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Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor

Comment On: NRC-2013-0136-0002
Draft Reports; Availability: Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor

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General Comment

July 31, 2013
Cindy Bladey
Chief, Rules, Announcements, and Directives Branch (RADB)
Office of Administration, Mail Stop: TWB-05-B01M
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Ms. Bladey:

Please accept the following comments on the NRC Spent Fuel Pool Study.

Sincerely,
Mark Kelly
Mark.kellyzr2013@gmail.com
See attached file(s)

Attachments

Comments on the NRC Draft Study Consequence Study 7-13 Mark Kelly

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Comments on the NRC Draft Study " Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor "

Mark Kelly July 31, 2013

The NRC Draft Study " Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor " fails in many respects to adequately examine the risks and consequences of spent fuel pool accidents that could occur. The study does not appear to realistically inform decision makers about whether or not "the NRC should require the expedited transfer of spent fuel from pools to dry cask storage containers" in the interest of safety.

Problems undermining the NRC Draft study concern NRC practices regarding technical information.

1) NRC relies on technical information from the nuclear industry, which sometimes fails to meet scientific standards necessary for studies to reliably inform decision makers. The NRC relied heavily upon industry data for the study. The NRC has failed to require the nuclear industry to maintain technical information on nuclear fuel rod cladding alloys and other materials.

2) The NRC draft study depends on information that was generated using MELCOR in inappropriate ways. Even with input of reliable data, MELCOR produces accurate projections for systems only under circumstances and conditions that are understood and modeled well by the program. The NRC descriptions of its use of MELCOR indicate that the NRC attempted to use MELCOR to predict outcomes under circumstances and conditions that are beyond its current capabilities. MELCOR may be the best currently-available program for this type of study, but MELCOR capabilities don't appear to be up to performance standards required for this type of NRC study of accidents.

3) The draft NRC report relies excessively on NUREGs and other information sources which themselves rely on information that may not have been adequately maintained. The NRC could be producing a report built on a foundation of sand to the extent that NUREGS and other NRC information sources are suspect.

The NRC draft report is information. Generation of reliable information is a central task of an agency like the NRC. Reports and other information generated by the NRC must meet the highest scientific standards if those reports are intended to inform decision-makers. NRC problems with information [1-4] that appear to undermine the report are described in more detail below.

1) NRC has relied excessively on industry information after failing to require the nuclear industry to maintain technical information which meets scientific standards necessary for studies to inform decision makers.

The NRC report correctly identifies zirconium fuel cladding failures as key events which transform accidents. Once cladding temperature exceeds the "gap release criteria", the model assumes release of radioisotopes. Release of radioisotopes transforms relatively contained accidents into serious accidents with widespread consequences.

The NRC draft study assumes that fuel cladding is composed of Zircaloy 2 or Zircaloy 4. This indicates that the NRC set cladding failure criteria in the MELCOR model based on the materials properties of these alloys.

Although the NRC study describes the generation of explosive hydrogen gas from zirconium reactions with coolant, formation of zirconium hydrides which embrittle zirconium alloys (thereby mechanically weakening cladding)* and which are more reactive with oxygen (thereby making cladding more susceptible to highly energetic oxidation reactions and failures, especially cladding that is cracked and mechanically weakened) are not described by the NRC study[5,6]. These reactions would be highly dependent on conditions in spent fuel pools. It is not clear if and how the MELCOR program addresses the roles of zirconium hydride formation in cladding failures and fires.

The NRC appears to rely to a significant extent on industry as a source for Zircaloy 2 and Zircaloy 4 cladding application and properties information. As described below, there is a well documented history of NRC tolerance of bad QA and distribution of inaccurate Zircaloy-4 and other zirconium alloy information in the nuclear industry.[1-4] Therefore, the NRC tolerance of distribution of inaccurate fuel rod cladding information compromises the draft study and some results that were obtained using MELCOR model, particularly those results indicating that cladding would or would not fail. The incidents involving inaccurate zirconium cladding information are described in some detail below in order to demonstrate how the credibility of the NRC draft study on spent fuel pool accidents is undermined by tolerance of inaccurate technical information and other suspect NRC information practices.

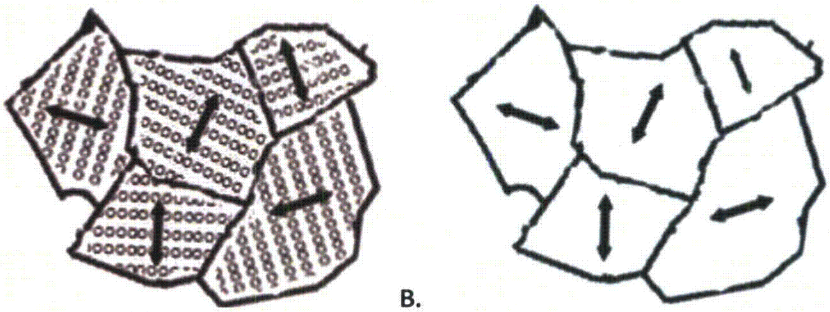
In one well documented incident, the NRC was notified that a nuclear industry supplier had repeatedly provided inaccurate technical information on zirconium nuclear fuel rod cladding properties to the nuclear industry. As an NRC report on the subject stated about the errors in reports on Zircaloy-4 and other alloy properties, the nuclear supplier "produced pole figures on several occasions which were indicative of a 90-degree specimen rotation problem". (Source: NRC Allegation NRR-1999-A-0057 Concerns 1 thru 3.1 Texture Analysis of Zirconium Alloy.[1] A copy is reproduced in the Appendix below.)

The property inaccurately described in the pole figures and in the reports is zirconium alloy crystallographic texture. Texture indicates crystallites are oriented within the alloy. Many scientific studies demonstrate that texture can determine how zirconium components can corrode*, become brittle, change dimensions (ie, warp)*, weaken*, and degrade when exposed to conditions like those that could occur in a nuclear reactor or spent fuel pool (SFP), especially in the course of a nuclear accident. Fuel rod cladding with inappropriate textures that have been weakened by use in a nuclear reactor can continue to weaken after removal from the core[5]. Cladding can fail and release radionuclides when spent fuel rods are stressed in SFPs and during handling[5].

Although texture is an unfamiliar property to many, it is a significant property of zirconium alloys. Most zirconium cladding alloys are processed to have hexagonal crystal structures. Therefore, important properties such as strengths, interstitial transport of hydrogen, and hydride precipitate orientations and distributions depend more on crystallite directions in zirconium alloys than in other alloys whose crystal structures have higher symmetries. Zirconium components with high degrees of alignments of crystals can be thought of as having alignments of "weak links" and "strong links" in different directions. Texture describes distributions of crystallographic alignments within zirconium components. (Figure 1.) Components composed of highly aligned crystallite are said to have a high degree of texture. Components with high degrees of texture can be thought of as having alignments of "weak links" and "strong links" in different directions. Texture indicates susceptibilities of components to failure when stressed along different directions. Because "weak links" cause component degradation and failures, studies usually focus on how inappropriate texture can cause component failures.

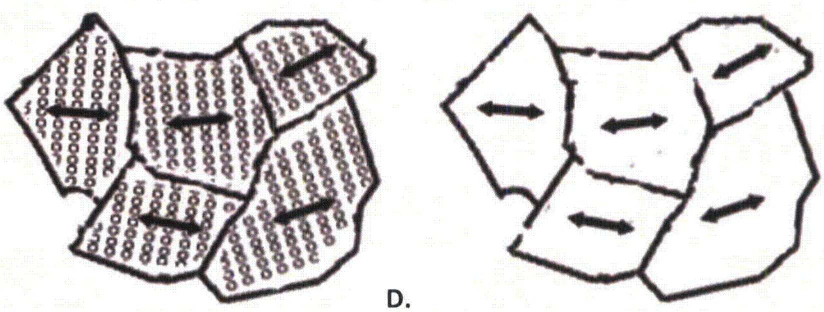
FIGURE 1. Texture in Polycrystalline Zirconium Alloys.

Alloy With Less Texture (Crystallites' alignments shown by arrows are more random. Weak directions of crystallites, indicated by arrows, are randomly oriented. "Weak links" are not frequently well aligned.)



A. B.

More Alloy Texture (Crystallites' alignments shown by arrows are less random. Weak directions of crystallites tend to be oriented sideways. Forces aligned with weak directions might be more likely to cause failures.)



