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ADVISORY COMMITTEE ON NUCLEAR WASTE

January 10, 2006

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE

167TH MEETING

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TUESDAY, JANUARY 10, 2006

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The meeting came to order at 8:30 a.m. in room T2B3 of Two White Flint North, Rockville, MD. Michael T. Ryan, Chairman, presiding.

PRESENT:

MICHAEL T. RYAN	CHAIRMAN
ALLEN G. CROFF	VICE CHAIRMAN
JAMES H. CLARKE	MEMBER
WILLIAM J. HINZE	MEMBER
RUTH F. WEINER	MEMBER
JOHN T. LARKINS	EXECUTIVE DIRECTOR
ASHOK C. THADANI	DEPUTY EXECUTIVE DIRECTOR
LATIF HAMDAN	DESIGNATED FEDERAL OFFICIAL
NEIL M. COLEMAN	STAFF

I-N-D-E-X

P-R-O-C-E-E-D-I-N-G-S

8:34 a.m.

CHAIRMAN RYAN: On the record. Good morning, everybody. Welcome to 2006. The meeting will come to order. This is the first day of the 167th Meeting of the Advisory Committee on Nuclear Waste. My name is Michael Ryan, Chairman of the ACNW. The other members of the Committee present are Vice Chairman Allen Croff, Ruth Weiner, James Clarke and William Hinze.

Today the Committee will:

1. be briefed by the NRC staff on the status of risk-informed decision making for nuclear materials and waste applications;

2. be briefed by the NRC staff on the fabrication of PWR uncanistered fuel waste package;

3. be updated by representatives from the NRC staff on spent fuel transportation package response to the Baltimore Tunnel fire scenario published in NUREG/CR-6886; and

4. will discuss plans for an ACNW white paper on transportation.

Neil Coleman is the Designated Federal Official for today's session. The meeting is being conducted in accordance with the provisions of the

Federal Advisory Committee Act. We have received no written comments or requests for time to make oral statements from members of the public regarding today's sessions. Should anyone wish to address the committee, please make your wishes known to one of the Committee's staff.

It is requested that the speakers use one of the microphones, identify themselves and speak with sufficient clarity and volume so that they can be readily heard. It is also requested that if you have cell phones or pagers, kindly turn them off or place them on mute. Thank you very much.

I think our first session will be lead by Professor James Clarke. Jim, good morning.

THE STATUS OF RISK INFORMED REGULATION IN THE OFFICE OF MATERIAL SAFETY AND SAFEGUARDS

MEMBER CLARKE: Good morning. Thank you. My first topic is Risk Informed Decision Making for Nuclear Materials and Waste Applications. This is a Tier 1 activity in the Committee's Action Plan and the presentation will be given by Dennis Damon. Dennis, welcome.

MR. DAMON: I guess I'm going to need a chair. My name is Dennis Damon. I am in the Office of Nuclear Material Safety and Safeguards Spent Fuel

Project Office Technical Review Directorate. I report to Wayne Hodges who is the Director of that Directorate. His role is champion of risk informing for NMSS and my job is Senior Level Advisor for Risk Assessment.

What I'm going to talk about is "The Status of Risk Informed Regulation in the Office of Material Safety and Safeguards." This is the title of a SECY paper that was sent up at the end of fiscal 2004 when the Risk Task Group was disestablished and I'm sort of the remnant of that activity. What I'm going to do in the briefing is very quickly go over what the SECY paper was doing. It was sent up along with a guidance document on Risk Informed Decision Making for Nuclear Material and Waste Applications.

Then it took quite awhile for the Commission to peruse this big, thick document that we had sent them and they finally came back after a number of months with an SRM that issued some directives regarding that document. So I'm going to primarily though summarize what's in the document and some of the things that have gone on since it was sent up and the changes that were made to it and perhaps that last bullet there where it says "success with the ACNW finds the added guidance acceptable" I'm certainly not saying we're soliciting that the Committee endorse everything that's in that big document.

The SECY paper was really a status report on what had been done in developing guidance on risk informing NMSS. So it gave the history of what had been done and then it focused on the systematic risk informing process that was described in the document and that it stated that the Risk Task Group would be disestablished and that there would be no funding of risk informing separate from the normal division budgets. The view was it was going into an implementation phase where the guidance and the risk informing would be done as specific projects in each of the divisions. But it stated that the NMSS would continue its commitment to risk informing.

The SRM that came back on it basically said that the Commission approved the staff's approach and then it issued several cautionary statements about the document that had directed us to take one of the appendices out that related to risk informing inspections and it had these cautionary statements in it. At the end, it said it didn't intend that we not risk inform inspections but that it should focus on the front end of the inspection.

There are two ways of risk informing inspections. You could risk inform what it is that you inspect or you could use it to assess the risk significance of inspection findings. So they're talking about yes, go ahead and do the risk informing of what you inspect but that latter thing is a compliance issue and they thought we should leave that alone for the time being.

So the guidance document described that was sent up describes a four step risk informing framework and then it goes on to provide two specific algorithms to address to very specific decision situations. So it's not a comprehensive document. The front part of it is comprehensive and totally generic but the specific decision algorithms, they only cover two particular things. The reason that it focused on those was because it looked to the existing guidance and saw that there was guidance on how to risk inform chronic doses, occupational exposures and other things covered under 10 CFR 20 and related regulations.

But where there was a lack of guidance about using quantitative risk information was in the area of accident risk which is the traditional PRA type of risk and where they looked at what had been done on the reactor side. They saw that there was existing guidance for how to use accident risk on the reactor side but that guidance was very specific to reactors. It used core damage frequency and large early release frequency which are risk metrics that don't necessarily apply to everything in NMSS. So that really was the focus of developing the latter part of this guidance document was to fill those two holes for NMSS and provide something that risk metrics NMSS applications could use.

The place where you find the guidance for how reactors do this is in NUREG-BR-0058 which is the NRC's guidelines for doing regulatory analysis which is back-fit analysis and it tells you how to use quantitative accident risk in screening out certain requirements that you're proposing to impose. The other place that NRR had guidance was in Reg Guide 1.174 which is the other way around. That's when you're relaxing requirements. That are the things that we were focusing on.

This is the four step risk informing process and the real purpose of this, originally it was called Screening which means that if you have an issue or a question that comes up which is like Step 1, define the issue, the question is should this be risk informed. But perhaps that's not such a good emphasis.

The point of this systematic process is really to get the division or the part of the regulatory structure that has an issue to define why they wanted risk inform it. What is the question you're trying to answer? Because so often what has been done is somebody just says, "Well, let's go do a big risk assessment" and they don't calculate the right risk metrics and they don't address the question that was asked. You get to the end and you have a nice risk assessment and you still can't answer your question. So that's really the purpose of this is to get people to focus on what is the question you're trying to answer and march through a process like that, calculate what you need to answer the question and get down to Step 4 here which is where you use that risk information to make a decision.

NRR has recently issues an office instruction for how to do a risk informed, decision making process that is highly analogous to this. It's a structured process. If you have a question for which you don't have an existing risk informing process, they now have a generic process like this one to march your way through the reasoning process.

As I said previously, the guidance document addresses this four step process. But I'm going to go focus on the Step 4 which is applying a risk informed decision method because that's where the Risk Task Group and the people that were involved from all the divisions put most of their effort in the latter phases of this process.

In that Step 4, there were these two algorithms. One is an analog to back-fit. It's when you're imposing a new requirement. How do you use risk in making decisions there? And the second one is when you're relaxing or exempting from an existing requirement. How do you use risk in forming that question?

I just want to emphasize that that's the lack of completeness of the guidance. The guidance document does not cover how to risk inform a license review or how to risk inform inspections. That's something that remains to be done.

The point of this slide is to emphasize that in making a decision in that Step 4 there are factors other than the quantitative risk that are involved. When you say risk informing, people think of the risk part. But the importance of the guidance document is to remind people that there may be other good reasons why you are doing something and that you need to consider all these other factors.

Defense-in-depth and safety margins are two that address the uncertainties involved in a situation. You may quantify the risk but how much confidence can you place in that and that defense-in-depth is certainly an important concept to address the fact that you can't have complete confidence. Of course, there are things other than safety. You may have quantified the risk but what about the environmental impacts or security against terrorist actions? So there are many different things that could be driving a decision and you need to make sure you've identified which ones of these are bearing on the question and not just be looking at the risk.

The underlying principles of the two decision algorithms, imposing a new requirement or relaxing, they both follow a basic decision analysis framework. That is there's a number of factors that need to be considered. Among them, those ones that I've listed up there and these factors need to be acceptable. If defense-in-depth is unacceptable, if you're planning on taking the containment off of the reactor, it's probably going to be something that's going to be rejected.

And then among those things that need to be acceptable is the risk to individuals. Once those are addressed then whatever alternative actions are still left on the table, optimization can be helpful in achieving further improvements. So that's the cost benefit analysis or reg analysis aspect of things.

The guidance document NUREG-BR-0058 and there's another guidance document, the Handbook, NUREG-BR-0184, they discuss these various factors, defense-in-depth and other things and so does the guidance document that we wrote. We've tried to put a little bit more guidance in there on these other factors because there is a somewhat of a weakness of guidance in those areas.

The guidance document refers the reader to other documents that the NRC has issued on how to handle routine and chronic doses under 10 CFR 20 and other regulations. That tends to focus like I said, on the second-to-the-last bullet there, on accident risk but not because that's any more important than any of this other stuff. It's just that there was a little hole. That's where the holes were in the existing guidance. By that, by accident risk, I mean that there are probabilities or frequencies involved as well as doses.

The main concept in dealing with accident risk to individuals is the idea that there are three significant different levels of interest to individual risk. At some level if the risk from an activity or from relaxing a regulation would cause the risk to an individual to rise to a very high level to some individual, any individual, the idea there is there's no acceptable level that the agency should not permit. They should be probated and prevented by regulatory action.

Below that level then, we refer to individual risk as in a tolerable region. The analogy here is to the annual dose limits that are in Part 20 that there's a 5 rem dose limit for individual workers and there's a 100 millirem per year dose limit for members of the offsite public or members of the general public.

So what we're invoking here is an analogy. It's an analogy of is accident risk really the same and there's an unacceptable level of accident risk that should not be permitted. If you're below that, you're in a tolerable zone. But in this zone, that doesn't mean you're done, that you should still seek through the principle of optimization to further reduce both individual risk and societal risk.

But at some point, there's a level of risk to individuals that negligible and this is a guideline level where it indicates to the NRC staff that perhaps they've done enough and maybe they should look elsewhere to apply their time. These are the three regions.

What was done under the Risk Task Group was to develop quantitative guidelines to this lower level of risk, the boundary there between tolerable and negligible. These, they call them QHGs, quantitative health guidelines and that phraseology comes partly from the reactor side and in the reactor side they are called QHOs. But the idea is risk to individuals below this is negligible and it's therefore a very simple indicator that perhaps the regulatory activity should focus on some other area.

As I said, this concept of negligibility and the idea of unacceptable risk, we see this as analogous to what's done for routine exposures. The International Commission on Radiological Protection has also recommended, made this same statement, that they see an analogy here and the document that did that is ICRP Publication 64. I'm just emphasizing here. These QHGs are the negligible level. They don't tell you where the unacceptable level is.

These guidelines are used in two places in the guidance document. One is Table 4.1 which provides the logic for evaluating the acceptability of a relaxation of an existing requirement. However, I have to point out. The QHGs don't really help you in many cases. They help you if you're below the QHGs. Then you clearly -- If you relax a regulation and the risk is still below those QHG levels, you're negligible. You're still okay.

If you're well above them, then it's not as much of an assistance to you because we haven't provided any quantitative guideline as to where that, we haven't provided a quantitative guideline for that boundary between tolerable and unacceptable. There's just the guidelines at the bottom level there.

The other place it's used, they're used in Table 4.2 and this is for the analog to back-fit. If you're imposing a new requirement and if the sole purpose of that requirement is to reduce individual risk yet your individual risk is already, the amount of reduction is negligible relative to these guidelines, then why are you doing it? So it's a screening criterion to let you know you've done enough on individual risk and that that new requirement shouldn't be imposed if that's the sole purpose.

This is a subtle point, a very important point to note. There are many other reasons why you might impose a regulatory requirement other than lowering individual risk. But it does give you that one reference point and this is analogous to what's been done by the reactors in NUREG-BR-0058. They have a screening criterion like this but in NMSS especially, you have to apply it very carefully. You have to ask yourself why are you imposing the requirement and then the requirement may be an information gathering requirement of some kind. It doesn't relate directly to trying to lower risk or a defense-in-depth is another good reason.

These are the quantitative guidelines. This is the base option we call this. There are many different ways you could formulate these things in terms of how you quantify them. This is the one. There are three for the public and three for workers and they cover risk of acute fatality, risk of exposures that are in the stochastic range that could cause latent effects and then deterministic injury level doses that we put those in for completeness because we asked ourselves how do you deal with a case where a worker exposes his hands and he has a deterministic radiation burn but it may not be covered by the latent fatality guidelines.

So we made a complete set of these, three for workers and three for public. The first two up there, QHGs 1 and 2, the quantitative values 5 X 10^{-7} per year, 2 X 10^{-6} per year, those are exactly the same as the analogous reactor accident risk QHOs.

DEP. EXEC. DIRECTOR THADANI: Can I ask you a quick question on this? The first two as you correctly noted they utilize for reactors. Those quantitative health objectives, the background to that was really driven by potential for a very large accident that could impact large numbers of people and there's built into that implicit was a societal consideration, certainly in the latent cancer part. How do you relate that to when you apply, I mean, the background and the thinking that went into those safety goals really perhaps were somewhat different?

