE stated that tanks AZ-101 and AZ-102 contain some of the highest sulfate waste and that this waste came from the last Purex campaigns in the 1980s. The waste feeds from those tanks are systematically being blended down to lower concentrations such that high sulfate concentrations in the feed are less of an issue now.

NRC inquired if the glass corrosion testing data included the presence of V_2O_5 .

- DOE indicated that variations have been tested that have included V_2O_5 .

NRC asked if a sulfate layer forms and the melter fails, what would happen to that layer. If the melter has to be replaced due to wear or operations end, what happens?

- DOE stated that they would not want that to occur during or after operations. However, the response to a floating sulfate layer, if it occurs, is to start feeding water into the melter and volatilize off the sulfate and capture it in the off-gas system. DOE said that they could also feed glass former into the melter to make less concentrated glass that could incorporate the sulfate phase. DOE's goal is to avoid the sulfate phase if possible because it is extremely corrosive and could rapidly damage the melter.
- DOE took an action to provide references RPP-PLAN-60520 and VSL-07R1230-1.

RAI 2-7 (Glass Wasteform Fractional Release Rates)

NRC observed that on page 80 of the RAI response document DOE made an argument that the Temkin coefficient should be 1 by theory, but it sounds like the value of this coefficient is uncertain. The NRC asked what the implications are if this coefficient is not equal to 1. NRC also requested reference VSL-20R4820-1.

- DOE replied the Temkin coefficient mathematically affects the chemical affinity term in the dissolution expression. DOE said that if the Temkin coefficient is different than one, it should not be much less than one. DOE said that they reviewed the references and concluded that the Temkin coefficient would be applicable for other materials, such as geologic materials. DOE noted that there is uncertainty in many other parameters affecting the rate law that might have a stronger influence than the Temkin coefficient. Early experiments at PNNL attempted to measure the Temkin coefficient but found that test data could not distinguish between the effects of K_g and the effects of the Temkin coefficient. Hence, in the chemical affinity term the theoretical value of 1.0 is used for the Temkin coefficient and variation is explained by K_g . DOE is working on developing more information in this area as part of the performance assessment (PA) maintenance process. The reference requested is under revision and will be provided.
- DOE provided a public webpage for reference VSL-20R4820-1, <https://www.osti.gov/servlets/purl/1784560>

NRC noted that a number of DOE's responses refer to the PA maintenance program and asked if there is a mechanism for NRC to be alerted to products produced as part of the PA maintenance program even if NRC does not have a formal review capacity for the product.

- DOE stated they could look into how to provide notification.

NRC indicated the text at the top of page 81 of the RAI response on the formation of secondary minerals is very good, but it was not clear what these results mean in terms of the predictive ability of the models. NRC noted that a calibration is not a validation. NRC further noted that there are other silicon phases that could be used in the modeling and the use of these phases could produce different results. NRC said that the work being done on the secondary mineral reaction networks is very good, but there seems to be a bit of a technical gap between the model results and the observed minerals.

- DOE responded that the challenge is that the secondary phases that develop thermodynamically drive the feedback mechanisms. DOE said that in the process of transitioning from amorphous to crystalline material, there is an intermediate amorphous phase, which is represented by chalcedony in their models. DOE indicated that chalcedony was chosen after reviewing available mineral data and assessing simulated dissolution results against over one hundred sets of laboratory dissolution tests. Chalcedony was observed to be a good representative phase because it is a silicon phase, is representative of other silicon phases, and it is the best representation to explain the experimental observations. However, this is a work in progress and DOE is continuing to investigate what the phases would be as the glass evolves.

NRC noted that on page 81 of the RAI response DOE had a section on the efforts to bound uncertainty in the 2017 Integrated Disposal Facility (IDF) PA. NRC asked if the section was a restatement of the results in the IDF PA or a new analysis. The NRC also noted that the word “capability” is used three times in the response to describe different capabilities of the system model. The NRC asked if those capabilities were used in DOE’s calculations.