C. D.

Figure 1 (Caption). Texture in Polycrystalline Zirconium Alloy . Atomic arrangements within grains and relative orientations of those grains can determine alloy strengths and weaknesses. [More technical description. Simplified 2-dimensional representations of a five-grain alloy sample with low texture (A and B) and an alloy sample with much higher texture (C and D) are shown. Arrows indicate crystallographic directions. O's were used to represent the atoms in A and C in order to indicate possible arrangements of atoms lying in alternating "basil planes" of individual hexagonal crystallites. The figures are not drawn to scale-- grains sizes are typically on the order of microns, while atoms are much smaller. The O's are removed in B and D to simplify the diagrams- their textures are the same as those indicated in A and C respectively . Individual grains in each of the two groups of five adjacent irregular crystallites were drawn with the same shapes and sizes in the figures in order to emphasize that texture is independent of crystallite shapes and sizes. In real alloys, three dimensional grain shapes, sizes, and orientations exhibit wide variations and rarely appear to be identical. Note that in the highly textured groups of grains shown in C and D, the arrows (or "weaker" crystallographic directions) roughly line up horizontally in the group of grains, indicating a high degree of texture. Susceptible sites in textured samples like that show in C and D are often more likely to degrade because weaknesses can fail synergistically or to link up to initiate or propagate cracks or other flaws. Distortion of part dimensions[12,14] (which can impede insertion of control rods) and formation of brittle hydride growth[5] (which lead to cracks that allow radioisotopes to leak into cooling water) are examples of alloy failures that can be caused by inappropriate component textures. Note that while sorting out the details of texture can be complex and that a single specimen can have multiple textures, in the final analysis, texture simply amounts to how the atoms are arranged. In components with strong texture, "weak links" can be more likely to line up and act in concert to cause failures. High energies in systems like nuclear cores can cause changes in texture that depend on "as manufactured" component texture.[*] Inaccurate texture information can produce inaccurate understandings of deterioration of alloy properties and can hinder optimization of materials properties. Appropriate texture can improve component performance under some circumstances. Note that, for alloys composed of hexagonal zirconium phases, alloy texture is often far more important for component designs than for cubic alloys. (Alloy microstructure is somewhat more complex than explained here. For example, zirconium alloys can form higher symmetry cubic phases. Transitions between the low temperature hexagonal zirconium phases and the higher temperature cubic zirconium phases can occur at significant rates and thereby alter texture within the temperature regime of a nuclear core, especially during an accident. See Tenckhoff [9] for a more sophisticated description of texture in zirconium alloys.)]

Texture can be considered as being an indicator of whether or not the alloy has a high degree of alignment of "weak links" in the alloy. Components should be designed with appropriate textures that ensure that alloys "weak links" are appropriately aligned or distributed to that the component is strong in the right directions and not weak in the wrong directions. Practically, producing optimal designs can be complicated. However, many studies indicate that texture properties play critical roles in how zirconium alloy components perform, degrade, and break.

Understanding directional strengths and weaknesses are particularly important in understanding the degradation of long, thin alloy components such as nuclear fuel rod cladding that will be subject to nonuniform direction stresses, chemical condtions, and radiation fields. Maintaining intact fuel rod cladding (which is usually composed of zirconium alloys) is critical to prevent release of radionuclides. Fuel rod cladding is usually a long thin tube welded shut to contain fuel and fission products. Texture affects properties of zirconium tubes [5-15] and the welds[13].

Figure 2 illustrates texture effects on hydride precipitation within a zirconium alloy. Although the NRC draft study describes how zirconium alloy – coolant reactions can produce explosive hydrogen gas, the NRC draft study fails to describe how significant fractions of the hydrogen produced (over a quarter under some conditions by some estimates) diffuse into zirconium interstitially in temperature-dependent processes.

Figure 2. Highly Textured Alloys Can Be More Susceptible To Deterioration and Failure. Hydrogen generated by oxidation of surface zirconium from coolant water can diffuse into alloys and react with zirconium to form weak and brittle zirconium hydrides . Grey areas indicate zirconium hydrides. Cracks like those shown in D can be initiated by horizontal tensile stresses (ie, stresses with components in the direction indicated by the arrows). At high hydride levels, alloy failures might be initiated by stresses in other directions.

A. As- Manufactured. B. Hydrides Precipitate C. Hydrides Grow D. Hydrides Crack and Fail

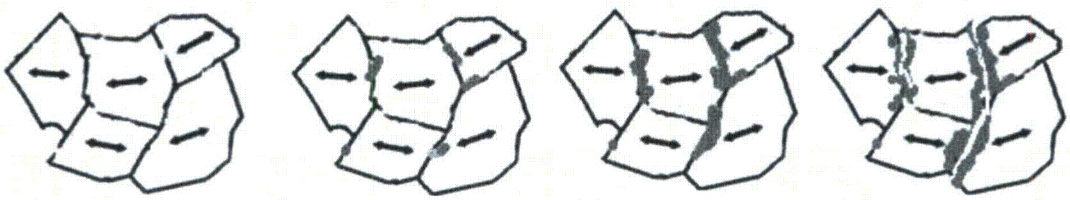


Figure 2 (caption). Highly Textured Alloys Can Be More Susceptible To Deterioration and Failures. Formation and growth of brittle hydride precipitates lead to formation of cracks in components manufactured with textured zirconium alloys**.** Simplified 2-dimensional diagram showing how hydrides form in a highly textured component. Arrows indicate the "c -crystallographic direction" of the three dimensional hexagonal arrangements of zirconium atoms in each of the grains composing the sample). The levels of zirconium hydrides (irregular grey areas) forming at some types of grain boundaries increase with time of exposure to coolant water (A to D).

A. As- manufactured zirconium has no or extremely low levels of zirconium hydrides. No exposure to coolant.

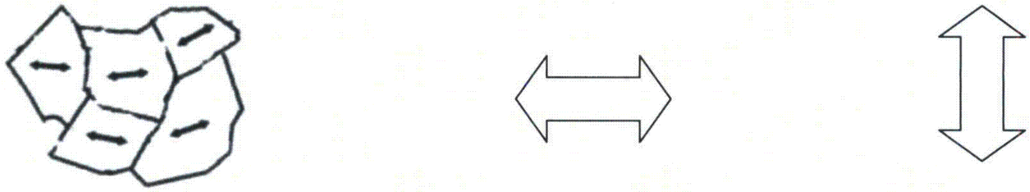
B. Coolant water reacts with zirconium at surfaces to form hydrogen. The hydrogen can diffuse into the alloy and react with zirconium at higher rates at certain surfaces to form localized hydride precipitates (shown in grey) at certain types of grain boundaries. Certain unfavorable textures facilitate hydrogen uptake and transport through the alloy, leading to hydride accumulations in certain areas. Hydride growth rates can increase with temperature.

C. Hydride precipitates grow and sometimes link up, forming larger brittle regions in the alloy.[5] Certain alloy textures facilitate coalescence of larger hydride precipitates. Taking fuel rods to higher burn-ups (ie, operating reactors at higher temperatures and using fuel rods for longer periods) increases the rates and extents of hydride formation. Accident conditions can increase rates of hydride formation and levels. Alloys with certain unfavorable textures are susceptible to formation of large hydride plates that are more susceptible to cracking.[5] Hydrides formed in some highly textured alloys are more likely to "link up". Zirconium hydride volumes are about 16% larger than parent alloy volumes and are unevenly distributed, so hydride formation increases mechanical stresses within components.

D. Brittle hydrides can crack due to thermal, pressure, or mechanical stresses. Cracks can spread and cause components to fail catastrophically. Cracks in fuel rod cladding can allow radionuclides to escape into cooling water and the environment. Zirconium hydrides are highly reactive. When cracked fuel rods containing hydrides are exposed to oxidizing conditions (eg, exposed to air), hydrides can react energetically. Large energy releases and temperature increases can occur very rapidly, initiating detonations. Cracks increase the amounts of alloy and hydrides exposed to oxidizers, thereby increasing rates of energy release and producing higher temperatures in shorter times. Components with unfavorable textures are more likely to form larger hydrides with orientations that make them susceptible to breaking completely when subjected to stresses. (See Chung et. al.[5] for a more sophisticated description of hydride formation in alloys.) Reactor operation and control depends on maintaining appropriate distributions of radioisotopes in the core. Fuel rod failures and releases of radioisotopes can change distributions of radioisotopes within the core and other critical reactor conditions. Failure to understand these processes can lead to poor decisions in response to incidents or accidents, making bad situations worse.