MR. DAMON: Yes, I think you're right. I was and over time this evolved and we tried to keep it focused on individual risk and we looked at, the group solicited input from many members of the NRC staff. We also interacted with international bodies and we looked at what other countries had done, what the ICRP had said, and so we tried to capture that idea of negligible risk to an individual. So we felt that even though the reactor numbers had been developed with somewhat different perspective that the magnitude of the numbers was still in the same ballpark as where everybody else was talking about considering risk to an individual negligible.

They're like a factor of, for the public, of 100 or so below where you would say it's unacceptable risk. The United Kingdom Health and Safety Executive, they put out a number for negligible risk for individuals. It was 10^{-6} which is right in between these two and the ICRP also did negligible individual risk level document which was equivalent to in this same ballpark. So we felt the numbers were all about the same. So why not just use the same numbers because the group had been directed by the Commission to do something analogous to reactor safety goals.

However, I'm going to go on to options. I mean you'll notice most of the numbers are about 10^{-6} per year. So one of the suggestions made by several different individuals was why make it this complicated. Why not just have one number? So that is one other way of doing this. And that's what the United Kingdom did. They did one number 10^{-6} and it's for workers and the public both.

But then when United Kingdom did the other end of the spectrum, the high risk level, the unacceptable risk level, they gave the workers another order of magnitude. So their guideline over there is 10^{-3} per year which is a very substantial risk to a worker. That's just the base option.

And one of the characteristics of this option is that the guidelines are expressed in units of probability of a deterministic effect per year. They're looking at the effect, not the deterministic dose. But you're looking at the effect and calculating the frequency of that per year. Like I mentioned, the values are the same.

The reason we included workers is because many of the areas that NMSS regulates is the worker risk that is really the important thing and it's an accident risk that is the important risk. That's why we did include workers.

But there may be a subtle difference here that we make this analogy to routine exposures and chronic exposures. Many of the things that are done in the regulations are done for compliance purposes and they're done in a way that you can make an objective determination that compliance has been achieved. To do that, sometimes things that are done, they're not like a real PRA where you're doing a realistic evaluation. They're bound in cases.

These QHGs right here are intended to be used with realistic PRA type quantification of risk, not with a bounding conservatisms applied in the process of evaluating for comparison. But you do some overall accident scenarios. You use some frequency times the dose and then you apply a conversion factor to convert from dose to probability of latent cancer or acute fatality or injury. So that's how the risk is calculated in doing these to compare to these guidelines.

Previous ACNW feedback was that it was desirable to express the QHGs as dose. So the Risk Task Group devised three options by which this could be done and there are other ways of doing it as well. One way is to divide it. This was suggested in ICRP 64. You take the total risk.

For example here, QHG 2 2 X $^{10-6}$ risk of latent cancer fatality. You divide up that risk. See, that's a risk. It's a sum over frequency times probability of effect. You divide up that risk over a wide range of dose intervals and then you back convert it to a frequency. So you're allocating this risk. Now you have a curve in dose space of frequency versus dose and if you stay under that, if your risk profile of your risk assessment stays under that curve, then you're in the negligible risk range. That's one way of doing it.

The one thing about this is that it's more constraining to meet this than it would be to just meet the one risk number that you have because you may have an application where all the risk is just in one interval. So this is a more constraining way of doing things.

The second option was to have a single guideline and use an expectation value of dose. So this again conforms to the ACNW recommendation of avoiding conversion from dose to health effects and in the sense that you stop it at expectation value of dose which is frequencies times dose and you sum them up over all accident frequencies.

In fact, the problem with this one is what if you have accident scenarios result in acute fatalities. How do you convert that to a dose? So then you're essentially doing a backwards conversion if you try to do an expectation value of dose. I mean you could do it. You could use something like 2,000 RADS and back calculate from an acute fatality. You count one acute fatality as 2,000 RADS. So that's the awkwardness of this one, but it does afford that four conversion. You could use a single guideline here for workers and public. That's another way of simplifying the thing.

The third option is to keep the deterministic effects and stochastic effect levels of dose separate. So you have these six different ones but you notice the QHG 2 and QHG 5 which deal with the stochastic dose levels that only lead to latent effects, those are expressed in expectation values of rem because that's the straightforward way of doing expectation value. You just end up with units of rem per year. But the other ones, acute fatality and other deterministic effects, when you get a dose that yields an acute effect like that you just count it as an effect.

So those are three options but there are other ways this can be done. Again, you could have one level for both workers and public. You could drop the injury QHGs. There are other ways of dealing with injury dose. The public health people have a thing called Qualies which is probably the better way of dealing with it. It's a way of equvalencing what is a Qualie. It's a way of converting injuries to an expectation value of life lost, so many years of life, and they have ways of doing that.

Appendix I in the document also identifies a bunch of issues and questions related to these QHGs that still remain to be -- They were considered in the process but they are the questions that are of interest. Again the risk when you calculate it for comparison of these you're calculating risk to individuals. But in practice, you typically evaluate for something analogous to a reasonably maximally exposed individual just as reactors did for the QHO 1 which is they averaged the risk to the individuals who reside within one mile of the facility. It's that kind of analog. But the RMEI or critical group is going to be different for different applications here.

Then the guidance also directs the user and has a primer on value-impact analysis. So we want to familiarize the staff with the value of doing that and we did several trial applications where that proved to be a very useful tool to illuminate different situations especially risk trade-offs.

There have been a number of pilot studies done over the years and most of this is in the public record. There are some studies that haven't been published yet but these are some of the things that I at least learned from them that the virtues of having this comprehensive systematic approach is you pick out some of these kind of situations like this where cases where the worker and public risk are affected in opposite directions. If you just focus on one factor or one type of risk, you can overlook things like this and there are actual practical cases where this has come up.

And the value-impact analysis also is useful in identifying risk, risk trade-offs. There are different kinds of risks to the workers. There was a case where there was a chemical risk and criticality accident risks were involved and you had to make sure that you weren't increasing one when you were trying to decrease the other one and you try to find the optimum point on that.

And then another one is defense-in-depth. There were decision situations that came up where it was clear that the risk really wasn't the issue. It was the question of whether you were giving up a whole barrier to accident risk and did you really want to do that.

Another thing we found out is risk is difficult to quantify in certain areas. There just is an absence. It can be quite difficult to get risk information in certain areas.

Then the last one was non-radiological versus radiological risk trade-offs because the NRC doesn't, there are some non-radiological risks that the NRC does regulate. But there are others that they don't. But we encounter decision situations where you came face to face with that fact that you were putting in a safety system that had the potential to kill the worker. So the safety system was there to prevent something but it could also kill the worker. Well, the NRC is responsible.

You have to be careful and pose that that you've considered what really makes sense. That's one of the virtues of going through reg analysis and individual risk analysis that includes the part of the risk that the NRC doesn't regulate. You put that in too and just see what you're really proposing, what the effect is of what your proposal is.

This has to do with potential future initiatives. As I mentioned before, the guidance document only in the end provided decision algorithms for two cases. One is imposing requirements and the other is relaxing requirements. And there's the other two big areas that the NRC staff does, their inspections and license review. That's where I think there would be actually probably a bigger impact on staff's activities if we could help the staff do those activities in a more risk-informed way through providing guidance and training and so on.

The last bullet there is I think there's an opportunity also to expose the NRC staff more to the ideas of risk informing through sharing their experiences in these difference areas because NMSS, I don't know what it's like in NRR because I've never worked there, but NMSS because of the fact that they've divided licensees up into categories they kind of compartmentalized and a lot of people don't really know what goes on in the other areas. So they don't learn from one another's experiences. That's a fruitful area.

In conclusion, this document ran into a problem when it went up. It ran into the sense of information screening issue and so it really hasn't been available to the staff for public use until just recently. But it was intended to be living. Unlike a formal approved new reg, it was recognized this document should be a living document to be changed as a result of trial applications and that it's not intended at the moment to formalize this as some kind of concrete guidance. That's my presentation.

MEMBER CLARKE: Dennis, thank you. That

was a very nice presentation. I'd like to get us started with just a couple of questions on implementation. As I understand it, the decision has been made that this will be approached on a case-by-case basis.

By that, I mean the divisions will, using your schematic and your first decision on the schematic, decide whether or not a risk assessment would be helpful to a decision that they need to make. The guidance that you have developed is a resource to them to do that. The task force has been disbanded. Are the members still available, is that a fair question, to be a resource as well?

MR. DAMON: I'm sure that we could call them back. They're all still around here. When we get into a case where a division needs to do risk informing, they're obviously going to need assistance. There's myself. Then there are many people around who have the appropriate background to give the staff guidance.

MEMBER CLARKE: I guess the reason I ask is I don't see an implementation process and it seems to me it's pretty much up to the divisions as I understand it whether or not they will need to do this or would be helpful to do this and then if they decide yes it would, then you do have guidance as a resource. And the other quick question is are there any applications that you're aware of on the horizon where this might be used.

MR. DAMON: Yes, there are things on the horizon where I think it may prove insightful to do some risk informing. One of them that's being worked on, the fuel cycle division, is they're looking at chemical hazards in the MOX fuel fabrication facility. But the difficulty with situation is that the way a MOX licensing process is done, they, the applicant, has not yet submitted the actual physical design of the facility yet. They submit a document in which they sign up for various design bases criteria but there's no design in hand.

But at the time the application is submitted, all of a sudden there will be a design and there may be in fact some quantitative risk information in what the applicant submits. So then I have a contractor. It's not me. It's fuel cycle division. Again, each division does their own thing but I help facilitate the process of getting somebody in place to look at the chemical hazards in that facility because that turns out to be a significant issue.

MEMBER CLARKE: Thank you. Ruth.

MEMBER WEINER: I have a couple of questions on your slide 19 if you could go back to that. In other applications, the right-hand column, the frequency column, well, the entire scheme is derived from an event tree that looks at actual events and their frequency. How did you determine these frequencies on the right-hand side?

MR. DAMON: This is done the way I said. You see the number at the top there, 2 X 10^{-6} per year.

MEMBER WEINER: Yes.

MR. DAMON: You take that and divide. There are five intervals there. You divide that number by five. So that's an expectation value of dose. Then I divide by the dose and I get a frequency value. It's not exactly this. It's rounded off to the nearest magnitude but that's how you do it.

MEMBER WEINER: In other words, this is not connected to any actual observations.

MR. DAMON: No, it's the criterion curve. It's the guideline curve that indicates what would be negligible and if you did an actual risk assessment and you had scenarios, suppose you had a scenario and it had a certain frequency which you estimated and then it produced a dose in that range, say 0.1 to 1.0 rem, then you would score that frequency in that bin. So when you did the risk assessment you would adding up contributors to each of these bins and when you were done you would have a frequency in each bin and it would be curve or a histogram just like this and you could compare it to this set of numbers and see whether you're over or under.

MEMBER WEINER: So this is used as a comparison and it's not intended to be a realistic assessment of frequencies of doses in real accidents so to speak.

MR. DAMON: This is intended to tell the reader what would be a negligible frequency of doses in that interval, of negligible frequency of -- Say if you had some accident scenarios in the range one to 10 rem that says that if the sum total of those is less than 10^{-4} per year, that's a negligible risk to the individual. That's what it's intended to tell you.

MEMBER WEINER: So okay. That's a different use from the use to which this kind of table is frequently put. This kind of table is frequency used as you get the frequencies from some frequency of actual events, how many accidents in a year and so on.

MR. DAMON: Right. This is the criterion

and then you have the actual risk assessment which would be a different set of numbers.

MEMBER WEINER: Right.

MR. DAMON: And it might have any -- You don't know what the profile would look like. It could be declining with dose like this or it could be something else. You don't know and there's another like an ICRP 64 and the United Kingdom did this in a document called "Safety Assessment Principles." They have two staircases like this. One is the unacceptable level and one is the negligible level. So this is just the negligible level staircase.

MEMBER WEINER: My other question deals with your trial applications slide 21 I guess. Keep going. The next one. That one. The case where you have the effects in opposite directions, have you considered using a multi-attribute utility analysis to analyze these cases because it seems to me a logical application for such an analysis?

MR. DAMON: These are usually we're looking at the same attribute. It's usually fatality is usually the one we're looking at.

MEMBER WEINER: Yes, but you are looking at worker fatality --

MR. DAMON: Oh, yeah, versus public.

MEMBER WEINER: -- versus public fatality and that's not the same.

MR. DAMON: Right. That's why I put it up there. It's an interesting question.

MEMBER WEINER: Well, it gets back to my question of have you looked at analyzing these with some kind of multi-attribute decision analysis technique.

MR. DAMON: No.

MEMBER WEINER: Because it seems to me that this would be a logical application. I'm quite familiar with the chemical versus radiological trade-off. In other words, do you do a trade-off analysis?

MR. DAMON: I think what I was just trying to point out here is the virtue of doing this in a systematic way where you do identify these different types of risks so that the decision makers are aware of whether they're going to be increasing the risk to the public when they're trying to address something for the worker or visa versa that they should certainly -- Whether somebody has found a way to do this that helps them, I don't know. But certainly you want to be aware of it I think.

MEMBER WEINER: I would suggest that part of your guideline address exactly this question because this is really the difficult question in risk mitigation is when you have a trade-off like this.

MR. DAMON: And there was one - Well, I can't say that. There was one case that came up where the focus initially was viewed as a relaxation of a requirement to protect the public. So they did a risk assessment for risk to the public. But fortunately in the process, they looked at the effect on workers.