- DOE responded that this section summarized what was done in the PA. DOE also said that the system model used for uncertainty analysis in the PA included the capabilities described in the RAI response, but only one glass type was analyzed, Envelope A (LAW A44). DOE indicated that the ranges of fractional release rates described on page 82 of the RAI response are for a variety of glass types whereas what was done in the PA analysis was only for Envelope A.

NRC asked if DOE has verified the actual performance of full-scale produced glass. NRC further asked if any of the other DOE facilities that make glass use recycle as DOE plans to at Hanford. If so, do those facilities have the same variability in the non-radiological components of the waste) that Hanford does? NRC asked what minor species (non-radiological) are expected to build-up in the recycle process along with Tc and I.

- DOE stated that the DWPF uses recycle, but the recycle system at DWPF is a larger loop. At DWPF, the condensate goes back to the tank farm and gets incorporated into other feeds. DOE indicated that the point about waste variability is well-taken. DOE said that components of the waste that are important for glass performance are things that could affect the melter, such as sulfate, which would result in lower waste loading. Other components that could affect the glass include the amount of sodium, nitrate, nitrite, and chromium. DOE said that in the LAW waste feed there is a lot of sodium, nitrate, and nitrite, but the nitrate/nitrite gets converted and released to the off-gas system. DOE said that they consider how much sodium can be added to glass without affecting its performance. For high sodium glass, there are ways to improve its performance, such as adding in tin oxide.
- DOE said that Product Consistency Tests (PCT) and Vapor Hydration Tests (VHT) can be used to help determine the durability of the glass. The VHT test is accelerated and is an indicator of long-term durability. DOE noted that they use a variety of flow through and coupon tests to evaluate glass durability.

NRC stated that there are some other chemical components in tank waste that will follow along the same path as Tc and I and could build-up in the recycle system. If laboratory testing does not have these components present or if the laboratory testing did not use an equivalent recycle system, then the laboratory testing might not reflect the actual conditions and there will be uncertainty in the performance of the glass product.

- DOE responded that most other volatile species, such as the halides, were not considered in some of the laboratory tests because they are expected to be present in the glass only at low concentrations. DOE indicated that there could be a fair amount of chromium. DOE said that they try to account for recycle as much as possible in the laboratory tests that are performed. The melter tests do not typically have off-gas concentrate recycle, but a representative composition of the recycle stream is added to the feed to represent what would occur with recycle. DOE indicated that the DM-10 test melter system includes many of the offgas system components and can be used to evaluate recycle.

NRC asked if what DOE is relying on at Hanford in terms of glass performance is the same as that used at West Valley and the Savannah River Site (i.e., no testing of glass produced at full-scale outside of developing specifications prior to making glass).

- DOE indicated that at West Valley and DWPF product control is realized by controlling the composition of the feed. DOE stated that the process is easier at those sites because they do not have direct recycle. At West Valley, a shard sample was taken from the top of each container and archived so it could be analyzed later if necessary. At DWPF, a glass pour stream sample from each batch of sludge processed was taken and archived for the same purpose. DOE said that they wanted to be able to go back and analyze these samples if they had a “non-conforming container” for HLW disposal.

NRC indicated that the principal component analysis approach to uncertainty described in the RAI response looks like it is a favorable change. On page 86 of the RAI response, two out of the three parameters were already modeled as uncertain (though not correlated). NRC asked about whether the third parameter shown, *riex*, was also uncertain. In addition, NRC asked how DOE knows that the alternate method described on page 89 is valid.