While details of alloy texture may be difficult to understand, the 90 degree rotation error is as fundamental as not knowing which way is up (as shown in Figure 3). The problem with the 90 degree rotation error that the NRC report described is that a 90 degree rotation in results could mislead an alloy designer or manufacturer into believing that they have produced cladding or other components whose textures are optimized for an application when the opposite is true. That is, a designer might believe that the component textures are oriented so that the strongest directions are aligned to counter the greatest stresses in a case when, in actuality, the component alloy textures are aligned in the ***worst possible*** orientations so that "weak links" align with important stresses.

Figure 3. Effects of a Ninety Degree Rotation Error on Reported Texture Results.



A. Individual Grains
Arrows Show Crystallographic
Orientations of Individual Grains

B. Accurate Indication
of Average Texture

C. A 90 Degree Rotation Error:
Inaccurate Indication of
Direction of Average Texture

Figure 3 (caption). Effects of a Ninety Degree Rotation Error on Reported Texture Results.
A. Texture of individual grains of actual specimen is indicates by arrows.
B. Large arrow indicates the actual average texture within a specimen.
C. In a report with a 90 degree rotation error, the specimen average texture is inaccurately described as being oriented in the wrong direction.
Technical notes of interest to those with technical backgrounds, but not necessary to understand the error: Texture in real specimens containing a multitude of microscopic crystallites is often more complex than that in the simple hypothetical five grain specimen shown. For example, a single specimens can appear to have two or more significant populations of crystallites with different orientations that could each be considered as having its own distinct texture. Using multiple arrows sometimes would not be a clear and effective way to indicate the crystallographic textures found in more complicated specimens. Therefore, materials scientists often rely on "pole figures", "orientation distribution functions", and other representations to indicate texture. As texture can be considered as the degree of randomness of crystallographic orientations, representations that indicate texture in terms statistical properties of crystallite populations such as "mean" orientations and calculated distributions of orientations about that mean are often used. **However, as complex as a detailed picture of texture might be, a 90 degree rotation error simply "flips" that picture on its side.**

90 degree rotation errors were found in several texture analysis reports sent to the nuclear, aviation, and other industries. Shortly a management change in the lab where the 90 degree rotation errors were being made, the rotation errors were discovered with the help of a steel industry client. Errors in other reports were found with the help of QA records that just happened to be accurate. These reports were corrected. Some of the inaccurate reports occurred because the former lab manager and company QA manager changed results to match expectations which appear to have been based on comparisons of results of zirconium alloy samples from different companies. Later, other inaccuracies in records concerning this 90 degree rotation error were discovered.

Changes were made to procedures were made to prevent future occurrences of the 90 degree rotation errors. These changes divided analysts' responsibilities in ways that made recognition of texture distortion errors that were identified later significantly more difficult.

GE Nuclear had audited the lab specifically for zirconium texture analysis compliance with nuclear industry requirements between the time that texture errors were identified and the time that clients were issued corrected reports. No mention of the 90 degree rotation errors were found in GE Nuclear audit records.

Just weeks after the 90 degree rotation errors were resolved, a completely different type of error in a zirconium texture analysis report was identified. GE Nuclear asked that analysis of a specimen described in a report as having "atypical texture" be repeated. The result was repeated on the initial specimen and then on a specimen prepared from a sample provided by GE Nuclear. Following written analysis procedures (which had been audited by GE Nuclear) on the original specimen produced the same result. However, analysis of a newly prepared specimen indicated that the GE Nuclear zirconium had typical texture. Investigation demonstrated that QA problems which included deficiencies in the written procedures, training, software, and QA checks had led to inclusion of distorted zirconium fuel rod cladding information in the report to GE Nuclear. The previous manager, who had introduced 90 degree rotation error into reports, trained the analysts involved in reports with distortion errors. (Note that the distortion error was different than the 90 degree rotation error. These distorted GE Nuclear results weren't rotated incorrectly.)

An NRC report stated that the NRC believed that the problems associated with the texture analysis "stem from poor control of specimen preparation, training, software, and texture analysis procedures. These deficiencies resulted in 'distorted' intensity distributions, and this has been substantiated." ". (Source: NRC Allegation NRR-1999-A-0057 Concerns 1 thru 3.1 Texture Analysis of Zirconium Alloy.[1] A copy is reproduced in the Appendix below.)

The GE Nuclear audit and purchase orders for other zirconium analysis had clearly indicated that errors in the zirconium texture analysis could "contribute to significant radiological hazards". After investigation showed that failures of procedures, training, software, and other QA elements contributed to the distortion errors, management was asked to allow review of past reports for the errors and to notify GE nuclear that past reports, including several with explicit safety warnings, could contain distortion errors. Past reports could have been reviewed and, if necessary corrected at this time without excessive costs and delays. (Notifications to clients that reports and procedures provided to them contained errors might have raised concerns about the company's credibility.)

Rather than review past reports for errors, the company's management requested that QA documentation signed by analysts involved be altered to conceal the extent of the errors, reliance on defective procedures, software, training, and other QA deficiencies. Employee requests for correction of procedures to include measurements that would verify procedure accuracy and address software failures were denied. Management made firing threats in reaction to being shown information indicating that changing a document as requested rendered them inaccurate and in reaction to failures to change the document as requested. The NRC was then contacted about the zirconium problems.

Rather than correct the problems immediately, the NRC consulted two select "experts" about texture analysis[1]. An industry consultant indicated that his company did not test for texture properties routinely. Both consultants indicated that they did not believe that the problems would result in bad zirconium alloy being qualified as good. Neither the NRC nor its two consultants knew the intended or potential ways in which the other nuclear industry clients, including GE Nuclear, used the zirconium information. Based on the limited and somewhat uninformed opinions of their experts, NRC officials stated that they would "not pursue" distribution of inaccurate and suspect zirconium information in the nuclear industry". GE Nuclear warnings that the inaccurate information could contribute to creation of significant radiological hazards were disregarded. (Studies published later indicate that distorted texture results that make zirconium alloy to appear to have less texture than is actually present can make "bad" zirconium alloy appear to be "good" alloy [11], apparently contradicting the NRC report conclusions.)

Months after employees refused to prepare inaccurate records, the zirconium analysis procedures again failed. The problems were recognized before errors were included in reports. Management demanded signatures on deficient QA documentation about the earlier GE Nuclear report containing distortion errors. This QA documentation was prepared by management and had the effect of concealing defects and past reports. Some demands for immediate signature were refused and resignations were made.

Although the NRC was contacted as these events occurred, the NRC did not respond until weeks later. The NRC did open an investigation and recommended that complaints be made to the Department of Labor. During the DOL process, more inaccurate information about the zirconium analysis was discovered. The NRC was notified.

NRC documents found in 2012 indicate that the NRC took no effective action to correct these errors. In a 2011 letter to Senator Lugar, the NRC "reaffirmed" their decision not to pursue distribution of the inaccurate and suspect zirconium information in the nuclear industry. These errors appear to persist in nuclear industry information. The NRC has expended far more effort preventing correction of the errors and concealing the nature of the errors than would have been required to correct known inaccurate industry technical information and reviewing suspect records. Due to the nature and expense of texture analysis, the long periods during which intact zirconium cladding is relied upon to contain radioisotopes, and the possibility that inaccurate information has filtered into the technical literature, correction of the inaccurate technical information and reviews of suspect records are still necessary.

Rather than require correction of the inaccurate information and review of the suspect reports, the NRC kept an investigation open until the DOL process was complete. Relying on the NRC report indicating that NRC would take no action[1], the DOL and other courts concluded that there were no safety concerns about errors in zirconium technical information and related records.

NRC officials did participate in two audits of the company. The first audit covered company analysis of materials used for high level nuclear waste containers. This audit identified QA deficiencies that included problems with training, software, procedures, and records. The company was allowed to continue work on high level nuclear waste containers. (Portions of records from this audit are reproduced in the Appendix Part C below.)