It turned out the public risk was still negligible. In fact, it might even have been a decrease. But the point was that they realized that if they had taken one decision, the worker risk would be enormously higher. So it was in the reactor vessel decommissioning but it's a typical thing in that kind of environment, a decommissioning, demantlement, all kind of other reacting to events. You could have a very large impact on workers to try to ameliorate something for the public to a much lower degree.

MEMBER WEINER: Let me suggest that it's exactly in decommissioning that these problems are going to come up repeatedly and I think it would be very wise to look into that. That's all I have.

MEMBER CLARKE: Okay. Dr. Ryan.

CHAIRMAN RYAN: Thanks, Jim. Dennis, it's a great presentation. I really appreciate your three options and the fact that you focused on dose.

A question on Option 2, do you think about an acute radiation injury as a radiation question or an occupational safety question? I'm sort of implying that if you look at fatality from a work injury what's the difference between a fatal exposure to radiation and a fatal accident where somebody gets crushed or some other horrible thing.

I wonder if treating that more in industrial accident framework might be a way to overcome this question of the fact that it's radiation dose and we can calculate risks from radiation. If it's an acute, non-stochastic effect it kind of takes on the flavor more of an industrial injury to me. Does that separating it out make sense?

MR. DAMON: Yes.

MR. RUBIN: And then you're kind of really focused on what's the right number. Is it 1,500 or 2,000 or 2,500 or medical intervention or not or those kind of things and that's a fairly straightforward decision, probably relatively insensitive to the dose you pick too versus trying to deal with what you've successfully binned into the fatal cancer arena for small chronic doses pretty well? Does that make sense?

MR. DAMON: Yes. I think that's the way the people who are involved in developing these guidelines viewed acute fatality. They don't view as any different from the chemical fatality or a mechanical fatality.

CHAIRMAN RYAN: Right. Sure.

MR. DAMON: It's just occupational fatality. That's the things in the document that we're comparing things to see is this, the levels we're talking about, negligible relative to occupational fatalities. They were looking at the total occupational fatalities of which I think there's 6,000 in the U.S. each year.

CHAIRMAN RYAN: Right.

MR. DAMON: And that's what they were comparing it to.

CHAIRMAN RYAN: So that's good. All right. That answered my question. Back to Option 1 for a second, it strikes me. Is there any value of looking at the function or the histogram for actual occupational radiation exposure in trying to figure out that those bins work and that those frequencies work?

MR. DAMON: That's an interesting question. My memory is that the median for occupational exposures are in that second interval there.

CHAIRMAN RYAN: Yeah.

MR. DAMON: It's right around in there.

CHAIRMAN RYAN: It's very compelling when you think about it because obviously it's greater than 100 rem. I don't know that we have any occupational exposure on record at that level or if we do, it's very small numbers and I'd have to think about agreement states, too. It would be interesting to see if that functionality held us up a little bit. That might be a way to justify those bins a little bit further. Something to think about.

But it looks an awful lot like the distributions we see with those documents are discussed. Something to think about. Anyway, Jim, thanks very much. That's all I had. Again, thanks for your great insight and great presentation.

One final question is I guess it gets to the implementation and more the lessons learned side. Is there any plan to systematically capture all the lessons learned in the applications and study them in any way as time goes on? I would hate to see the momentum fade a bit.

MR. DAMON: I think that they are relying on me to facilitate that. But I would like some help and so the idea was that when there would be actual application of this guidance document on a trial basis that the process of lessons learned and evaluating the approach and so on would be done as part of the process. I think it's described that way in SECY paper that they didn't have any separate funding to fund a generic team to just do, except for me, this process.

So they recognized that what would have to happen is when an application would be done that they expect the division that's doing it to support this kind of a process. I would be available as one resource but they could bring in others as well.

CHAIRMAN RYAN: Sure. And that's something for us to consider as we think about it that maybe that's something to address. Thanks. Thank you, Jim.

MEMBER CLARKE: Allen.

VICE CHAIRMAN CROFF: Yes. I'd first like to come back to the implementation issue that Jim started to raise and maybe take a different direction. As I understand the initial decision, if you will, this is Step 2 in that diagram, somebody in NMSS is faced an issue that they have to address and if I read the guidance correctly, it's suggested that in a time span of no more than a few hours that they reach a decision on whether a risk assessment would be a worthwhile or potentially valuable thing to do or not.

That seems to me it's not a lot of time. But also, it's very difficult to decide whether a risk assessment would be valuable until you have some inkling of what the answer is. The value of it is to sort of lead to those cases where maybe some things are maybe a little bit overdone or this kind of thing. And that would seem to be without some inkling of the result very subjective. Is there any mechanism to encourage getting a little bit further into the risk assessment to see whether it would be valuable?

MR. DAMON: I think I mentioned when I described that diagram is that the real purpose, the diagram is a little bit, more than a little bit, misleading. It tends to imply that it's just a tool to avoid doing risk informing because you have a flow chart and you branch out and you don't do it. The real intent was to focus the people who wanted to do the risk informing on why they're doing it, to ask the questions and clarify their objectives up front so that when you do the risk -- So it really wasn't expected that -- The times when you really run into not being able to do the risk assessment I'd say would be cases where you're under some kind of time pressure, you need an answer, you have to make the decision now and you just don't have the time to do it or a case where it really isn't really technically feasible and you just have to --

But usually what the case is is there is some kind of risk information you can bring to bear. It's certainly true if you have a case where you really don't have a good understanding of what can go wrong or what it's magnitude is. You're certainly in a position where that's why you should be doing the risk assessment and it's basically answering yes to the first question up there of why are you doing this. It's because we have no idea whether this is a high risk or a low risk impact thing. So then you would pass the criterion and you should go on.

I think as a result of my meeting with the Committee in June that that made me more aware of the importance of being proactive to the divisions about what they might learn if they had some risk information because this is really the difficulty for some of the divisions. It's that they don't have a comprehensive set of risk information. Some divisions do and others don't. And perhaps we need to focus on where in these divisions that don't have the information where's the dark. Where's the unilluminated areas that they don't really have a good picture of.

VICE CHAIRMAN CROFF: It seems to me as the guidance goes forward it's stated as being a living document but language at the outset including what you've articulated here might be useful, a little bit stronger lever to get people to do this.

A second thing, in a couple of places in the presentation, you mentioned factors that might modify a strictly risk-based decision and I certainly agree that there are any numbers of these. But one you brought up was defense-in-depth and you didn't state but I think you sort of indicated that if you did a risk assessment and it looks like the risk, let's say, was negligible but that would lead you to give up a barrier and maybe that wouldn't be such a good thing to do. But isn't that the point of risk informing if resources are being devoted to a place? I'm not sure whether you really meant to go there or not.

MR. DAMON: I see what you're saying. What I'm saying is this whole discussion is pointing out is that it would be useful to have some kind of criterion of some way of evaluating defense-in-depth and saying there's a minimum level needed and if you go beyond that, now you're in this more risk-informing area. If the risk criteria tend to tell you you really don't need anymore, then you don't have any more.

The point is the concept of a minimal level based upon uncertainties in your ability to assess risk, on the consequence levels that you would get to if the event happens, criteria like that. That's the way I would look at it. People have written guidance along these lines before and the idea is if the maximum dose you can get from something is one less than one rem, then maybe you don't need more than one barrier.

But if it gets up in the deterministic range, maybe you need two barriers. And if you get higher, you need more barriers, but a minimal level and not just the fact that you're giving up one level. You may have completely adequate defense-in-depth. So it's not necessarily I'm biasing the thing in favor of defense-in-depth. It's just I'm advocating that we ought to have criteria for it.

VICE CHAIRMAN CROFF: I think an uncertainty analysis might illuminate a lot of that as to what the spread in the risk values is. I think finally taking off a little bit on what Ruth was saying it seems to me there's some very interesting cases for risk informing, the whole decommissioning area where you're invariably going to trade off more worker risk to remove more things against presumably some reduction in risk to the public and as a specific subset of that, this whole tank clean-up waste determination business that the NRC is involved in. Are the folks in NMSS that work in those two areas, is it your sense they've reasonably well embraced this whole risk informing thing?

MR. DAMON: Yeah, I think the Division of Low Level Waste, they've had several efforts in risk informing things. The specific thing about how do you trade off public versus worker, I don't recall having seen anything from that division on that. There probably is something but I'm not aware of it.

VICE CHAIRMAN CROFF: Okay. Thanks.

MEMBER CLARKE: Thanks. Bill.

MEMBER HINZE: Just a few questions, Dennis. I notice in your flow chart that one of the inputs to No. 2 is cost information. You haven't mentioned cost information in your discussion with us. Where does that feed in and why? Initial risk and cost information?

MR. DAMON: There is cost information that comes here in at least two different places. One, it comes in up here and then it comes in down here, Step 4.

MEMBER HINZE: Where is that? I'm sorry. I didn't see it.

MR. DAMON: Steps 2 and 4 are both may involve considering cost.

MEMBER HINZE: Okay.

MR. DAMON: In Step 2 what you're doing there if you look in the guidance document, that step has a chapter in it of screening consideration. The screening considerations involve first deciding what question you have. Does a question that you have need risk information to answer it? So if you have a question and you don't need risk information, then I guess you don't need to do a risk assessment.

Given that while risk information would be useful, the second type of criteria are feasibility and then finally feasibility literally, do you have the time to do it, do you have the people, do you have whatever, could you get the risk information and the last criterion is a cost versus benefit consideration.

If the risk assessment costs you a lot of money and answering the question isn't really that important of a question, then you get screened out on that basis. So it's just a common sense thing which probably the staff would never need to, I mean they don't need our guidance to figure those out usually. They know when you're asking somebody to spend a lot of money they're going to ask the question is really worth spending the money to do this.

MEMBER HINZE: But you have to have a certain amount of information upon risk before you can answer that question.

MR. DAMON: Yes, that's the point.

MEMBER HINZE: It's your chasing yourself.

MR. DAMON: Yes. This is the same point as was made before is that this is really not as simple as it looks. You can't do this stuff without some information and it's a Catch-22 kind of thing.

CHAIRMAN RYAN: Right. So it needs to be a much bigger diagram with loops.

MR. DAMON: Yes, it has loops in it and the recent NRR guidance on risk-informed decision making for emerging issues, they came to the same thing. You almost do this simultaneously. You have to gather some risk information, some cost information and you take a look at that and you say do we need to go any further here. Would more information help us make a better decision and then you just keep gathering information until you're comfortable that we have enough here to make the decision with. So it's really as discreet as it looks.

MEMBER HINZE: Another very simple question, I think this really revolves around your discussion with Allen here just a moment ago, and that is these factors that seem to trump risk, defense-in-depth, environment security, etc. how are those weighted? How do you know whether they really trump? Is there some weighting function that's applied to this? Is there any quantification of this or is this just strictly subjective?

MR. DAMON: I wouldn't say they trump risk anymore than risk trumps them. Risk to individuals is one of those specific things that the idea of identifying these factors is that each factor is something you need to consider and a factor might be important enough to drive the decision. But it will all depend on the circumstances of it. The thing about it is that there's relatively little guidance as to what is a minimal necessary level of defense-in-depth.

Safety margins are even more problematic because safety margins are usually in there to cover some uncertainty about the physical performance of something that you literally don't have a very good -- There's some residual uncertainty about what will the temperature go to or whatever and you need some margin in there to address that, how big and there's no easy answers here.

MEMBER HINZE: It's not an on/off answer. It's very much of a --

MR. DAMON: But it's something that should be thought about is the point of this. Just as in the reg analysis guidance documents, they list all these things. They have a little section on them so that the analysts think about each specific one of these so that something doesn't get overlooked. That's more the gist of this. But it would be nice to have criteria as well.

MEMBER HINZE: Let me ask a final question, a naive question. Why shouldn't Option 2 be the name of the game because workers and public are equally important to us? I understand your statement here that worker accident risk is important NMSS but worker and public dose from an ethical standpoint, is there really a difference here?

MR. DAMON: That's the question. The

practice generally has been, as in Part 20, to allow risk to workers to be incurred that are in some cases higher, they could be conceivably higher, than for the public. And the same is true with what the United Kingdom did when they faced up to this decision. They said workers could be allowed to be exposed to higher occupational risk fatality. But it's not for me to answer that question. It's just outright, but we raise it anyway.

MEMBER HINZE: It's an important ethical question. What was the basis -

CHAIRMAN RYAN: Bill, if I can interrupt for just a second.

MEMBER HINZE: Sure.

MR. RUBIN: And maybe give you an additional insight there and add to Dennis's comment. I think in both cases the principle of ALARA is also involved. I don't think it's fair to pick on a number versus a number. That's not really appropriate at all and, in fact, in the workplace even though limits at the 5 rem level per year, it's extraordinary for anybody to even approximate that because of the overriding ALARA principle and in fact as we've pointed out in looking at Option 1 that the 100 millirem or so range is probably where the mean worker exposure at least in the power industry and perhaps across the board. So I don't think it can be taken up as an ethical question without really thinking about the overriding principle of ALARA and how that enters into the discussion.

MEMBER HINZE: They're both important to us of course.

CHAIRMAN RYAN: Yes.

MEMBER HINZE: Let me ask you, Dennis. What was the basis of the United Kingdom's decision on the worker dose? Is there a simple answer to that?

MR. DAMON: I believe they may have some discussion. They have a document called "Reducing Risks - Protecting People" that you can access on their website and they have a whole section on this. I'm sure they say something about it in there but I don't know.

In the development of the guidelines here, the same question comes up. Should they be different and, if so, why? There was a feeling. I think the feeling was it kind of did align with the UK thing and that is the level of unacceptable risk might be higher for worker but maybe the negligible level should be the same. If you're saying when is risk negligible to a worker, it's when if he doesn't really feel like he should be exposed to a risk, he's not really volunteering for it and he wants somebody to tell him what's a negligible level, maybe it's the same number. So it was along those lines, but it's kind of a philosophical question.