- DOE stated that ion exchange is added arithmetically (appended) to the rate law to represent a phenomenon that they know exists but is not captured in the original form of the rate law. DOE said that researchers have recognized that it is not insignificant and that researchers are considering changing the form of the expression to recognize that ion exchange is not a constant but is a process with dependence on time, pH, and temperature. If the ion exchange process was purely diffusion-based, then it would depend on time^{1/2}. DOE indicated that research in this area is ongoing. DOE noted that the pH has a feedback effect on the dissolution rate. DOE thinks that having used a constant rate in previous analyses has been conservative (estimated a higher dissolution rate than will actually occur). DOE said the ion exchange rate should continue to slow over time.
- DOE indicated that the ion exchange rates were extracted from tests and a constant value was chosen. Though sufficient, this approach is not really consistent with ion exchange theory. Pulse flow testing has been performed for 10 glasses and DOE is working on results for 4 others. Those tests are designed to understand the time, pH,

and temperature dependence of ion exchange. In those tests, DOE exposes glass and measures the ion exchange rate (sodium release vs. bulk glass corrosion) at numerous time points and fits the data to an expression like the one on the upper half of page 89 of the RAI response. DOE said that they are observing a response as they would predict for a time dependent process.

NRC asked a follow-up question about the expression with respect to the initial hydronium and the alpha exponent. NRC thought there was an argument to not co-locate DFLAW glass with cementitious wasteforms because glass performance was sensitive to alkalinity/high pH.

- DOE indicated that glass release does have a pH dependence. In the solution contacting the glass, the pH is very important to how much silica can dissolve. If a lot of silica can dissolve, then a feedback mechanism exists for dissolution of glass. At a pH of 11 to 12, there is a strong feedback mechanism for the glass to rapidly dissolve. Without co-location with other waste (i.e., grout), DOE would never expect to have these pH values at IDF. DOE said that for this reason they would not want to co-dispose these wasteforms. DOE noted that their lysimeter tests will be useful to understanding how large the zone of influence is in terms of one type of wasteform impacting another. DOE said that they can use that information to determine how much separation of the wasteforms is needed to avoid these conditions. DOE indicated that the pH mentioned by the NRC is not an initial pH but rather is a reference pH.

NRC commented that the lysimeter work and secondary mineral reaction network work is very strong and should give DOE a lot of information to verify the assumptions they are using in PA. NRC noted that there are a lot of uncertainties in this complex problem. The NRC thinks that the DOE scientists recognize the uncertainties and NRC acknowledges DOE for supporting the scientists in these activities.

RAI 2-9 (Glass Stage III)

NRC stated that DOE asserts that the system will be open (in the RAI response), but to its knowledge no measurements have been made to support this assertion.

- DOE indicated that this question, in part, gets back to questions about how to design laboratory tests to mimic conditions that the wasteforms will see in the actual environment. Traditionally, DOE has used closed system tests (e.g., PCT) that are accelerated to identify the worst case for glass corrosion. Then DOE progressed to using single pass flow through tests. These tests are open system tests that mimic feedback effects of the solution contacting the glass. DOE said that they tried to look at a range of conditions in their tests (e.g., open vs. closed systems). As far as how it translates into conditions in PA in near field, this is an unknown, but the modeling has all the knobs to turn to see what happens as conditions change. To the extent the system is more closed vs. open, or more open after the engineered cap may fail, they believe they have collected appropriate data to understand the impact on performance of variation in parameters in the rate law.

NRC asked what is the nature of an open versus closed system that drives the formation of zeolites and the performance of the system. The NRC said that it is not sure that the information generated by the modeling for flow and transport, such as liquid saturations and darcy flux, is the same as the information needed to predict the formation of zeolites. For example, is a reaction path calculation needed to determine the composition of fluid and gas contacting the glass?

- DOE indicated this is a complex question. DOE said that they understand the moisture and pH conditions at the interface of the glass system. If components in solution near the glass favor formation of zeolites, then zeolites could form, leading to Stage III behavior. DOE indicated that the cause of zeolite formation has not yet been fully determined. DOE said that zeolite formation has to do with thermodynamics and chemistry and that zeolites have been observed to form in super saturated systems and higher temperatures. DOE said that modeling the formation of zeolites in the disposal system would require an understanding of the pertinent kinetics and thermodynamics and also how the soil gas in the system behaves. DOE indicated that if they do see Stage III forming, they expect that it would be at lower end of the glass stacks where the solutions near the glass would be more concentration. DOE's current approach is to look more into how and why formation of zeolites may occur. DOE said that the approach in past years had been to answer "what if" questions regarding the formation of Stage III, such as whether the formation of Stage III would cause a problem with the groundwater concentrations of contaminants. DOE is finalizing a report on experiments with seeded zeolite tests in closed systems. The data will be evaluated in the PA maintenance process.