The NRC officials who participated in investigation of the zirconium analysis errors later audited the company zirconium analysis. This audit also identified QA deficiencies which included problems with training, software, procedures, and records. This audit defined "safety-related" report errors as those reports which included both known errors and work for which GE Nuclear had submitted their warning that defects could contribute to creation of significant radiological hazards. Reports with the safety notification that were prepared using known defective procedures and software by analysts who records indicate were inadequately trained and who were involved in the earlier 90 degree rotation errors and, in some cases, the later distortion errors were not reviewed by the NRC auditors. To date, these suspect reports do not appear to have been reviewed objectively. The NRC auditors did not address how GE Nuclear audits of the zirconium analysis repeatedly missed the problems that led to inclusion of 90 degree rotation errors and distortions in zirconium cladding alloy reports sent to the nuclear industry. The NRC auditor also included false statements in the NRC audit report inaccurately indicating that there had been no previous NRC audits at the company. In event of an accident investigation, the NRC audit records could have the effect of concealing the history of errors, QA deficiencies, and misconduct from investigators as well as decoupling inaccurate zirconium nuclear fuel rod cladding information from explicit safety warnings from the nuclear industry. (Portions of records from this audit are reproduced in the Appendix Part D below.)

The well-documented history of problems at this company and the NRC's reactions demonstrates that the NRC has repeatedly failed to ensure the integrity of nuclear industry technical information. The NRC draft study states that its purpose is to "inform" decision makers. However, if the information is bad or suspect, the decision makers could make the wrong decisions. Furthermore, the NRC relies on industry data for input into their MELCOR program used to generate much of the information in the report. Programmers succinctly use the expression "garbage in- garbage out" describe the quality of information produced by such practices.

2) Inappropriate reliance on MELCOR and other predictive programs.

MELCOR is a computer program whose purpose is to model the progression of accidents in light water reactor nuclear power plants. [16] The NRC draft study relies on MELCOR to determine the effects of large earthquakes on spent fuel pool, the likelihood of materials failures, and the nature of any consequential radionuclide releases.

Even with input of reliable data, accurate MELCOR predictions are limited to accidents where accident circumstances and conditions are well understood and the underlying factors are appropriately integrated into the program. The NRC descriptions of its use of MELCOR appear to indicate that the NRC attempted to use MELCOR to predict outcomes under circumstances beyond MELCOR's current capabilities. MELCOR may be the best currently-available program for this type of study, but MELCOR capabilities don't appear to be up to the task of providing reliable projections for the type of SFP damage described in the NRC draft study.

Some limitations of MELCOR can be understood in terms of its structure. MELCOR handles complex interacting systems through the use of coupled program modules. Although most MELCOR models are mechanistic (meaning that they are structured to reflect the real physics and chemistry occurring in the nuclear system studied), some models are entirely or largely parametric. Parametric models are based on past statistical observations of system changes in response to changes in circumstances and conditions. Parametric code within models works without regard to the underling chemistry and physics of the system being modeled. Parametric models necessary because some predictive models of events in the cascades of failures characterizing nuclear accidents are not yet available. Some events develop with a high degree of phenomenological uncertainty, and there is no consensus (much less demonstration) of acceptable mechanistic approaches to predicting the onset or outcomes of these events based on known chemistry and physics.

While the underlying physics and chemistry of some events may not be understood in detail, observations of the statistical behavior under various circumstances often allows modeling of an event by entering parameters that indicate the probability of the event into the projections. Somewhat simplistically, parametric models can be considered as modeling systems based upon application of statistical methods to output predictions of future behavior based on observations of past behavior under various circumstances.

Good examples of the NRC application of largely parametric approaches to predictive modeling are the earthquake predictions described in the draft study. The frequencies or probabilities of future earthquakes of various severities are based upon the past geological record obtained from various sites. Although geological measurements and studies can be used to refine understanding of circumstances, the best available predictors of future severe earthquake probabilities at a given location appear to be the frequencies of earthquakes observed in the past. This parametric approach is the best available approach because the current understanding of earthquakes is inadequate to predict future earthquakes mechanistically. Parametric modeling does not reliably produce accurate and precise results. Will a nuclear plant experience a severe earthquake exactly one year from now? It anybody's guess.

Parametric approaches can produce useful predictive modeling under circumstances where the ranges of system behaviors have been well characterized-eg, by interpolation. However, extension of parametric modeling to conditions and circumstances that have not been well characterized can be questionable at best and a completely invalid approach at worse. Extrapolation of parametric models can yield wildly inaccurate projections. Given the NRC descriptions of conditions modeled, some of the NRC draft study's projections from the MELCOR model do not appear to be accurate with any degree of certainty.

Mechanistic models attempt to capture and model behavior based on mathematical descriptions of the actual system. Because designers attempt to program them based on their understanding of reality, extrapolation to new circumstances can be valid as long as the quantitative descriptions and understanding of the new circumstances is accurate. Clear examples of reliance on mechanistic modeling to predict events and conditions that could occur during an accident are descriptions of the coolant; eg, liquid water boiling and steam condensation. If there is water in the system, the states of that water (liquid, vapor, and reacting chemically) are determined mainly by the temperature and pressure of the system. MELCOR computer code attempts to accurately predict the states and effects of water and steam within the system based on known chemistry and physics of water and other system components.

The accuracy of predictions by mechanistic models is often checked against measurements of "circumstances and conditions" in real systems. However, mechanistic models often can be "extrapolated" beyond real systems actually measured to new systems if the "circumstances and conditions" of those new systems are well understood. (Not perfect, but better than parametrics.) Mechanistic models remove much of the "guess work" from predictions. It is fairly certain that SFP water will be in a liquid state if the SPF temperature is 80 C at atmospheric pressure in any plant. It is fairly certain that any water in a SFP will be vapor (or steam) if the SFP temperature is 500 C at atmospheric pressure no matter what the circumstances.

Inaccurate information undermines mechanistic models in several ways. First, inaccurate technical information can create errors in the understanding of systems, which can produce errors in the underlying assumptions and mechanics of the model. Second, the output of a model is only as good as its input: " garbage in-- garbage out". NRC tolerance of inaccurate cladding technical information could prevent improvements and refinements of MELCOR and similar models. Limited resources could be squandered trying to sort out the mess created by inaccurate materials information.

The NRC draft study appears to rely heavily on MELCOR for critical predictions, such as cladding failure events which lead to releases of radioisotopes. While the graphs of spent fuel pool and cladding temperatures are impressive, the NRC study fails to explain the basis of the predictions of cladding failures in sufficient detail. The study does appear to describe "ball park" averages, but cladding failures are irreversible discrete "go- no go" event when initiating conditions occur.

Important questions about the projections on cladding behavior remained unanswered in the NRC draft study. Nuclear fuel is obtained from various sources and employs various types of zirconium cladding. Recently, fuel rods have been taken to higher burn-ups; some cladding in SFP may have been subjected to radiation and higher temperatures for longer periods than others. Higher burn-ups render cladding more fragile and more susceptible to failure both when subjected to stresses during storage in SFPs or when being handled during transfers. How would these factors influence decisions on fuel rod storage and transfers to dry cask storage? Were these variations considered in MELCOR or other parts of the study? Or did the study assume "best case" or "past case" behaviors based on information archived in decades-old NUREGs?

3) The draft NRC report relies excessively on NUREGs and other information sources which themselves rely on information that may not have been adequately maintained. Is the NRC producing self-referencing reports and information authorities built on foundations of sand?

The draft NRC report relies heavily on references to NUREGs and other governmental publications of various origins and vintages. Serious questions have been raised about NUREGs.

Interesting perspectives on NUREGs and their uses appear in the transcripts of the 2012 NRC Atomic Safety and Licensing Board evidentiary hearings. A panel of three judges presided over hearings involving contentions and concerns raised by New York State, Riverkeeper, Hudson River Sloop Clearwater, and other parties opposing relicensing of the applicant Entergy's Indian Point Generating Station. The transcripts of this hearing* include some discussions of NUREGs and other NRC publications that raise questions about whether the practice of citing NUREGs as sources and authorities amounts to good scientific practice. (In the following, the location of the discussion in the hearing transcript* is indicated by a "T." followed by the page number in the hearing transcript. "The staff" refers to NRC staff.)

NUREG-1150 is cited repeatedly in the NRC draft study. Discussion of differences in results obtained from computer models included testimony about NUREG-1150 (Nuclear Regulation 1150), which concerns consequences of nuclear reactor accidents. Origins of certain "numbers", input parameters, and other information important to accident cleanup calculations were questioned. (T. page 2006). This led a judge to ask if a witness if it was his "position that Sandia study referenced in a NUREG actually looked into a dispersion of primarily plutonium contamination?" (T. page 2007.) A witness identified the referenced Sandia study (also called Os84): "It's Ostmeyer and Runkle, 'An assessment of decontamination costs and effectiveness for accident radiological releases, Sandia National Labs. And, again, it's stated as "To Be Published.'" (T. page 2008.)