CHAIRMAN RYAN: I guess my view is I don't know that consistency is necessarily a goal one should reach for but certainly widely divergence is probably something you don't want to have either. So I think the fact that they're compatible is probably okay. That's fine. But it's not that one is better than the other I wouldn't guess. Why would one be preferred over the other?

Again in the context of uses of radiation in medicine for example, we expect individual diagnostic doses that dwarf these doses and dwarf the workers doses. It's hard to take a number and a number and just say let's compare the numbers without some sense of the context and other principles that are applied as well like ALARA.

MEMBER CLARKE: Ruth, you had another question.

MEMBER WEINER: Just a quick one. We're frequently asked to disaggregate risk and look at the consequence. One of the charges that is often made is you say it has a very low probability but look what happens if it happens. How are you prepared to respond to that or have you thought about how to prepare to respond to that kind of question from the public? The risk is very small but you're dealing with a low probability, high consequence event.

MR. DAMON: One of the things that we recognized that hadn't been done, I made up one slide there that said we did these two things and there are other risk-informing things that haven't been done. There's another kind of risk informing that hasn't been done. It's what I would call qualitative risk informing. How do you instruct those who are going to do a risk informing to do what you just said, disaggregate? That's what I do.

If somebody comes to me and said I did a risk assessment and I got 10^{-6}, I say show me the risk assessment. Show me the scenario. I want to know how you got that, what went into that and I'm not really interested in the number alone.

I think the area where in decision making space it comes in is a couple things. One of them is are you convinced that this was a good risk assessment and that they've thought of everything and secondly, I think comes into the defense-in-depth question because as you said frequencies can sometimes rest on prediction of future human behavior or something else that isn't too, you're not too comfortable with. The consequences, sometimes you have a much better feel that that's about the level of consequence. So when you have high consequences you want defense-in-depth and the risk assessment should help tell you whether you have that or not.

MEMBER WEINER: That's a very interesting point of view. I appreciate that. Thank you.

MEMBER CLARKE: That's Ruth. Do we have time for further questions from the staff? Dr. Larkins?

EXEC. DIRECTOR LARKINS: Yes, one of the things that keeps coming up in PRA space is the quality and you just touched on it. In some of these areas, you don't have a lot of information and reliability and other things. So are you looking at some guidance in terms of developing something in the quality needs in these areas?

And another question, you mention under applications that possibly you might be looking at the MOX facility and Part 70 lies CD to do ISAs (sic). Are you going to be able to use that type of information?

MR. DAMON: I think the staff hopes to be able to do that. The ISAs are done and there's a diversity of approaches. They don't all use the same thing but they do usually do a pretty good job of identifying what could go wrong. So that's certainly an important starting point and also of categorizing the magnitude of the consequences where they don't do as much as in realistic frequency estimation and partly that's just a feasibility question. It's applicable data and things like that. But there's a lot useful information I think and just to simply identify what you're relying on to prevent the accident is a very useful thing I think.

EXEC. DIRECTOR LARKINS: There are no plans on doing a PRA for a MOX facility.

MR. DAMON: At one point, I was told the applicant should have some quantitative information in regard to risk to the offsite public but not to the workers. That's what I was told at one time. They were thinking about doing quantitative assessment for offsite but not for the workers.

EXEC. DIRECTOR LARKINS: What about this question of quality? The big thing in PRA right now is developing standards, consensus standards, other types of standards to be used in PRAs. Do you see a need as we develop applications in the non-reactor arena to move in a similar direction?

MR. DAMON: I think it would be useful to have something but what I would be doing is tasking myself I think with doing that. But I've thought about this a lot in the past and I used risk information when I was an active license reviewer and it's a context in which I think you can use the information to illuminate the situation and give you further guidance. But I don't think I ever put it into a standard safety evaluation report and said I calculated this risk number. So it's okay to do this. But I did do little risk assessments to illuminate.

What I think is true is there's a hierarchy of situations in which certain situations advocate in favor of you bet have darn good risk information if you're going to base your decision on it, for example, enforcement situations, relaxation of safety requirements and now you're going to rely on risk information. Well, that had better be good risk information or you're reducing defense-in-depth. So there's someone could write a nice qualitative document on when do you need to be very sure that you're right and in other cases if what you're doing is risk informing where you're going to do your inspections, it's certainly important but it may not have as dramatic of an effect if you're not exactly inspecting exactly in the most important areas. So there's that kind of thing.

Risk informing a license review is the same way. I've been in situations where they wanted the review done in two months. Well, what's important and you focus on that. In that context, the quality doesn't need to be as good because you're doing the best you can. Whereas in the other case, you may be have more time. You have a more important question and the quality needs to be better.

MEMBER CLARKE: Okay. Mr. Thadani.

DEP. EXEC. DIRECTOR THADANI: Dennis, I think you and Wayne had an extremely difficult job. Are there champions within the divisions that are looking out for initiatives that could be then risk informed? I mean for you it seems to me to be very difficult to move forward. So are there champions within the divisions to move in this direction?

MR. DAMON: There are personnel who are designated to have a responsibility in their risk informing. How much of a champion they are, I can't -- Some of the divisions are very vigorously quantitatively pursing risk informing. So they tend to have very focused, strong programs with individuals responsible for them. The Yucca Mountain does their sensitivity study. It's quantitative and they try and risk inform the Yucca Mountain review plan and it's very vigorously pursued. And others, they'll have a designated person but they don't have it, they're at a different place in the process I think in some divisions.

DEP. EXEC. DIRECTOR THADANI: I think it's important because Allen's point and Bill's point, one can look a fairly narrow look at that risk analysis or you can take a broader look and say you think about uncertainties that somehow risk analysis should help you in deciding what's an appropriate level of defense-in-depth and things of that sort.

As you know, the ACRS coined the "terminology of structuralist and a rationalist." Listening to you, you sound to me like you're close to a rationalist. Now if you don't have champions within the divisions, you may find perhaps people suggesting that these elements are mutually exclusive which at least I don't think they are. I think they are interconnected and it would be important to have some, I'd say, level playing field within the divisions. It would be important to pay attention to these points that have been raised as you go forward.

Let me ask you a brief question on the inspection. The SRM on your Chart No. 4 said the charter used risk-informed approach to the front end of the inspection program. I assume this because of the cost considerations and so on. They said front end. Does that mean areas you inspect but excludes any enforcement aspects? What does that last sentence really mean?

MR. DAMON: That's the way I took it was that they were sensitive to the idea because what was put in the guidance document originally as Appendix F on inspection was an analog to what had been done in the reactor oversight program which is to have a color-coded thing for identifying the significance of certain kinds of findings and so when I saw that they rejected that and said this, I took that to mean stay away from the enforcement end and focus on where you inspect.

CHAIRMAN RYAN: Just a question that follows right up on that, Ashok. I remember from Paul Wellhouse's presentation on the agreement state programs update that they have a leading indicators view of that when they look at individual agreement state programs. Is that the kind of concept that you're thinking about there as well?

MR. DAMON: I think if you stay away from compliance. I see compliance as being a very legalistic thing and risk is little bit of a difficult thing in some of the areas of NMSS in that it's different if you have a priori risk assessment and you've already preidentified and said if this goes wrong, this is going to be considered risk significant. Then it goes wrong. Okay, you got fair warning. We're going to enforce on you.

What usually happens in some of these other areas is you don't have a risk assessment. Something goes wrong. Then you do the risk assessment and say you guys, did something bad.

CHAIRMAN RYAN: Yes, I think the leading indicators is really the prospective kind of an assessment that would have a tendency I would think to address. If you don't address this problem, then you are getting into an area where compliance could be in question or you could be taking risks and so on. So leading indicators is maybe an interesting thing to think about in that context.

MR. FLACK: John Flack, ACNW staff. The Committee asked so many good risk-informed questions that I'm running out of things to ask you over here.

But I did have a couple of things and I think the question about the infrastructure is a very good one because if you don't know what the risk can do for you, how do you go about asking questions on what it can do for you? To some extent, there's a start-up cost in all that and if you don't pay up front, you don't get the benefits out at the back and a lot of that has to do with the questions that were being asked here. So they were good questions.

The only question I have is the difference between what you call "guidelines" and "goals." You used the word guidelines and of course, the reactor side have goals. Can you clarify what the difference in its use in the terminology? Do you use them the same way or they are really the same things or are they really different?

MR. DAMON: I would say that if you talk to someone who has been through the whole process by which the reactor safety goals were developed and thoroughly understands what the intent was that they are really the same thing. However we tried to pursue that approach in NMSS and we consistently had the same result which was that if you use the term "goal" or "objective" it was misunderstood to be something with which you must comply and we kept telling people no.

We finally gave up and said let's try changing all the terminology and maybe we'll have more success. So that's we changed from objectives to guidelines was we just had a consistent record of failure to communicate.

MR. FLACK: Just one other question too on that. If one interprets them as goals, it seems like they would be applied universally across the different groups. I guess the question as we talked about before is these things have benefits to society and some groups might have more benefit than others. Would it be appropriate then to use the same goals? In other words, you may want to accept more risk for those that have a much more benefit to society than in other groups where you may find it doesn't have as much. I wonder what your comment might be on that.

MR. DAMON: My perspective on that is more like Dr. Ryan's. Where you really get to depends on applying the principle of ALARA or optimization. That's really where you want to be. These guidelines as to where risk is negligible is where you want to be in some hypothetical universe where you weren't constrained by all kinds of physical realities.

But in the real world you want to optimize. You have to still think of everything and come out to the best place. So it would be nice if risk to individuals is negligible but, in fact, it isn't yet. But people were making progress. The accident risk to workers in the United States has consistently continued to go down every year.

MR. FLACK: And that would kind of move you away from having an absolute goal for that sort of thing that's universally accepted.

MR. DAMON: That's why we abandoned the idea of objectives. These are not goals in a real, practical, applied sense. They're just a level that is very negligible and that's all they're intended to do is to alert the staff that if you're thinking about working on individual risk you're probably already good enough when you're down at these levels.

CHAIRMAN RYAN: In fact, the workers, I'm just looking up here in NUREG 0713 the trend in the average measurable total effective dose equivalent per worker has decreased in every one of six NRC categories from '94 to 2003. So it's interesting to see that that's the trend there as well.

MEMBER CLARKE: Any other questions from the staff?

CHAIRMAN RYAN: You have our guest at the Center.

MR. FLACK: I'm sorry. There may be a question you want to ask. I don't know if you intend to do that but what would be the follow-on meetings that we might have or workshops?

MEMBER CLARKE: Yes. Dennis and I did talk about that briefly and we've talked about it among the Committee as well. But we have a vehicle that we call our working group sessions where we can round people up and pursue topics that have merit towards things that we're dealing with. We may not be able to do that this year but that's something that we wanted you to know that we would like to talk to you about if you're interested.

CHAIRMAN RYAN: I think as perhaps other applications come up and there's some experience base to build on that would be interesting to hear about for sure.

MEMBER CLARKE: Yes. Absolutely.

CHAIRMAN RYAN: Probably at the Center too.

MEMBER CLARKE: Right, and our folks in San Antonio, do you have any questions?

MR. DUNN: We don't have any questions from here at this time.

MEMBER CLARKE: Okay. Thank you. We do

have a few more minutes. Okay, Latif.

DESIGNATED FED. OFFICIAL HAMDAN: I want to restate Ashok's question and ask you, Dennis, what do you think is really going to happen to this guidance in the way of implementation?

MR. DAMON: First off, the intent is to train the staff in it. There are these risk champions or whatever you want to call it. There are people in each division that have been assigned to have cognizance of this stuff. So my first intent is to expose the staff to this, to find other mechanisms to expose more staff to it.

That's really the way I see this eventually becoming used is to have people who understand when it's appropriate to apply it. I've thought about writing a little, short, simple guidance document on when should you be thinking about risk informing in NMSS.

CHAIRMAN RYAN: That's a great idea.

MR. DAMON: And just identify some specific situations. If this happens and this happens, you should think about risk informing. So there's a mechanism. I think the management supports this type of guidance. There is a risk steering committee for NMSS and they supported this stuff. But

I think the general staff, it is sufficiently subtle content here and sufficient complexity that it takes awhile to train people and bring them up to speed on it.

Like I say, we had a lot of trouble exposing people to risk guidelines that they would immediately say that they're compliance, that they get these two levels confused here. So there are subtleties like that that you just have to educate the staff.

MEMBER CLARKE: Okay. Can you take us to the schematic? I just have one brief comment.

MR. DAMON: The flow chart?

MEMBER CLARKE: I don't know which slide that is. The flow chart? I think what's come out of the discussion at least it seems to me to have come out of the discussion is that the text in No. 2 is misleading and there may be a better way to say that. The decision really is not whether to risk in -- I think the decision is whether or not a risk assessment would have merit in making the decision might be one way to say it. I'm just throwing this out.

But the other thing that I think has emerged is the value of additional guidance on the pros and cons of doing what a risk assessment adds.

You have a section on ways to do the risk assessment, your standard approaches. I think Allen or others have suggested making it possible to have a better appreciation for what a risk assessment could do for you would be good contribution as well I think.

So let me just close with that. What I wanted to say was we do have a few more minutes and later on in the agenda we decide whether or not we think there's a merit to writing letters to the Commission on presentations that we've heard. You're here, Dennis, and we have a few minutes. I would like to talk about that.

I'm inclined to think that we should. I think a number of things have come out of the discussion that would have merit. But I would like to hear from the Committee what they think about those.

CHAIRMAN RYAN: Okay. How do you want to start? It's up to you.