NRC stated that the testing that DOE is doing on Stage III is great, but it was not clear how DOE would use the results. For example, a factor of 10 to 100 increase is probably significant from a performance standpoint. NRC noted that the zeolite seeding experiments are missing the probability component of the risk triplet. NRC stated that DOE has a large and complicated multi-dimensional space to investigate with respect to formation of zeolites. NRC commented that perhaps DOE should consider designing the system to be open if zeolite formation is a detriment to performance.

- DOE stated that they were concerned that the seeded tests would not provide information on nucleation, which is another aspect that is important. DOE used the seeded tests because they wanted to force zeolite formation to occur to see how zeolite formation affects the corrosion rates. DOE indicated that zeolite formation does occur rapidly at higher temperatures but is slower at lower temperatures. Some of the glasses tested showed no increase in corrosion rates with zeolite present, which DOE said was very encouraging. DOE said that they want to understand what the composition variables are that are allowing that to be the case. DOE indicated that designing the system to be open was an interesting point.

RAI 2-10 (Volatile Species and Glass)

NRC asked if the off-gas system is redundant and if it will have 100% up time (reliability)?

- DOE indicated that the off-gas system must be running when they are making glass. If there are any problems with the off-gas system, DOE said that they would have to stop making glass. The off-gas system is not a redundant system, but the majority of system is designed to be online all of the time.

NRC commented on page 116 of the RAI response. NRC indicated that it is highly uncertain to translate the small-scale results to the production scale. The revised inventory partitioning between glass and secondary wastes does not appear to reflect this uncertainty. NRC said that this was initially the biggest source of uncertainty in the 2017 PA, but the fractionation of Tc and I between glass and secondary solid waste has now been fixed at 98% and 96%. NRC asked if there is a zero percent chance the actual values are less than this. NRC asked how they were to interpret the approach DOE was taking and indicated that they wanted to understand the basis for the revised approach.

- DOE said that the higher percentages are based on flow sheet calculations. DOE noted that some of the details of these calculations are provided in VSL-13-R-2800-1 and DOE committed to making sure that NRC has this report. Otherwise, DOE will provide follow-up information on this topic when the relevant staff are available. DOE indicated that the percentages used are their latest and best estimate, but there is uncertainty because they have not operated the facility yet.

NRC asked about rinses of the WESP and the evaporator head space, such as what are they rinsed with and where does this rinse go. NRC also requested reference VSL-16R3840-1.

- DOE stated the WESP is rinsed into the vessel and this rinse goes into the recycle system. The rinsed material goes into the separators and then back into the evaporators of the recycle loop. Both systems are rinsed with demineralized water.

NRC asked similar questions about page 118 of the RAI response document. How does the flush work? What is the system flushed with? How often is it flushed? Does the system have to be down in order to flush it? What about at the end of processing? NRC noted that at the end of the mission the opposite of the beginning of a cycle should occur, with Tc continuing to volatilize into the recycle loop in an exponentially decreasing manner.

- DOE indicated that most of the lines have flush capability and flush back into the SBS vessel. DOE plans to flush those lines when they do a melter change out. DOE indicated that they have done a lot of thinking about how to manage the system at the end of the mission. DOE said that they will need to identify the concentrations of Tc that are safe to leave in the off-gas system. If that system can be disposed as secondary waste, then managing it is much simpler. DOE said that feeding cold (non-radioactive) glass into the system is a good way to handle this issue and remove Tc from the system. DOE noted that there will always be some contamination in the system, but the question is how clean is clean enough and how to show that what is left is acceptable.