However, the Sandia study referenced by the NUREG appeared to have remained unpublished. An attorney for the state of New York said "... we searched libraries. I also contacted Brian Harris, counsel for NRC Staff and requested a copy of Os84. Mr. Harris represented to me that he searched internal NRC libraries, as well as Sandia libraries, and that no copy of Os84 in any form, draft, or otherwise could be located, so we do not—none of the parties have a copy of this document." (T. page 2010.)

One hearing judge questioned the situation. "Let me ask, if the NRC doesn't have a copy of it, how can the NRC -- how did the NRC rely on it in developing this guidance on NUREG/CR-3673? How were you able to reference it if you never had it?" (T. page 2010.)

A copy could not be located. Mr. Joseph Jones of the NRC responded to a question about whether Sandia Lab could provide the study. "No, I checked with our librarians, as well, and we were unable to locate it." (T. page 2011.)

There were guesses about assumptions about the kinds of contamination described in the lost Sandia study. Dr. Anita Ghosh stated "And it does talk about severe accidents, so I guess we would have no reason to assume that they were looking at a different composition than what a severe reactor accident would produce." (T. page 2011.)

Judge Michael Kennedy commented on the lost Sandia study. "So, okay, we lost the reference to 1984. Someone convinced themselves, and then the Staff viewed it as reasonable—and, again, I know we're not looking at great science, but what I'm struggling with is, okay, we lost the reference, but it is 30 years later, and we're trying to deal with a plant-specific analysis for this facility." (T. page 2016.)

Judge Lawrence McDade commented. "But what this does is leave us with a degree of uncertainty as to exactly what the source for the contaminants that are referred to. It may have been plutonium...but at this point there's no way to really be sure of that." (T. page 2026.) (Note that plutonium contamination can have serious implications.)

It's unclear from the available transcripts if the lost and apparently unpublished Sandia study was located. It's difficult to determine from the available transcripts if the questions about values were resolved. Was acceptance of the values rationalized based on a guess about what the NRC would have done at the time (T. page 2011), on the observation that, so far, the NUREGs have "stood the test of time" (T. 2251), or on a responsible and reviewable scientific basis that many would expect (T. page 2010)? Even if the issues were all resolved in a technically responsible manner, the course of the hearing did seem to indicate that the NRC had significant problems with information that they should have maintained. The NRC's failures may have undermined the credibility of the NUREGs that rely upon the lost information, may have cast doubts on the credibility of hearings like these, and did lead to the waste of hearing time and the waste of the limited resources of the parties.

The judges' approach to the information problems in the hearing seemed appropriate for a legal exercise. Would the same approach be appropriate (or even be possible) if answers to question questions about the origins and the reliabilities of values used to derive or derived from NUREG information were needed by engineers making urgent decisions that that would determine responses to an ongoing nuclear accident? In legal proceedings, there is time to question NUREG references (T. page 2010), guess about assumptions (T. page 2011), and consult with librarians (T. page 2011). Lawyers and judges don't need "great science" for their legal semantics (T. Page 2016). In event of a nuclear accident, decisions would probably have to be made quickly. Guesses and assumptions would not be welcome. There might not be time to ask question librarians about document locations so that source information could be retrieved and reviewed. Decisions would be difficult if information sources did not answer questions like "Were these estimates of cleanup effectiveness of a certain set of available methods based on an accident involving plutonium or just other radioisotopes?" Would information whose credibility was largely based on the fact that it "stood the test of time" for all of three decades be regarded as reliable?

"Great science" is required for NRC reports that will "inform" decision makers about the consequences of spent fuel pool accidents. "Great science" is require to "inform" decisions about whether or not to expedite transfer of nuclear fuel from spent fuel pools to dry cask storage. However, the NRC sometimes appears to work to ensure that the best science available in event of a nuclear accident will fall far short of "great science". (The resulting doubts and confusion about information would serve the purposes of parties attempting to evade being held responsible for their roles in nuclear accidents quite well.)

The NRC should be careful about publishing information lest its practices actually impair nuclear safety. For example, one court decision appears to have interpreted the NRC report as authoritatively ruling out that inaccurate cladding texture analysis could create hazards.

> In counterpoint, the NRC report's analytic conclusion that no safety menace existed was the product of a specific investigation into the potential dangers posed by zirconium-cladded fuel rods which had been inaccurately tested for "pole figure" properties, conducted by NRC consultants including "a senior engineer of one of the major nuclear fuel fabrication companies who has experience in texture analysis from a fuel cladding design perspective." By contrast, Kelly and Glavacic were research chemists; neither possessed engineering credentials.

(Source: United States Court of Appeals for the Sixth Circuit. Case No. 02-3035. Decision. On Appeal from the United States District Court for the Southern District of Ohio. [15])

Relying in large part on the NRC report, another court appears to have found that generation of false documentation is legal and acceptable practice for labs testing fuel rod cladding and other nuclear materials.

> Lambda did not, as far as the Court can determine, violate any federal, state, or local laws by allegedly attempting to file internally a false quality assurance incident report.

(Source: Order. Case No. C-1-00-661. United States District Court for the Southern District of Ohio Western Division. 12-3-01.)

While models and simulations applied by the NRC to difficult situation may be among the best and most sophisticated available, the question is not whether or not they are the best, but the question is whether or not they are adequate for NRC purposes. Examination of NRC information practices, NRC applications of models such as MELCOR to generate the information for their draft study, and cited NURGs indicate that the NRC draft study is inadequate for its stated purposes of informing decision makers about consequences of SFP accidents and the cost/benefit analysis of expediting transfer of spent fuel rods to dry cask storage.

The NRC draft study does cite a NAS study recommending expedited transfer to dry cask storage. The NRC draft study does not appear to provide adequate reasons to disregard those recommendations.

One aspect of the situation is that the NRC is that poor information practices could eventually be self-limiting. After Fukushima, TEPCO officials placed significant blame on NISA, stating that TEPCO only did what NISA allowed. Eventually, TEPCO was bailed out. NISA was abolished.

Appendix. Four NRC Records Documenting Flawed NRC Information Practices

Part A. The Initial NRC Report Describing Zirconium Texture Analysis Errors

NRC correspondence and a report indicating that the NRC did not consider dissemination of known bad texture information in industry to be a safety concern and indicating that the NRC took no action to curtail the distribution of inaccurate information on zirconium fuel rod cladding material properties.

At the NRC's request, a copy of this report to the NRC in mid-2011. This is the report referred to in the NRC's November 2011 letter to Senator Lugar included in Appendix I Part B.

Note that the NRC cites the unpublished and unreviewed opinions of two experts to support its conclusions. One consulted expert, described as "an engineer of one of the major nuclear fuel fabrication companies who has experience in texture analysis from a fuel cladding design perspective, appears to be from Westinghouse. Westinghouse failed to recognize texture analysis errors in multiple reports and also received fraudulent information which inaccurately describes causes of errors.

Note that the NRC report does not explicitly address information in published papers indicating that texture influences the deterioration and failure of zirconium alloys in nuclear application. For example, see "The Influence of Crystallographic Texture and Test Temperature on Initiation and Propagation of Stress-Corrosion Cracks in Zircaloy", Zirconium in the Nuclear Industry. 6th International Symposium (1982) * and citations therein. Note that numerous studies have since confirmed that understanding zirconium texture is necessary for some nuclear applications. *

120

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 16, 1999

Mr. Mark J. Kelly

SUBJECT: ALLEGATION NO. NRR-1999-A-0057

Dear Mr. Kelly:

This letter refers to your letter dated September 12, 1999, to Fiona Tobler, Nuclear Regulatory Commission (NRC). In this letter you expressed concerns related to X-ray diffraction texture analyses of zirconium alloy tubing performed at Lambda Research Laboratory. This letter also refers to your letter dated October 19, 1999, to Mary Kay Fahey, NRC, in which you provided examples of erroneous pole figure data used in the texture analysis. In summary, you believe that erroneous or distorted analysis results may have been reported to fuel cladding manufacturers in the nuclear industry.