MEMBER CLARKE: Go ahead.

CHAIRMAN RYAN: I agree. I think we've heard a number of interesting comments. One is to I think support the options that you presented for example for criteria and maybe some suggestions for example how does that profile line up with worker exposure, histograms and so forth. Your comment about maybe a short training pamphlet or brochure or smaller document that would give some insights would be helpful and just off the top of my head there seems to be a number of real positive things to help keep it moving forward.

I think the Committee is well on record with the idea that risk informing decision making is certainly the way to go. I think a letter from us would help keep that flame alive and keep the ball moving in that direction. I certainly think there's plenty to talk about and let's go forward.

MEMBER CLARKE: Any others? Ruth?

MEMBER WEINER: I think both the notion of a working group and the notion that we write a letter now are a good idea. I would really like to explore further the dealing with the trade-off question and I think that is something we might explore and we might touch on in the letter and explore in a working group session.

CHAIRMAN RYAN: Yes, again I agree with Ruth's comment and yours, Jim, earlier on the working group. But I think the timing is probably further out rather than closer in for the reason you stated that we need a body of experience from which to draw.

MEMBER CLARKE: It would be most

productive if we had a specific case.

CHAIRMAN RYAN: So let's put that on the to-do list but not with any particular calendar spot in mind at this point.

MEMBER CLARKE: Allen? Bill?

VICE CHAIRMAN CROFF: I agree.

MEMBER HINZE: I agree.

CHAIRMAN RYAN: Well, that saves you a trip up and down the stairs for later today, Dennis. We though we'd get that out of the way early. Any other questions or comments? All right. We're almost right on schedule. We're scheduled for a short break and in order to facilitate people who have made plans to attend on the schedule as published, we'll take a break until 10:30 a.m. and resume promptly with the presentation on the "Fabrication of PWR Uncanistered Fuel Waste Packages." Thank you. Thank you, Dennis. We appreciate you being here. Off the record.

(Whereupon, the foregoing matter went off the record at 10:08 a.m. and went back on the record at 10:33 a.m.)

CHAIRMAN RYAN: Could I have everybody come back to order please? We'll go back on the record. Our next session will be led by Dr. Weiner. So I'll leave it in your hands.

FABRICATION OF PWR UNCANISTERED FUEL WASTE PACKAGE

MEMBER WEINER: Thank you, and I apologize for my lateness. We're going to have a presentation on the fabrication of PWR Uncanistered Fuel Waste Package and we'll be briefed on that by Dr. Csontos.

DR. CSONTOS: Csontos.

MEMBER WEINER: Csontos. Thank you.

DR. CSONTOS: We don't have a Center.

MEMBER WEINER: We should have the Center.

DR. CSONTOS: We'll just go on. My talk today will be on waste package fabrication like you said, Dr. Weiner. It will be on the manufacturing processes and the effects thereof. I'll go into a little overview in a little bit here. Just going to what I'll be talking about today, I'll just talk about why we're giving this talk, why we're worrying about fabrication processes, go into the meat of the talk, the fabrication processes and then the effects and then to summarize.

So why are we giving this talk? We're giving this talk to present the staff's current understanding and observations regarding the design, fabrication and assembly of the 21 pressurized water reactor uncanistered fuel prototype waste package.

Now, Dr. Hinze, you asked before to give you a little overview. This is not the new TAD design from the DOE. This is the uncanistered fuel. DOE is evaluating whether or not they're going to go to an canisterized system. That is not what this talk is about. This is about the older design of the most popular waste package that would have been at a potential Yucca Mountain repository. So that's why we're looking at 21-PWR UCF waste package.

The second objective of our talk was to present an overview of the effects of potential fabrication processes on three areas. One is phase stability. The other one is corrosion behavior. And the third one is mechanical behavior. These are general overview kinds of discussion points. If you want anything more specific, we can go ahead and see about coming back to the Board later on.

So why are we worried about fabrication processes? This is Slide 4. We're worried about fabrication assembly processes because they affect long term performance of the waste package in the potential repository. I'm going to break this talk up into two sections basically. First, it will be the engineering area which are the fabrication processes, the design, the use of codes and standards for the fabrication and then the last will be the prototype assembly, the actual prototype assembly that we saw at the Joseph Oat Corporation.

The second area that I'd really like to talk about is the potential effects from fabrication on the long term performance of the waste package in the repository and those again phase stability, corrosion behavior and mechanical behavior.

So first, we'll go through the fabrication processes. This is the 21 pressurized water reactor uncanistered design that DOE has suggested in several documents to us. First of all, it's about 16 feet seven inches long. It's about my height on a good day in diameter and then we have the inner vessel and the outer barrier. The inner vessel is made out 316 stainless steel. The outer barrier is a corrosion-resistant Alloy 22. Then you have the bottom lid assembly on this side which is blown up in profile here and then you have a top lid assembly which is here which is blown and profiled here.

MEMBER WEINER: Is the inner vessel separate from the outer container?

DR. CSONTOS: Yes.

MEMBER WEINER: It can just be pulled out.

DR. CSONTOS: Yes and you see there's a little gap there. That's the gap for the thermal expansion. The thermal coefficient of expansion for stainless steel is greater than the Alloy 22. So you need to create a gap there because if it's not then you would put a pressure on the Alloy 22. And this sleeves right in.

MEMBER HINZE: Excuse me. What kind of temperatures will that take?

DR. CSONTOS: I believe the last time we heard it was around 300.

MEMBER WEINER: Centigrade.

DR. CSONTOS: Centigrade. Three hundred Centigrade. Would anybody like to -- But it's about 320, something like that. And that's not just the gap from the circumference of that but there's also a longitudinal gap as well at the ends.

MEMBER WEINER: Just to interrupt because this was the former prototype.

DR. CSONTOS: That's right.

MEMBER WEINER: And we may be looking at a different one. How would this differ if you use canistered fuel? If you canistered the fuel, would you then do away with that sleeve?

DR. CSONTOS: Not to our knowledge. What we were told by Paul Harrington at a manager meeting was that, and he just said this, this inner sleeve would still be there. The canister would fit into that inner sleeve.

MEMBER WEINER: I see.

DR. CSONTOS: So you would have three cylinders. The major difference is that you can see there. There are what we call the basket assembly where you have these carbon steel tubes, carbon steel structured grids, to guide the PWR fuel assemblies in and there are 21 of them there. But that would obviously change. That's the biggest change. You wouldn't have this being done at the fabricator for transport to Yucca Mountain.

Let me just go through. I was just talking about the basket assembly here. The thermal shunts, and that's not on here, but the thermal shunts are made out of an aluminum alloy, there it is, 6061, the nickel gadbiolinium is the neutron absorber plates in there. This end cap will be fabricated at the fabricator and actually welded at the fabricator. There is an inner lid and an outer lid. There are trunnions here and here, trunnion sleeves.

This lid assembly is right here. You can see the trunnion sleeve there and you can see the welds and then you can see the Alloy 22 outer barrier and this is the outer lid of the Alloy 22. There's an middle lid of Alloy 22 and then there's a stainless steel inner lid. The stainless steel inner lid has a perch port on it and it also has a cover plate. That perch port is there to help evacuate and backfill so that you have a vacuum into the waste package.

You then have these spread rings that are seal welded as well and the spread ring is put in place to keep this lid down. Like I said, the cover plate here and the spread ring areas will be seal welded to keep the vacuum.

Just to give the background, the stainless steel final thickness is a minimum of two inches. That's fairly thick material. For the Alloy 22 it's about three-quarters of an inch, two centimeters. That will be useful later on.

How does DOE plan to fabricate this? What are the guides? DOE has stated in several documents that they plan to use the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section 3, Division 1 to fabricate the inner vessel barrier.

We need to make a distinction here between the stainless steel inner vessel and the Alloy 22 outer barrier. They call the Alloy 22 a barrier because they use that in their performance assessment.

There is no performance that they picked up from the inner vessel. Therefore it's not called a barrier. So sometimes I kind of switch things around. So bear with me. It's hard to keep them separated sometimes, not to call the inner vessel a barrier.

We should note that the Section 3 does take into account load stresses but it doesn't cover deterioration that may occur in the service as a result of these effects. Although it does say in the Ford I believe that the design should allow for loss of thickness if corrosion will be an issue. Now there are margins built into the codes and standards, especially this boiler and pressure vessel code and standards, to account for certain types of degradation processes but not a million years worth of degradation processes. So that's why we'll go into that distinction between how DOE plans to fabricate the inner and the outer.

The inner vessel will be built to this ASME Section 3 Division 1 Subsection NC code. It will be N-stamped meaning that it is a stamped pressure vessel and it will be built to those requirements in that subsection. The outer barrier will be built to relevant portions of the Section 3 Division 1 both subsection NC and NB with enhancements.

Now when I went and talk about the thickness of the Alloy 22 one of the enhancements that DOE has proposed has been that instead of using what we call one-third-T flaw indicator which is one-third of the thickness of the waste package, would be about 6.7 millimeter flaw size, that's a big indicator, they've decided to go with an enhancement and use a 1 millimeter flaw indicator size which is much better. So that's where you can see where DOE has chosen a more stringent standard than what is called for in ASME.

And again, I would just like to reiterate that DOE is using these portions of the code because the outer barrier, it's a corrosion barrier. It isn't a pressure vessel and ASME is a boiler and pressure vessel code. So since it's not a pressure vessel and a corrosion barrier, the code doesn't really, it's not really made for something for that application, that long service life. Because of that, the waste package outer barrier won't be N-stamped meaning that it wouldn't fulfill all the requirements of these two subsections.

This is the basket assembly which if it's a canisterized system will not be in the waste package in this fashion right now at the fabricator itself.

Again, this is the nickel gadbiolinium neutron absorber plates, the carbon steel structural guides, the carbon steel fuel tubes. You'll see those in later pictures and that will be fabricating using ASME Section 3 Division 1 Subsection NF.

So where will these be fabricated? Joseph Oat Corporation is where this 21 PWR uncanistered fuel waste package is being assembled right now, the prototype. It's in lovely Camden, New Jersey and so it's a great visit for anybody. DOE has said back in 2003 that they are going to have 15 waste package prototypes by 2009 to create a pool of qualified vendors. This waste package prototype was supposed to built and finished back in February of '05. So I don't know if these two, at least this one, will be viable by 2009. That's two and a half year old data.

The purpose of our Joseph Oat visits was to understand the fabrication processes, just to see what the real world of fabrication was like so that we can go ahead and help our understanding of what the performance would be later on in -- space.

This is how the plan is to fabricate and this is where many of the casks and canisters are built in this fashion in a generic way. I'll try to just go ahead and this is from the Yucca Mountain

Science of Engineering Report by DOE and I've broken down the major operations by fabrication operations and the field operations at Yucca Mountain.

That picture. You can see that plate. Right? There's just basically a flat plate there that you buy and that's what whoever makes these waste packages will buy the plates 316 and Alloy 22 from their vendor. You then roll the plates. Usually you roll them up in a three roller process into a cylinder. You then do a longitudinal seam weld. Okay. So you roll the plates. You inspect the seams. You try to fit them to make sure they're concentric cylinders.

You then weld them, inspect them and then after you've done the longitudinal seams and you have two or more, there's only I believe two fabricators in the country who can actually get plate that wide so that you can get two cylinders to weld only one circumference. Well, usually it will be at least two and maybe more.

So you have one circumferential there. Like I said, you may have one there and one there as a normal waste package and then you weld the circumferential weld, inspect it and then you weld on this bottom lid, weld it, inspect it. Then after that, you weld these thrones. You can see these trunnions that are there. Those are there for preclosure to thick them up and move them around. You weld those out. You weld and inspect them.

Then this operation here will be a very interesting operation. The thought there is you heat this up at a very high temperature and then you quench it right away and you do a couple of things and I'll talk about that at a later point. But that will be for a very large piece of metal like this. It's going to be a daunting task for BSC or whoever will be doing it.

You then sleeve. At that field operations, you sleeve the inner cylinder into the outer cylinder and then you weld on this top lid area and then you do what we call a laser peen or a burnishing. That's what we call a residual stress mitigation method technique to impart a compressor stress on the surface of that top lid so that you have better stress corrosion cracking resistance because of the weld residual stresses that are built up there.

MEMBER WEINER: Do they inspect for any stresses, work hardening stresses, that might have occurred during the rolling process? How do they inspect for that? Or do they just inspect the welds?

DR. CSONTOS: They inspect the weld because this operation right here is the solution annealing quench operation is there to get rid of all those manufacturing residual stresses when you roll them and you put that end cap on. You just can't do that with the fuel inside because you're taking that up 1150 degrees C. So you have to do it when it's this state right here without the top lid on.

These are some pictures from our initial Joseph Oat Corporation visit in Camden, New Jersey. This is the prototype waste package, 21 PWR UCF waste package. These are strong backs. This plate right now, the rolled cylinder has been received back from the roller. The roller is put on what we call these strong backs welded on these strong backs at the end to keep them safe during transport and keep them whole.

You then see there's a J groove weld in both. This is the inner vessel and this is outer barrier. You can see the thickness difference between the two and there's what we call root pass, the first pass of the weld, the longitudinal weld going down and then another longitudinal weld going down. You can see the grinding marks on the surface of where they've cleared off some debris on the surface before they started welding and this is the preparation for their major longitudinal weld passes that they're going through.

MEMBER HINZE: While you have that there, can you point out specifically where the various sleeves are. Is the darker one the Alloy 22?

DR. CSONTOS: This one over here is Alloy 22.

MEMBER HINZE: No, on the one in the lower left.