On September 30, 1999, we had a conference call with you to gather information relating specifically to a potential discrimination issue you identified to us on September 29, 1999. On October 9, 1999, we a had follow up conference call with you to identify the agent assigned to the investigation and to schedule an interview. During our conversation you requested NRC to put the discrimination investigation on hold, but pursue the technical allegations. Based upon your request the Office of Investigations will not pursue your allegation of discrimination.

In pursuing the technical issues we informed you on October 27, 1999, of our intentions to contact experts in the field of texture analyses to help us understand the safety significance of your allegation. Based upon our review and the information obtained from the experts, we believe that the problems with Lambda Research's texture analysis may be attributed to poor control of specimen preparation and texture analysis procedures. Further, we believe that texture analyses, in general, cannot be used to inadvertently qualify unacceptable material. The intrinsic mechanical properties of zirconium-based tubing material cannot be determined from texture analysis. Therefore, we have concluded that errors resulting from the texture analysis at Lambda Research in the development of engineered components is not a safety concern. NRC did not pursue the issue further since we determined it is not a safety concern.

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

The enclosure to this letter provides a more detailed summary of the resolution of your concerns. Thank you for informing us of your concerns. We feel that our actions in this matter have been responsive to those concerns. We take our safety responsibilities to the public very seriously and will continue to do so within the bounds of our lawful authority. Unless the NRC receives additional information that suggests that our conclusions should be altered, we plan no further action on this matter. Should you have any additional questions, or if we can be of further assistance in this matter, please call Fiona Tobler or Greg Cwalina, Senior Allegation Coordinators, on the NRC Safety Hotline at 1-800-368-5642 or Fax Number 1-301-415-3741.

Sincerely,

Theodore R. Quay

Theodore R. Quay, Chief
Quality Assurance, Vendor Inspection,
Maintenance and Allegations Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

Enclosure: Statement of Concerns and
NRC Response Allegation No. NRR-1999-A-0057

(The NRC report sent with the attached letter is reproduced below under "Allegation NRR-A-0057.)

172

ALLEGATION NRR-1999-A-0057
CONCERNS 1 THRU 3
TEXTURE ANALYSES OF ZIRCONIUM ALLOY

CONCERN 1

X-ray diffraction texture analyses of zirconium alloy tubing performed at Lambda Research Laboratory are in question. The alleger believes that analyses performed at Lambda are in error and distorted results may have been reported to clients like GE Nuclear. He also suspects other clients like Westinghouse Bettis and Western Zirconium may be involved. Written procedures at the laboratory were not followed, and some simply cannot be followed, because of the problems with the procedure, training, and software.

NRC RESPONSE:

The area of texture analysis is very specialized and requires that proper sample preparation, procedures, personnel training and equipment are utilized to produce accurate results. As noted in a 1982 paper, "Texture Measurement Techniques for Zircaloy Cladding: A Round-Robin Study," which was published by J.E., Lewis, et al. in the Fifth Conference on Zirconium in the Nuclear Industry, there are many areas that require careful consideration when performing texture analyses. These areas include proper specimen preparation with particular attention to the flatness of the specimen, proper specimen alignment on the goniometer axis, diffraction focusing circle, and selection of the correct 2θ-peak, among other things.

As noted in your September 12, 1999, letter to NRC and other supporting documents, Lambda Research seems to have had some problems controlling the flatness of the specimen and identifying the correct 2θ-peak position prior to conducting texture analyses. These deficiencies were reported by the alleger to have resulted in "distorted" intensity distributions and this has been substantiated. Lambda Research also produced pole figures on several occasions which were indicative of a 90-degree specimen rotation problem. However, it seems that Lambda's clients were cognizant of this type of error and requested that Lambda repeat the analysis. Overall, these problems are indicative of the need for better training of Lambda Research's personnel who prepare the specimens, run the equipment and acquire the data.

With respect to the deficiencies in specimen preparation and the texture analysis technique (i.e., identification of the correct 2θ-peak position), we believe that the alleger is making every attempt to correct the situation and produce more accurate, consistent data. Adherence to the most recent ASTM Standard E 81-96, "Standard Test Method for Preparing Quantitative Pole Figures," which contains up-to-date procedures for conducting texture analysis with modern x-ray diffraction equipment, may help to prevent these types of problems in the future. Further, the references provided at the end of this document may be useful for making comparisons between Lambda Research's data and other data sets regarding the texture of various zirconium materials.

Complainant Exhibit
23 Page: 13

B 11904 Enclosure

173

Since the area of texture analysis is very specialized, we consulted with two experts in this field. One of the interviews was conducted with a materials science and engineering professor who has published many papers on the texture analysis of zirconium-based alloys. The second interview was conducted with a senior engineer of one of the major nuclear fuel fabrication companies who has experience in texture analysis from a fuel cladding design perspective.

These two experts stated that the generation of "bad data" and/or "distorted results" can be attributed to many sources, including poor sample preparation, inexperienced analysts or technicians, and inadequate control of the data acquisition equipment and procedures. However, they believed that the techniques employed for texture analysis cannot inadvertently be used to qualify substandard material. In other words, the data from a properly prepared specimen, using equipment that has been adequately prepared for texture analysis, will produce results that are representative of the specimen's (or material's) texture. For example, one expert concluded that, using the basal direct pole figure, substandard material could be identified if the peak intensities and/or the locations of the peak maxima were outside their acceptable ranges. Thus, if the texture analyses were conducted on "good material" but the specimen was poorly prepared (e.g., the surface is rough or wavy), the texture analysis results would tend to have characteristics that could indicate the material may be "unacceptable." Alternatively, if the texture analysis is performed on poor quality material, the characteristics of the data would show the material is poor. Both experts believed that texture analysis, alone, cannot be used to determine the intrinsic mechanical properties of zirconium-based tubing material. Rather, as one expert suggested, texture analysis can be used to estimate mechanical properties relative to certain directions of the tubing (e.g., the results of a texture analysis may show that the tensile strength of the tube in the axial direction is larger, or smaller, than the tensile strength in the radial direction).

We are unsure how GE Nuclear or Lambda Research's other clients use the texture analysis results. However, one of the experts stated that his company does not conduct texture analyses, i.e., direct pole figures, on a routine basis to evaluate characteristics of the tubing. The texture analyses are conducted typically as part of an evaluation of new product material or a new manufacturing process. Alternatively, his company employs a test that evaluates the contractile strain ratio (CSR) as a check on the control of the tubing manufacturing processes. Then, the mechanical properties of the cladding are correlated to the CSR. When the calculated CSR is found to be within a specified range, the mechanical properties of the material are found to be acceptable. In addition to the CSR, the expert's company also performs a tensile test to evaluate the mechanical properties of the cladding on a per lot basis.

In summary, the problems associated with Lambda Research's texture analysis, we believe, stem from poor control of specimen preparation, training, software and texture analysis procedures. These deficiencies resulted in "distorted" intensity distributions, and this has been substantiated. However, we also believe that texture analyses alone cannot be used to inadvertently qualify unacceptable material. The intrinsic mechanical properties of zirconium-based tubing material cannot be determined from texture analysis. We have concluded that errors resulting from the texture analysis at Lambda Research in the development of engineered components is not a safety concern. Therefore, the NRC did not pursue whether distorted results were reported to Lambda's clients.

CONCERN 2:

The owner of the company repeatedly refused to allow the alleger or anyone else to review the past zirconium alloy texture analysis reports and data, which would determine if the problems with the analyses have caused bad data to be reported to the clients.

NRC RESPONSE:

Based upon our response to Concern 1 and our determination that the issues involved were not safety significant the NRC will not pursue this concern.

CONCERN 3:

Fear of Retaliation:

The alleger believes, if the owner of Lambda Research were to find out that he discussed these concerns with NRC, GE Nuclear, or other clients, he would probably make changes.

NRC RESPONSE:

On September 30, 1999, we had a conference call with you to gather information relating specifically to a potential discrimination issue you identified to us on September 29, 1999. On October 9, 1999, we had a follow up conference call to identify the agent assigned to the investigation and to schedule an interview. We explained that an investigation by our Office of Investigations into your allegation of discrimination by Lambda Research could not be pursued without your approval to release your identity. During our conversation you requested NRC to put the discrimination investigation on hold, but pursue the technical allegations. Based upon your request the Office of Investigations will not pursue your allegation of discrimination. Therefore, NRC does not plan on taking any action on this concern.

Appendix Part B. 2011 NRC Correspondence to Senator Lugar

2011 NRC Correspondence to Senator Lugar reaffirming the initial NRC report. The NRC indicates that they believe problems "were remediated". However, the NRC did not appear to understand what data and records were later found to contain errors. Record dates indicate that no "remediation" was done. No record of "remediation" is available. The NRC appears to have taken no effective action to curtail the distribution of the bad data, to require review of suspect data, or correction of inaccurate records identified after their earlier report.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 21, 2011

The Honorable Richard Lugar
United States Senate
Washington, D.C. 20510

Dear Senator Lugar:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letter of October 21, 2011, forwarding correspondence from your constituent, Mark Kelly. Dr. Kelly is concerned with the use of bad data within the nuclear industry that could lead to faulty analysis or decision making and have an effect on nuclear safety. In support of his views, he provided you with materials associated with a concern on this topic that he raised to the NRC in 1999.

As described in the enclosures to Dr. Kelly's letter, in 1999, the agency thoroughly investigated his concerns regarding faulty analysis associated with zirconium alloy tubing and concluded that there was no safety concern that warranted further investigation. The NRC did corroborate some shortcomings in the case identified by Dr. Kelly, which we believe were remediated. However, the experts consulted by the NRC in its investigation concluded that, even with those shortcomings, decisions based on the analysis in question would not have resulted in substandard material being qualified for use.

The NRC recognizes the importance of accurate and current data in decision making and works to ensure the use of such data at all times. Therefore, while we fully understand Dr. Kelly's concern in principle, without any new information the NRC reaffirms its earlier findings and conclusions on this matter. If you need any additional information, please contact me or Ms. Rebecca Schmidt, Director of the Office of Congressional Affairs, at (301) 415-1776.

Sincerely,

R. W. Borchardt
Executive Director
for Operations

Appendix I

Part C. NRC Observation Audit Record of High-Level Waste Container Material Analysis

NRC audit records of nuclear industry work on high-level waste container design for Yucca Mountains describing QA deficiencies. Note that the report states "The audit team identified potential deficiencies in training, calibrations, document control, software verification and validation, and corrective action." The same types of deficiencies led to distribution of reports with inaccurate texture information to the nuclear industry. Note also that this Yucca Mountain work was itself QA work. This record was posted on the NRC web site in ML013330072.pdf.[3]

U.S. NUCLEAR REGULATORY COMMISSION

OBSERVATION AUDIT REPORT NO. OAR-02-01

"OBSERVATION AUDIT OF THE

BECHTEL SAIC COMPANY, LLC

AUDIT NO. BSC-SA-01-30 OF Lambda Research, Inc."

1.0 INTRODUCTION

1.1 Lambda Research, Inc. (Background)

The current "Statement of Work Agreement" between the U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM), Management and Operating Contractor (M&O) and Lambda Research, Inc (Lambda) is Bechtel SAIC Company, LLC (BSC) Purchase Order 24540-000-TSA-0005, Rev. 1, and the "Technical Services Statement of Work for Lambda Research Incorporated, Revision 03," dated September 24, 2001.

The scope of Lambda's work under the current statement of work is to measure residual stresses of welded mockups of selected materials related to the high-level waste container design for the proposed repository at Yucca Mountain, Nevada.

1.2 Performance of the Audit

Staff from the U.S. Nuclear Regulatory Commission (NRC), Division of Waste Management, and the Center for Nuclear Waste Regulatory Analyses Center (CNWRA) observed the M&O, BSC, audit BSC-SA-01-30 of activities regarding the implementation of Lambda's Quality Assurance Manual (QAM). This audit was conducted on October 31 through November 1, 2001, at Lambda's facilities in Cincinnati, Ohio.

The purpose of this audit was to evaluate the effectiveness of the implementation of Lambda's QAM, and to determine if applicable requirements of the OCRWM Quality Assurance Program Description (QARD) were being met. The scope of the audit included evaluating the implementation of the QARD and QAM for residual stress measurements supporting the design of the high-level waste containers for the proposed repository at Yucca Mountain, Nevada.

The NRC observers' (observers') objective was to assess whether BSC Quality Assurance (QA), Product Quality Engineering/Supplier Audits and Evaluation Section, audit team (audit team) and Lambda were properly implementing the QA requirements contained in Subpart G, "Quality Assurance," to Part 60, of Title 10 of the U.S. Code of Federal Regulations (10 CFR Part 60) and the provisions contained in the QARD. Before the start of the audit, the audit team and observers were given a tour of the Lambda facility.

This report presents the observers' determination of the effectiveness of the BSC audit and whether Lambda implemented adequate QARD and QAM controls in the audited areas.

November 28, 2001

Mr. Ronald A. Milner, Chief Operating Officer
Office of Civilian Radioactive Waste Management
U. S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION'S OBSERVATION AUDIT REPORT NO. OAR-02-01, "OBSERVATION AUDIT OF THE BECHTEL SAIC COMPANY, LLC, AUDIT NO. BSC-SA-01-030 OF LAMBDA RESEARCH, INC."

Dear Mr. Milner:

I am transmitting the U.S. Nuclear Regulatory Commission's (NRC's) Observation Audit Report (No. OAR-02-01) of the U.S. Department of Energy's (DOE's), Office of Civilian Radioactive Waste Management (OCRWM), Management and Operating Contractor, Bechtel SAIC Company, LLC (BSC), Quality Assurance (QA), audit of Lambda Research, Inc. (Lambda). This audit was conducted on October 31 and November 1, 2001, at Lambda facilities in Cincinnati, Ohio.

The purpose of this audit was to evaluate the effectiveness of the implementation of Lambda's QA Manual (QAM) and to determine if applicable requirements of the OCRWM Quality Assurance Program Description (QARD) were being met. The scope of the audit included evaluating the implementation of the QARD and QAM for the residual stress measurements of welded mockups supporting the design of the high-level waste containers for the proposed repository at Yucca Mountain, Nevada.

The NRC observers (observers) determined that this audit was effective in identifying potential deficiencies and recommending improvements for the Lambda activities reviewed. During the conduct of the audit, both the BSC audit team (audit team) and the observers reviewed applicable documents, procedures, and activities within the audit's scope.

Also, the audit team and observers reviewed and observed ongoing testing activities. The audit team identified potential deficiencies in training, calibrations, document control, software verification and validation, and corrective action. The staff believes that this BSC audit was well-planned, thorough, and adequately evaluated Lambda's residual stress measurement activities.

The observers agreed with the audit team's conclusions, findings, and recommendations presented at the audit exit. Notwithstanding the audit team's findings, the staff believes that Lambda is properly controlling residual stress measurement activities within the scope of the audit. The staff will continue to interface with OCRWM and follow the progress that Lambda is making to address the issues identified during this audit.

A written response to this letter and the enclosed report is not required. If you have any questions, please contact Ted Carter at (301) 415-6684.

Sincerely,

/RA/

C. William Reamer, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: NRC Observation Audit Report No. OAR-02-01, "Observation Audit of the Bechtel SAIC Company, LLC, Audit No. BSC-SA-01-030 of Lambda Research, Inc."

Appendix I. Part D. NRC Audit Record Containing False and Misleading Information

Excerpts from 2004 NRC Audit Records of industry zirconium analysis work. (The full audit record was available on the NRC web site in the document posted as "ML042750057".)

Note that part "2.0 STATUS OF PREVIOUS INSPECTION FINDINGS" inaccurately states "There were no NRC inspections or technical reviews performed at the ... facility prior to this inspection." Note that this statement can be shown to be inaccurate because it conflicts with the records from the 2001 NRC audit of the same company (reproduced in Appendix I Part C above), which demonstrates that NRC auditors did perform a technical review at the same company of the same QA system and some of the same procedures. This inaccuracy is significant in that it could conceal earlier audit records that describe QA deficiencies related to the analysis of high level nuclear waste container material. Accident investigators could be misled into believing that the zirconium audit was the first NRC audit of the company; investigators might not look for earlier records.