DR. CSONTOS: Oh, this. This is strong back as well. What you have is at the ends, you can't see it there. Can you see that little piece right there? That's another 316 L piece that they just put in there and they weld on the inside to keep it from moving at all during welding. Once the welds are completed, these come off. Then they're ground down and cleared. This is the same thing for the outer barrier as well. They have the strong backs. I just didn't have a picture here. They have this on the outside because they were doing the inner section.

So there are two welding operations that are done, two types of welding that are done. One is what we call submerged arc welding. That's done on the inner vessel, the one that's going to be N-stamped, the 316 stainless steel. It's a little cheaper way to go. It's a little dirtier than what I'll show in the next stage but it may be sufficient for what they need. We don't know yet.

What it is is you form an arc between a continuously fed wire. This is what we call a slide right here, a flux and then that's a slide right there and that's the weld nugget. The flux is there so when you heat it up it creates a gas, a protective gas, at the weld area so that you get this nice weld there. It's employed again on the 316. This is the actual weld. You see the weld wire there. This is the hose that the flux falls into while you're welding and that's the weld afterward. You can see there's a little slag. It's probably hard to see in that picture. But there's a little ground slag left behind.

This is the operator. This was done on the outside weld. There are usually two welds, one on the inside and one on the outside. They go from halfway in and halfway out and they fill up that weld that way. So this is on the outside and the operator here is doing it semi-autonomously. He's guiding this rig and that's what we call the flux hopper. There's a lot of this flux. It's like sand. It's granular and it feels like sand and it fills in and then there's this vacuum. After it's gone past, it vacuums up and sticks all the rest of the flux left over back into the hopper.

This is the second process. This will be done on the outer barrier. We're on slide 14. The outer vessel or the outer barrier will be welded with gas tungsten arc welding. This process uses this filler metal here and the electrode is a tungsten electrode and that creates the arc between that and the metal. There's usually a shielding gas imparted. There's a helium argon continuously being fed in. And the weld wire there is to the side and these are typically of high quality, these gas tungsten arc welds.

Like I said the 1 millimeter flaw indicator that DOE was using as an enhancement to the code, because of that, they were using this gas tungsten arc weld to try to get below that limit. It's a clean process and it's going to be used on both the longitudinal circumferential welds for the outer barrier.

You can see here now they are doing the inside welds. There are two welds like I said, one on the inside and one on the outside. It could take 20 passes. Each pass means you're going down one length of the cylinder and back to weld one pass and then you have to go back over it. So what you have here is this is the shielding gas line. This is the shielding gas area. That's the tungsten electrode. The tip is way down there. This is the weld filler metal being placed into the weld area.

This apparatus is going in this direction I believe and then you see the weld right there. That's the longitudinal weld and this is the actual weld actually occurring and it's done again semi-autonomously by an operator outside of this area. As you can see, there's a little camera right there. I think that's an infrared camera that they use to see the weld area without blinding themselves.

So this is the next step, the next major operations that we went to go and observe.

CHAIRMAN RYAN: I'm sorry. A quick question. Is the welding done in one pass?

DR. CSONTOS: Each weld lays a certain thickness of material down. So you have one weld pass that lays a certain, a millimeter, maybe less, of material. Then you have to keep on doing that. So between every step, there's usually some sort of grinding operation or some sort of cleaning operation that's done. Then you grind that area and there's usually a guy goes in there and grinds it out and then the next pass goes in. It's in iterative process, over and over again.

CHAIRMAN RYAN: Is there any quality inspection along the way?

DR. CSONTOS: Well, there's visible.

CHAIRMAN RYAN: Visual, yes.

DR. CSONTOS: But it's all done I believe after the fact.

CHAIRMAN RYAN: Okay. Interesting. Thank you.

DR. CSONTOS: That was the longitudinal welds. Those are what we call the longitudinal seam welds. If there are two cylinders on each side and they get fit up, there's a circumferential weld. This is the inner vessel right here. That's a QA guy from NRC here who you can see. He's about five foot ten maybe and that's what we call the fit-up wires or chains and that's where they're being fit-up and placed together so they can do some -- There are different welders that go in there and just do hand welds and to get these things fit-up properly.

These circumferentials like I said when you have two of the cylinders those longitudinal welds will be separated 180 degrees from each other from what we were told. If there are three cylinders, they'll be separated by 120 degrees so that you don't have one longitudinal weld right impacting another one.

To get these fit up properly you weld them and this is not a clean room but it's made up to be a clean room. That's the weld operator. This is the outer vessel. The outer vessel needs a secure area from dust and debris and dirt. This area was basically a plastic scaffold, a sheet put over a scaffold, and vacuum out and what you have here is the initial pass, what we call the root pass of the weld. All these figures are from the outer barrier, the Alloy 22. You have the gas tungsten arc weld while the pass is going off. The actual metal cylinder is being rotated, not the weld piece.

What you have here is that as it's going over you can see the weld being done at the bottom. This is from the outside now. The weld is being done on the inside. This is the purge, the shielding gas coming from the back side as well. So you have the gas purge on the inside and on the outside to make sure you have a good weld there.

This is the operator of the weld. He's

making sure he's keeping the weld wire aligned properly. He has the electrode properly. The speed proper. Proper speeds.

This is the final product. This is the first, this is a longitudinal seam weld right along here. That was done previously. You can see here this is the first pass and what you're looking at is the outside, the back side, that has the bleed through of the metal of the weld coming through that little crack that's there, right here. This is the first root pass what we call.

Now again, this is the 21 PWR uncanistered fuel. We're on slide 16 now. Again this is not the TAD. This is an uncanistered fuel assembly package and because of that, Joseph Oat was also tasked to build the basket and I went through the basket diagram before. These are the actual carbon steel tubes that the fuel assemblies were going to be put into and these are the carbon steel guides. There you can see they're on the outside there.

So now what I just talked about were all the general fabrication processes. What we're worried about next or what the next part of the talk will be will be on what the effects and what we're not concerned with but what we are continuing to develop a knowledge base on so that we have a defensible position in case we're worried about this.

There are three areas that we're worried about or that we're thinking about, phase stability, corrosion behavior and mechanical behavior. And we could go into this. It could be an extremely lengthy discussion but I wanted to focus in on only the waste package outer barrier on this part of it. There's all these issues with the 316. This could be a plethora of slides. But I just went ahead and tried to create an overview for the waste package outer barrier fabrication effects.

Now the corrosion barrier, Alloy 22 outer barrier, is in a millennial state meaning what you get from the plate manufacturer. It is a single phase, solid solution alloy meaning it's a single phase. It doesn't have any secondary phases. For corrosion resistance, that's the best way to go. If you really want to have very little corrosion, you want to have a single phase. That's just a general type of metal understanding.

Waste package fabrication processes though can produce what we call secondary phases. Secondary phases can change the mechanical and the corrosion properties of the alloy. So because of that, we're concerned and we want to make sure that we're considering these fabrication effects. This is just an example. Short-term exposures at high temperatures during welding, welding you're solidifying. You're resolidifying metal and then you do these other heat treatments that you could get other problems or issues to occur. We'll go into that in a little more detail.

So we'll focus right now on the solution annealing quench. Again the solution annealing quench is a high temperature heat treatment. You take this metal after you've formed it up, this -- package up. You take it up to 1150 degrees C is what DOE has suggested. We don't know how long. You then quench it right away in a water bath or you spray it with water. And the purpose of that is to do several things. One is your homogenize the alloy. You start to go back to that single phase alloy. You don't want to have the secondary phases.

The next step would be to resolve or the mitigate those residual stresses that you've developed during the fabrication processes and also you want to develop these compressor stresses on the Alloy 22 surface that if you keep that compressor stresses on there, you reduce the chance for stress corrosion cracking. So by keeping the compressor stresses there, you don't have any tensile stresses to aid in cracking.

We have looked, NRC studies have looked, at solution anneals between 1125 and 1300 degrees C and in the weld area only, we don't see that it completely dissolves the secondary phases. These are SCM photomicrographs of the solution anneal quench operation and what we get from the actual welding process and what effect these secondary phases, what's the phase stability of these secondary phases.

You have here the weld nugget and this weld area here, you have what we call a solidification microstructure. You have two phase microstructure and you have these little particles that form, usually what we call in grain boundaries and what you have are these little white particles. This volume percent up here indicates how much of those secondary white phases are there. This is for one peen of Alloy 22 meaning one piece of metal. There's another fabrication of another piece of metal and we'll talk about that down here.

This is the as-welded condition, the gas tungsten arc welded. You have 0.37 of those white phases. You heat-treat it at 1125 degrees C at 20 minutes which is a potential solution annealing quench operation after the welding. You reduce those secondary precipitates by 0.11. So you do have some reduction there.

But there's also what we call heat-to-heat variability. When you have one heat of metal and you have another heat of metal. You have one weld and you have another weld. You have variability. It's not cut and dry as simple as just having this being done. You see here.

This is another heat of metal. This is a heat that was, up here, welded at the center. This was a DOE heat that was provided to us and you can see this heat there's substantially more of those secondary phases. And you take it up to 1300 degrees C, the solution annealing quench up to even that temperature, and you still see those secondary particles there. So usually you go higher in temperature or longer in time and you get rid of these secondary precipitates but you go up to even 1300 degrees C and you still have them.

PARTICIPANT: What's the scale on that?

DR. CSONTOS: These are 100 microns.

PARTICIPANT: Okay. Thank you.

DR. CSONTOS: That's pretty hard to see.

MEMBER WEINER: Are those on the upper

right pictures, those white dots, are still the secondary phases?

DR. CSONTOS: Yes, and it's hard to see in this one but there are white dots around here as well. But you can see that they are substantially different.

MEMBER WEINER: Right.

DR. CSONTOS: So what are the effects? What's the bottom line here what we've developed in our studies? What are our understandings to this?

For general corrosion, the thermally age or the welded area only has about three to five times general corrosion rate of the milled annealed material which you get from a plate fabricator. This we should note though. This three to five times faster corrosion rate was done with what we call short-term tests. Those, if we took out the longer times, would probably drop. The corrosion rate would probably drop (1). (2) We're accounting for this in our PA code. This distribution, we created a distribution and the distribution that we use in our corrosion rates accounts for this. So we're taking it into account.

For localized corrosion, we have these fabrication processes reduce the resistance to localized corrosion for Alloy 22 only in the weld area. We want to make sure that we get that across that this is just the weld area. The mill anneal, the rest of the waste package, this doesn't occur to that on that area.

Solution annealing what I just showed you before where you take it up to the high temperature and you solution treat this and you quench this material, it does improve the localized corrosion resistance of the weld area. So it does do something. Even though you don't get rid of all those secondary particles as you saw, you still do something beneficial to the alloy weld area.

Stress corrosion cracking. We did not see an increase in the susceptibility to stress corrosion cracking with a welded area. We have several studies. In fact, one of the papers that I present that I gave to you, Neil, described some of that.

So fabrication effects in terms of mechanical behavior, mechanical properties. When you have a millennial material, the millennial Alloy 22, the mechanical behavior is one that's characterized as a low yield strength, high ductility, high toughness, meaning that it can take a beating if it was required. This has a very high toughness material. Alloy 22 undergoes significant plastic deformations prior to ductile failure and that's what I mean. It's very tough. This material is very tough.

What you have here is when you have welding typically when you weld something especially in the code, you usually have a higher yield strength so that you don't have any failures mechanically in those areas when you build a pressure vessel. So usually welding fabrication processes increase the strength but the toughness and the ductility typically drop. We evaluated this. We looked at this and when we did it, you welded it. You solution annealed it. You still got quite a bit of strength and quite a bit of ductility but really the ductility is what's important there and the toughness.

We constructed failure assessment diagrams and that's another paper that I gave you, Neil, to hand out. We had a paper that we presented at a conference that showed that even though you heat-treat and you weld these areas up, you're still in what we call the ductile failure regime meaning that continued mechanics can govern the failure of these and you don't have fracture. You don't have brittle fracture. You don't have this type of typical mode of failure that a lot of other people have.

So to summarize, we've told you how DOE plans to fabricate the waste package, what codes they're going to use, what the design of that 21 PWR uncanistered fuel assembly prototype is going to be.

We've shown you the fabrication and assembly of the 21 PWR waste package prototype at Joseph Oat. We'll actually be going back there tomorrow to see the thrones being welded on. That's the next step to it and that's fairly close to the end. They're within probably six months. That's just a rough estimate.

Effects of typical fabrication processes that we talked about, we talked about solution annealing and the phase stability of these secondary phases and how they affect general corrosion, stress corrosion cracking, localized corrosion and then also the mechanical behavior.

So the bottom line is that we have evaluated these effects of fabrication and have accounted for them. That's it.

MEMBER WEINER: Thank you. I'll start with Dr. Hinze.

MEMBER HINZE: Thank you very much, Dr. Csontos. A couple of questions if I might. The relative effect on the strength of the canister from the stainless steel sleeve to the outer corrosion bound area, what's the relative percentage? When a rock falls in on this, where is the strength going to come from?

DR. CSONTOS: The stainless steel has a lower yield strength than Alloy 22. Alloy 22 is actually a little stronger than the stainless steel. However, you have two inches of the stainless steel versus three-quarters of an inch of the Alloy 22. Like I said, the ductility is tremendous for Alloy 22. The toughness is tremendous. So when you have an impact like that, Alloy 22 typically deforms quite a bit and it's very ductile. The impact would then be carried over because you have a gap there between the inner and outer vessel.

The bottom line there is that the stainless steel, how thick it is, that's two inches of stainless steel, will be there to impart the real strong strength to impact, let's say, dynamic rock fall. If you have static rock fall, still the inner container holds up a lot of strength. It may be lower yield strength than the Alloy 22 but there's two inches of it. There's twice as much, more than twice as much.