Also note that company records, GE Nuclear records, and court records indicate that the same deficient procedures, software, and training that created errors in the GE Nuclear work described in the QAIR (Quality Assurance Incident Report) were employed in work whose purchase orders explicitly stated that 10CFR21 was applicable. Records show that these NRC auditors knew the following: 1) Defective texture analysis procedures, software, and QA had been used zirconium analysis work which did explicitly state that 10CFR21 was applicable (eg, see ML011430464.pdf). 2) Defective texture analysis procedures, software, and QA had supposedly been audited by GE Nuclear and Global Nuclear Fuels under the NIAC (Nuclear Industry Assessment Committee) audit standard for compliance with 10CFR21 and 10CFR50b (eg, see ML011430464.pdf). However, the following NRC audit record states that "The inspectors were not able to identify any QAIR records relating to a 10CFR Part 50, Appendix B purchase order" and "...Part 21 was not applicable to the ... activities performed for the specific testing". Two of the NRC auditors had been provided with copies of the GE Nuclear and NIAC audit records and information describing violations of 10CFR50b and 10CFR21 requirements. The following NRC audit records do not mention the initial NRC report describing errors in the audited zirconium texture analysis (reproduced in Part A above). The NRC audit records do not mention the problems getting information corrected, which included threats that employees reviewing or discussing the errors and deficiencies would be fired.

This 2004 NRC Audit Report contains false statements that are significant in that they conceal the history and extent of deficiencies in analysis for GE Nuclear, Global Nuclear Fuels, Westinghouse, and other nuclear industry clients.

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION

Report No:	99901345/2004-201
Organization:	Lambda Research, Incorporated 5521 Fair Lane Cincinnati, Ohio 45227
Vendor Contact:	Ms. Sandy Messerly Quality Assurance Administrator (513) 561-0883
Nuclear Industry:	Lambda Research, Incorporated (Lambda) is an independent laboratory specializing in x-ray diffraction and related methods of material testing. Lambda focuses its testing in the areas of residual stress measurement, texture analysis, and quantitative phase analysis of polycrystalline and ceramic materials. Additionally, Lambda performs x-ray diffraction crystallographic texture analysis of zircalloy products for nuclear industry customers.
Inspection Dates:	September 27-28, 2004

Inspectors:

(Original /s/ by J. Petrosino) Date: 09/30/04
Joseph J. Petrosino, IPSB/DIPM/NRR
Inspection Team Leader

(Original /s/ by G. C. Cwalina) Date: 09/30/04
Gregory C. Cwalina, IPSB/DIPM/NRR

Approved by:

(Original /s/ by D. F. Thatcher) Date: 09/30/04
Dale F. Thatcher, Section Chief
Plant Support Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

1.0 INSPECTION SUMMARY

The purpose of this inspection was to evaluate selected portions of the quality assurance (QA) and 10 CFR Part 21 (Part 21) controls that Lambda Research, Incorporated (Lambda) has established and implemented. The inspection was conducted at Lambda's office and laboratory facility in Cincinnati, Ohio. The inspection bases were:

- Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Part 50 of Title 10 of the Code of Federal Regulations (Appendix B), and

- 10 CFR Part 21, "Reporting of Defects and Noncompliance."

2.0 STATUS OF PREVIOUS INSPECTION FINDINGS

There were no NRC inspections or technical reviews performed at the Lambda facility prior to this inspection.

3.0 INSPECTION FINDINGS AND OTHER COMMENTS

3.1 10 CFR PART 21 PROGRAM

a. Inspection Scope

The NRC inspectors reviewed Lambda Procedure 3P5001.01, "Reporting of Defects and Noncompliance-10CFR21," associated documents and records related to the implementation of its program that had been established to comply with the requirements of Part 21.

b. Observations and Findings

The NRC inspectors noted Section III.A of Procedure 3P5001 requires personnel to report identified problems to the Quality Assurance Administrator. However, a review of the Part 21 training module indicates that personnel are instructed to report problems to the Director of Research. The inconsistency was discussed with Lambda staff who stated the Director of Research or the Vice President, Director of Laboratories, were the correct persons to whom reports should be made. During the inspection, the training module was revised to add the Vice President, Director of Laboratories as a recipient of reports. In addition, Lambda revised Procedure 3P5001 to require reporting to the Director of Research or the Vice President, Director of Laboratories, consistent with the training module.

The inspectors also noted that Lambda's procedure requires informing clients whenever a deviation is discovered, as Lambda does not have the capability to determine if a deviation could cause a substantial safety hazard as discussed in §21.21(b) of Part 21.

(The full NRC audit record is posted on the NRC web site as "ML013330072.pdf".)

References.

[1] NRC Allegation NRR-1999-A-0057 Concerns 1 thru 3. Texture Analysis of Zirconium Alloy. NRC correspondence and report stating that the NRC does not regard known bad texture information to be a safety concern and will not pursue bad data distributed in industry. (A copy is reproduced above in the appendix and has been posted on the Internet at Scribd.com as "NRCAllegationNRR-1999-A-0057".)

[2] Correspondence. R. W. Borchardt, NRC Executive Director for Operations, to Senator Richard Lugar, United States Senate. November 21,2011. NRC correspondence reaffirming NRC Report NRR-1999-A-0057. (A copy is reproduced in appendix and has been posted on the Internet at Scribd.com as "NRCBorchardtToSenateLugarNov212011".)

[3] NRC ADAMS ML013330072.pdf. NRC Observation Audit Report No. OAR-02-01 and related DOE correspondence. (Portions of this document are reproduced in appendix.)

[4] NRC ADAMS ML042750057.pdf. Source: NRC Inspection Report 99901345/2004-201. (Portions of this document are reproduced in the appendix.)

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[7] Nuclear Fuel Behavior in Loss-of-Coolant Accident (LOCA) Conditions. State of the Art Report. Nuclear Energy Agency (NEA No. 6846). Organization for Economic Co-operation and Development (OECD) Report. 2009.

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[11] Grytsyna et al. "Destruction of Crystallographic Texture in Zirconium Alloy Tubes." Zirconium in the Nuclear Industry. 14th International Symposium, p 305. Journal of ASTM International, Sept. 2005 Vol 2 No. 8.

[12] Dahlback M. Dahlback, M. Limback, L. Hallstadiu, P. Barberis, G. Bunel, C. Simonot, T. Anderson, P. Askeljung, J. Flygare, B. Lehtinen, A. Massish, ""The Effect of Beta-Quenching in Final Dimension on the Irradiation Growth of Tubes and Channels". Zirconium in the Nuclear Industry. 14th International Symposium, P. 276. Journal of ASTM International, June. 2005 Vol 2 No. 6 .

[13] P. Rudling et. al. "Welding of Zirconium Alloys. " IZNA7 Special Topic Report Welding of Zirconium Alloys 2007. Advanced Nuclear Technology International. 4-3(4-13).

[14] King, S. J., Kesterson, R. L., Yueh, K. H., Comstock, R. J., Herwig, W. M. and Ferguson, S. D., "Impact of Hydrogen on Dimensionaly Stability of ZIRLO Fuel Assemblies. Zirconium in the Nuclear Industry: Thirteenth International Symposium. ASTM SPT 1423, G. D. Moan and P. Rudling, Eds. ASTM. pp. 471-489.

[15] "The Influence of Crystallographic Texture and Test Temperature on Initiation and Propagation of Stress-Corrosion Cracks in Zircaloy", Zirconium in the Nuclear Industry. 6th International Symposium (1982)- Append

[16.] MELCOR web site. <http://melcor.sandia.gov/about.html>

[17] United States of America Nuclear Regulatory Commission. Atomic Safety and Licensing Board Panel Hearing. Docket Nos. 50-247-LR and 50-286-LR. ASLBP 07-858-03-LR-BD01. In the Matter of: Entergy Nuclear Operations, Inc. (Indian Point Generating Units 2 and 3). Note that the transcript was provide by Hudson River Sloop Clearwater (for other purposes). Copies of the transcripts could not be located on the NRC web site for reference and verification, so the copy provided by Clearwater has been posted on the internet at Scribed.com under the following file names: IndianPointTranscript of Oct 15 2012.pdf (pages 1252-1456), IndianPointTranscript of Oct 16 2012 (pages 1457-1779), IndianPointTranscript of Oct 17 2012 (pages 1780-2083), IndianPointTranscript of Oct 18 2012 (pages 2084-2387), IndianPointTranscript of Oct 22 2012 (pages2388- 2721), IndianPointTranscript of Oct 23 2012 (pages 2722-2918), IndianPointTranscript of Oct 24 2012 (pages 2919-3169). Note that these copies of the files may not display properly on some devices due to formatting problems.