MEMBER HINZE: You mentioned the gap between them.

DR. CSONTOS: Yes.

MEMBER HINZE: How is that gap being preserved? Are there spacers?

DR. CSONTOS: Oh, no. What they do is there's machining operations involved. When you create the cylinder, when, what we call, in a fit-up, you're never going to get a concentric sphere. You're going to have some misshaping if you want to call it that.

They take that to a machine shop and usually you take it to a machine shop to get it milled out on the inside to create a concentric circle for the cylinder. You can measure --

MEMBER HINZE: Now this is for both of them.

DR. CSONTOS: Right.

MEMBER HINZE: Okay.

DR. CSONTOS: And so you do the inner/outer for the stainless steel and typically you do the inner and you have to do something on the outer because there's a picture where I showed before. If you look at this bottom right corner there you see there's little rings there. That's where the fit-up occurred. You do a little damage to the outer waste package, the outside of it and so you have to go to one of these mill shops to get it milled down. So you do both of them and the minimum gap I believe -- Well, there's a certain minimum gap.

MEMBER HINZE: But how is that preserved? How is that gap preserved?

DR. CSONTOS: Through the milling operations. You measure what those diameters are after you create this.

MEMBER HINZE: So there are some places where the stainless steel is actually in contact with the Alloy 22.

DR. CSONTOS: Yes.

MEMBER HINZE: Okay.

DR. CSONTOS: Oh, that's what you were going at.

MEMBER HINZE: Right. So there are some places where thermal expansion will be affected then.

DR. CSONTOS: If it's sitting horizontally and let's say this is the bottom, the inner vessel is being put sitting on the outer vessel. You still have a large gap on the top so that it will expand upward and not outward.

MEMBER HINZE: Following up on that, what's the strength of the weld? I'm surprised to see that the inner and outer containers are both welded together. When these two segments are brought together, they're welded together at the same point. Is that correct? At the same point?

DR. CSONTOS: There are two different procedures obviously.

MEMBER HINZE: Let me ask the question. Is the weld a strong point or a weak point?

DR. CSONTOS: Well, in terms of strength only, when you look at welds typically they have to be stronger. You don't want that to be the weak point. So the strength of the weld is usually much greater than the base materials.

MEMBER HINZE: So you can have the two then junctioning together at the same point and not lose any strength.

DR. CSONTOS: Yes. The problem there is when you have degradation processes, degradation processes, your colleagues at the ACRS, I say a majority of their issues are on welds and that's because degradation processes when you have these high strength areas create certain types of stress patterns that are centered in those areas because they are higher stress and you have this transition between high stress to low stress strength materials. So you create what we call triaxial stresses, certain types of stresses that occur at those areas, those junctions. Because of that and degradation processes on top of that, that's why stress corrosion cracking is a major issue in pipes and reactors because you have these types of situations occurring.

For this, there's a million years of degradation that we have to account for and Alloy 22, so far what we've seen for stress corrosion cracking, it's looking pretty good.

MEMBER HINZE: Is the coefficient of thermal expansion of the weld material the same as that of the containers themselves if you get any stresses there?

DR. CSONTOS: Oh, yes, you'll have stresses there. I'm not certain about that answer. Darryl, do you have, or Yi-ming, the coefficient of thermal expansion of the welds? It should be fairly similar. It should be very similar.

This is the matching filler metal. This is a filler metal for Alloy 22. When you do the actual welding, you're going to get what we call solidification of microstructure. You have that kind of two phase microstructure there. After you solution-anneal it, the only difference between the weld and the base material are those secondary phases and a little bit of grain size difference. But for the most part, there shouldn't be as dramatic as between 316 and Alloy 22.

MEMBER HINZE: Are there any contact defects from the individual welds?

DR. CSONTOS: Contact defects meaning?

MEMBER HINZE: The interface between sequential welds.

DR. CSONTOS: Yes and there are issues with cleanliness. I mean there's always going to be issues with trying to make sure you grind out oxide particles that form during the weld. That's why they do various operations to clean the passes. In between each pass, there are cleaning operations, too, that are done.

MEMBER HINZE: Let me ask a question about the heat treatment and the quenching. How do you assure to yourself that you have 1150 throughout the entire canister and not have hot spots or cold spots?

DR. CSONTOS: That's a good question. We have no idea how DOE is going to solution annealing quenching right now. We have a generic idea from a couple of documents but questions like that are what we're trying to find out. The obvious I think just from a fabrication point of view is that there are different types of paints that you could, not paints, but there are various -- that you can measure, you can see. They're color change paints basically and you can put them in certain areas to see what temperature it ever got to in those areas.

There are other techniques. There are standoff techniques as well, sensors, that you can put on there. So there are a lot of ways to do it. We just don't know how they're going to do right now.

MEMBER HINZE: My major interest in your conversation with us relates to testing.

DR. CSONTOS: Yes.

MEMBER HINZE: And that's testing on a generic level and on a specific case by case canister level. Can you give us a view of what kind of testing we can see at the generic and the individual level and also the relative role of NRC versus DOE in this testing procedure?

DR. CSONTOS: Wow.

MEMBER HINZE: And you only have a half an hour.

DR. CSONTOS: Okay. With regard to testing, the only testing that's being done right now during the process is what we call non-instructive evaluation and make sure the welds are being done properly. That's the only real testing that's going on now, die penetrant, ultrasonic testing that's being done right now. We don't have any access to that kind of data right now.

After the fact, after this waste package has been fabricated, there's been talk about a dozen different things that this waste package could be used for. One is it could just be a paperweight at DOE headquarters to show people that it can make it. The second thing would be to cut it up to destructive testing to see what kind of residual stresses you get, what kind of weld flaws you get, to create a statistical database from which you could go ahead and determine what kind of flaw distributions you may have. It runs the gambit right now. We have no idea what DOE will be using this waste package for in terms of testing.

MEMBER HINZE: You were talking about 15 prototypes, weren't you? Didn't you mention that?

DR. CSONTOS: Fifteen by 2009.

MEMBER HINZE: Yeah.

DR. CSONTOS: They're already a year behind schedule on this one. It will probably be more like a year and a half behind schedule on this one. And with the new TAD design, I don't know. Why would they want to make these then if they're going to a new potential design?

MEMBER HINZE: What generic testing has been done on the prototype canister at this point in time?

DR. CSONTOS: Only the nondestructive evaluation, techniques that are done on welds.

MEMBER HINZE: On welds.

DR. CSONTOS: That's it.

MEMBER HINZE: What can we expect that NRC will be doing in the way of generic testing and then also specific testing?

DR. CSONTOS: What we've done is on this slide, for example, we're comparing, this is Center's weld versus DOE's weld. We're conducting these types of tests to determine what post closure performance is. We don't have the capability to go ahead and make a mockup ourselves. But what we do do is we take two plates from a fabricator and we have someone weld it for us in the welding process, the procedures that have been expressed to us by DOE.

MEMBER HINZE: What I'm getting from you is that there is no protocol really in place at this time for the generic testing of the canisters.

DR. CSONTOS: That's right from DOE's point of view. That's to our knowledge. They may have a protocol developed but we just don't.

MEMBER HINZE: Where is NRC moving with respect to this protocol?

DR. CSONTOS: We're trying to stay up to speed with this knowledge base. That's all we can do. We can't go out ahead of them.

MEMBER HINZE: In discussions of these canisters, I think the term you hear is zero defects.

DR. CSONTOS: Yes.

MEMBER HINZE: Devoutly to be wished as the Bard said. How are you planning to assure yourself and the country that we are going to have zero defects?

DR. CSONTOS: Well, we don't. We are not saying there are zero defects. In fact, there's a report the Center has done, V.J. Jain is one of the co-authors on it, that we've evaluated what we call early failures. I didn't put that into the discussion here. But through use of welding statistics from other industries, we developed a methodology, an approach, to determine how many what we call early waste package failures from flaws that could occur from welding and fabrication.

I didn't put it in here because it's a detailed study. If you want more information on that, we can go into it maybe. But in our TPA analysis we do account for a certain amount of early failures. We account for quite a bit of them actually.

MEMBER HINZE: That's based upon similar types of fabrications?

DR. CSONTOS: Similar types, that's true. We're trying to get the kind of database or kind of data from industry for welds. But there is no database available for Alloy 22 welding. So we're using analogs of steels. I think it's phreatic steels that we used. Right, V.J.?

MR. JAIN: Pressure metal steels basically used for reactor pressure vessels. There is significant data on the distribution and we use that distribution to examine number of flaws that we can observe.

DR. CSONTOS: Yes. DOE has done, what they've done is they've done two concentric rings of Alloy 22, small samples that they viced together and they welded to see what kind of flaw distribution they can get and that's all the data that we have right now.

MEMBER WEINER: We have to move a little faster.

MEMBER HINZE: If that information, if

that document, is available to us.

DR. CSONTOS: Yes.

MEMBER HINZE: And we don't have it, could we see it?

DR. CSONTOS: Sure. That's no problem.

MEMBER HINZE: Pass it to you.

MEMBER WEINER: Allen? Dr. Ryan?

CHAIRMAN RYAN: Just a comment. I think you had one in the audience that wanted to help you out. I think the kind of risk insights information you just described from your testing, your statistical analysis of other industries, would be of keen interest to the Committee (1). (2) I think it would be interesting to the Committee to figure out how this information has been somehow transmitted or translated into a performance assessment that's being done by that group.

DR. CSONTOS: Yes.

CHAIRMAN RYAN: So I just leave that with you as a question if we could shape a follow-up presentation on what by the way has been a fascinating presentation this morning. That would be a great next step. So I look forward to do that.

DR. CSONTOS: The reason I didn't want to put it into this discussion because it just would have

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CHAIRMAN RYAN: Overpowered us. So great first step. We all have Welding 101 under our belt now at least for me who doesn't know much about it. That's great. I think those two goals for our next step in presentation would actually be a great addition.

DR. CSONTOS: Okay.

CHAIRMAN RYAN: Ruth. Did you have an additional comment you wanted to make? Just tell us who you are and who you're with please.

MR. AHN: Tae Ahn, NRC staff. Regarding your question about whether we have prototype examples or not, what's NRC goal is really to evaluate the performance of such a generic case. Even though we do not have a prototype by examples, we still study the tungsten performance of such welding process. That's what he showed our various microstructures related to corrosion and decaying performance.

MEMBER CLARKE: No questions. Very nice presentation. Thank you.

MEMBER WEINER: I have only one quick one. Does this coordinate well with the experimental work that is now going on at the Center on corrosion?

DR. CSONTOS: This is up to date data,

yes. In fact, just the information we presented about localized corrosion resistance, it being the resistance increasing with solution annealing was at the 2005 Material Science and Technology Conference back in October, November of '05. So that's very recent data.

MEMBER WEINER: So this came from the work at the Center?

DR. CSONTOS: Yes.

MEMBER WEINER: Thank you. Very interesting presentation.

CHAIRMAN RYAN: Bill, take it away. We have a couple minutes. I just want to give everyone one chance. Did we exhaust your questions?

MEMBER HINZE: I've had it.

CHAIRMAN RYAN: Okay. Thanks very much. With that, I think we are adjourned until 1:00 p.m. and we'll reconvene promptly at 1:00 p.m. Thank you very much. Off the record.

(Whereupon, the foregoing matter went off the record at 11:29 a.m. and went back on the record at 11:29 a.m.)

CHAIRMAN RYAN: On the record. Excuse me. Pardon me. Could I have everybody's attention? We will go back on the record for a minute. There's a question from the Center.

PARTICIPANT: Could you give us the fax number? If you can let us know the fax number, we can send the --

CHAIRMAN RYAN: Okay. Great. I think, Michelle, you can maybe contact him at lunch and give him that number. We'll contact you by telephone and get you that number. Okay?

PARTICIPANT: Thank you very much.

CHAIRMAN RYAN: All right. Thank you all. Appreciate your participation this morning. We'll adjourn here. Off the record.

(Whereupon, at 11:30 a.m., the above-entitled matter recessed to reconvene at 1:02 p.m. the same day.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

1:02 p.m.

CHAIRMAN RYAN: We're reconvene and go on the record please. Come to order. This afternoon we have a presentation on Spent Fuel Transportation Response, the Baltimore Tunnel Fire Scenario based on NUREG CR-6886 and Dr. Weiner will lead us in this hour.

SPENT FUEL TRANSPORTATION RESPONSE,

THE BALTIMORE FIRE SCENARIO

MEMBER WEINER: We have Earl Easton who will make a presentation on NUREG CR-6886 which has been handed out. But I don't think any of us have had a chance to read it between this morning and now. It's all yours, Earl.

MR. EASTON: Okay.

MEMBER WEINER: And please allow plenty of time for questions.

MR. EASTON: Any questions? Thanks. It's always a pleasure to come speak to this group. Today I would like to go through the study we recently finished on the Baltimore Tunnel Fire. We did this in an unusual way in that usually when we do just a technical study we finish it, put it on the shelf. But this case we actually put this out for public comment. We went out and actively solicited comments to make sure that we did everything right. We intend to get those comments and either address them in a Q&A fashion or incorporate them into the body of the text.

CHAIRMAN RYAN: Earl, just for clarity sake, this version we have in our hand is the one sent out for public comment.

MR. EASTON: Right.

CHAIRMAN RYAN: Okay.

MR. EASTON: I had a limited number of hard bound. This is on the website but I gave each member a copy, the hard bound version. This was put out for comment last fall. The comment period was extended 60 days and ended December 30th. So at the end, I will just give a brief summary of some of the comments we got. I understand maybe some of the commentors are in the audience and rather than me trying to characterize them, they might want to do that themselves. But that's a space at the end.

Why did we do the Baltimore Tunnel fire? As you know, we have pretty prescriptive regulations for approving spent fuel casks, 30 foot drop, fire test, puncture test. The reason they're written in the form they are is they have to be reproducible. They don't represent any one accident in particular.

But from time to time, we like to do case studies to make sure that they really accomplish the mission of providing protection against real accidents.

We had a real accident in Baltimore in July of 2001 in which there was a tunnel fire. It happened when a train derailed. The train had I think about 60 cars on it pulled by about three locomotives. It derailed in the Howard Street Tunnel which is in the middle of downtown Baltimore. I want to mention right up front that the train had no radioactive material actually on it but we used that as the basis for a case study.

The train did have a tank car with about 29,000 gallons of a highly flammable liquid, tripropylene. It also had paper products, pulp wood, hydrochloric acid. So basically the purpose of our study, we took three different cask designs and subjected them to the environment that we thought was present in the Baltimore Tunnel fire.

This is just the picture of the fire in progress with the smoke pouring out and this is the actual tripropylene tanker once it was pulled out of the fire.

How did we go about constructing the model? Well, this is basically a depiction of the model. This is the spent fuel representation of a spent fuel car, a buffer car and the tank car. Now why did we have a buffer car? DOT regulations say that when you ship spent fuel with a flammable liquid and other hazmat, you have to have a one buffer car separation. So we tried to model an accident how it could actually occur. We're not trying to do a worst case analyst. We're trying to do a case study.

What that is is about 20 meters, the length of a car. That was modeled. The fire resulted from a leak from this tank car and that's where the fire was initiated. Later on, the fire looked something like this as the tank car was engulfed in the heat and the smoke was carried down the length of the tunnel.

This is what we attempted to model. It used a seven hour duration fire. We have reports from the National Transportation Safety Board who interviewed emergency responders and what they said is the most severe portion of the fire lasted approximately three hours. After about 12 hours, the firefighters actually were able to visually get into the tunnel and confirm that the tank car was no longer on fire.

We went to the National Institute of

Standards to help us develop a tunnel fire model. This model is based on actual experiments done in a real tunnel with a real fire. They have a facility and they've developed a code which is benchmarked against those particular experiments.

We took that code and then developed a model of the tunnel. Just to make sure as a check that we were doing things approximately right, we took samples from the rail car, the tank car, and had them subjected to a metallurgical examination to see if the coupons collected were consistent with the temperatures and durations predicted at that point. Exactly they were from this car. This car was really not in the real fire. That was a check that we did to make sure that the code was giving us the answers that were accurate.

To construct the model, we then took the answers we got from the tunnel fire code and used those as a boundary condition and this chart here illustrates what the boundary condition is where the cask is located. This is the surface temperatures of the tunnel where the cask is located. Remember it has the 20 meters down from the fire and you see that the ceiling temperature is about 1900 degrees and the floor is only about 600 degrees. So there's a great deal of gradation.

We also looked at the air temperatures. This model was able to predict air flow and air temperatures. We see that the air temperatures at the top of the tunnel where the spent fuel car would be located peak at about 1600 degrees with again a gradation.

So what we did or what PNNL (Pacific Northwest Laboratory) did the calculations. They took a cask, actually we did a series of three casks, divided it into three sections for purpose of the model. The top section here was subjected to the highest tunnel temperature which occurred up here but we applied it all along here. To predict radiation, this section was from here to here. Remember the chart with the temperatures and this bottom section was subjected to the temperature from the last graph that indicated the floor temperature.

We feel this is conservative because this whole area here was subjected to the highest temperature although there's a gradient. This whole area here was subjected to the highest wall temperature although there's a gradient. So we feel this was a conservative way of picking temperatures as an input to this model.

Just to give you a flavor for how these calculations turn out, you see that the ceiling temperature is higher than the cask temperature which is higher than the air temperature.

CHAIRMAN RYAN: Just a question. You said the temperatures selected were conservative. They are the highest values but the conservative in regard to what? I'm not sure I understand exactly what you're saying.

MR. EASTON: What I'm saying is there's a constant gradation of temperature.

CHAIRMAN RYAN: Right.

MR. EASTON: For the top part of the tunnel, we took the highest temperature in that --

CHAIRMAN RYAN: I understand what you did. But I'm asking you why is that conservative. Conservative in regard to what?

MR. EASTON: To heat input because the --

CHAIRMAN RYAN: The internals of the cask.

MR. EASTON: Why is it conservative? Because your heat input is coming from force convection and radiation from the tunnel surface and the higher the temperature of the tunnel surface the greater the radiation.

CHAIRMAN RYAN: I'm with you. I just

wanted to make sure I understood that it's conservative with regard and what it is overall heat.

MR. EASTON: Right.

CHAIRMAN RYAN: Okay. I'm with you.

MR. EASTON: So what this says is that from this graph most of the heat input is from radiation. The actual air temperature is less than the cask surface temperature. Now there's heat inside being generated but most of the heat input is from radiation from the tunnel walls as opposed to force convection.

DR. LARKINS: Where is the top air temperature measured? What point is that in the tunnel or whatever?

MR. EASTON: Let me see if I can figure how to go back here. I think it was measured up in this range here, the top air temperature above the cask.

DR. LARKINS: Okay. But at some point doesn't the air temperature have to be higher than the highest surface temperature?

MR. EASTON: Not when most of the heat is coming from radiation and we have Chris Bajwa here in the audience. Let's go to the --

DR. LARKINS: When you say air

temperature, you don't mean flame temperature then.

MR. EASTON: No, air temperature. We're talking about air flow.

DR. LARKINS: Okay. So it's not in the flame. It's away from the flame.

MR. EASTON: Right. Remember the model was that you had a tank car fully engulfed and about one car length away you had the spent fuel gas.

DR. LARKINS: It's the air temperature above the cask.

MR. EASTON: Right. It's the flow of air by the cask.

MEMBER WEINER: Is the sharp drop due to the fire using up oxygen in the tunnel?

MR. EASTON: This line is the duration of the fire. This is when we stopped the fire.

MEMBER WEINER: Oh, you stopped the fire.

MR. EASTON: Right. The calculations stopped at about seven hours. That was the exercise. But again these numbers are just to set the boundary conditions for heat flow into the cask. It's not directly in the flame because we're trying to model a real case study where there would be separation. Is that clear?

CHAIRMAN RYAN: Yes.

MR. EASTON: I know it's complicated. These are the three particular cask models that we chose to analyze and why did we chose these particular models? Well, they're representative of the type of cask we think that have been used or will be used for major shipping campaigns.

This HI-STAR 100 is a so-called dual purpose cask that has inner canister and then a transportation overpack. This was the one that forms the basic for private fuel storage facility. This is the one that most of the shipments to PFS would be made in.

The TN-68 is a rail spent fuel cask which doesn't have an inner canister. It's just a transportation overpack, holds a basket, spent fuel.

The NAC-LWT is a truck cask which has been on many occasions shipped by rail, most notably when DOE returned the foreign reactor fuel. Most of the shipments were put into an NAC-LWT cask inside an ISO container and shipped that way across the country. So these are the three cases we chose to analyze. We could have picked other casks but these were the three in particular we chose to analyze.

Two of them you can see are very heavy, have a large thermal inertia and one is a relatively lightweight compared to the other two. They have different capacities. This LWT only holds one PWR fuel assembly. Bolted lid with O-rings. Bolted lid with O-rings. Bolted lid with O-rings.

This was the conceptual image of the dual purpose cask. This is what it would look like. This is basically the results. Once we did the analysis for the HI-STAR 100 and Chris Bajwa gave this presentation last year to a couple groups about the results of this particular cask.

We don't think much happens here. The inner canister remains intact over the period of interest. We don't think nothing would get out. The other one we don't think anything happens to the fuel cladding which is a major barrier against release and we don't think that the seal on the outer overpack makes much difference since you have an inner canister in this case. This was the one that was reported that no release from this cask whatsoever.

This is schematic of the lid end of the TN-68 cask. It has about 48 bolts. These bolts are about nine inches long, about two inches in diameter. They are torqued to about 850 foot pounds which for reference is about eight times what you would torque your car tire to. It's about eight times as tight for lack of a better way of saying it. This is the impact limiter which security tells me I can't put real dimensions on there, about four feet. This is about four feet.

This is about five inches or so of solid metal. This is another four or five inches of solid metal. Very thick lid. Need it for shielding. These are the O-rings. This is the cask body. This is neutron shielding, gamma shielding, ten day, the cask inner wall. What you would do is put a fuel basket inside here and then bolt down the lid. This is the one that we looked at.

Here are the results from the seven hour fire. We saw the peak cladding temperature get up to 845 degrees which is well below what we think is the minimum temperature that you would get burst of that cladding, about 537 degrees below. So we don't think anything would get from the inside of the fuel rods to the outside to start with.

The seal temperature, this one happens to have a metallic seal that is rated by the manufacturer to 644 degrees F. That's what the manufacturers stand behind. It doesn't mean when you get to 645 the seal disappears. But this is what the manufacturers guarantee and this is how people buy seals. So, yes, the temperature in the seal region is exceeded by about 170 degrees. That said, doing the academic exercise, we predicted that you could possibly, not probably get a minor release of maybe CRUD out of the cask. Probably you'll get no CRUD and I'll give a couple of reasons why we think you don't get any. But doing the academic exercise, playing the what if, we think that you might, at worst, get a minor release of CRUD.

This is just to give you a flavor of we tracked the temperature of a lot of different components in the cask. I won't go over this. I know we have a lot of questions. So I'll just say this is the seven hour fire and these are different components we tracked. This is the one that is of interest. The seal peaked out at about 800 degree maximum and then when the fire stopped, went back down.

CHAIRMAN RYAN: Let me just back up to that slide. I'm struggling with what you said earlier. If we could just back up to that slide no. 11. Sorry.

MR. EASTON: This one?

CHAIRMAN RYAN: No, it's the one with the cask. You said the gasket in essence goes away at 644. Is that right?

MR. EASTON: No, the gasket is rated by the manufacturer to hold basically a leak-tight seal up to 644. Do you want me to go back one more?

CHAIRMAN RYAN: Yes, I'm trying to figure out exactly what you're saying.

MR. EASTON: Okay.

CHAIRMAN RYAN: So this 644 degree temperature failure is where exactly in the cask?

MR. EASTON: Right here.

CHAIRMAN RYAN: So both seals in essence can fail at that temperature or higher.

MR. EASTON: Right. What we're saying is this is the seal. These two O-rings here is the seal. One of those is metallic, the containment O-ring. And what we're saying is when the cask vendor bought that from the manufacturer, he is saying we will guarantee your leak rate up to 644 degrees.

CHAIRMAN RYAN: So basically it fails to hold pressure is what failure mode is. Is that right?

MR. EASTON: It begins to not meet the manufacturer's -- It's in a state that's really not determined.

CHAIRMAN RYAN: Okay. I'm with you now. I understand what you're saying. I just wanted to --

MR. EASTON: But a metallic seal does not go away at 644.

CHAIRMAN RYAN: Yes, I got it. I just wanted to understand what you were saying. Thank you.

MR. EASTON: And the other thing is remember these are 48 bolts.

CHAIRMAN RYAN: I understand all that. I just wanted to understand the point about the O-ring spec.

MR. EASTON: Okay. Again this is a metallic O-ring where over the limit. I just wanted to show you the maximum predicted for the O-ring is at the end of the fire. Whereas the maximum predicted for the fuel cladding is not at the end of the fire. It continues to increase because heat is being generated trying to get out of the cask. So we took this maximum here.

CHAIRMAN RYAN: It looks to me like there's a maximum in the dashed line area.

MR. EASTON: Yes, right here.

CHAIRMAN RYAN: How come it's dashed instead of --

MR. EASTON: That's extrapolated. That's where the --

CHAIRMAN RYAN: The whole thing is a calculation.

MR. EASTON: Yes. What they did when this says NIST dataset, this is where they had data on the fire. They ran that code out to get that data from the code predicting fire if you will.

CHAIRMAN RYAN: Well, it's either data or it's a calculation using a code. Which is it?

MR. EASTON: All right. Here's what they did. NIST dataset implies that, remember when we were doing the boundary conditions? They used that code to do the boundary conditions out to -

CHAIRMAN RYAN: So it's not physical data from a fire. It's calculated data.

MR. EASTON: Right. Calculated and then the other contractor took that set out further.

CHAIRMAN RYAN: With a different code or the same code?

MR. EASTON: The same code I believe.

CHAIRMAN RYAN: Okay. So really it shouldn't be a dashed line. It's all calculated values. Is that right?

MR. EASTON: Yes, I believe that's correct.

CHAIRMAN RYAN: I'm not trying to be picky but when you say data versus calculated, extrapolated versus NIST, it's important to understand that if it's all calculated values using one model, then --

MR. BAJWA: Yes. Just to clarify. What they did is NIST used FDS to get the data out to 30 hours and then PNNL actually did use an extrapolated set that they generated from 30 hours out to here at 50.

CHAIRMAN RYAN: Using the same code.

MR. BAJWA: They didn't use a code. They didn't use a code to do that.

CHAIRMAN RYAN: What did they use?

MR. BAJWA: They used a power function to extrapolate the data out.

CHAIRMAN RYAN: Based on?

MR. BAJWA: Based on the trending of the data that they were seeing from the NIST code and the report goes into a little bit more of an explanation of how they did that.

CHAIRMAN RYAN: I'll ask the dumb guy question. Why didn't you just keep going with the same code?

MR. BAJWA: It was just a matter of time running that code. NIST just picked that time and that's what they ran it out to.

CHAIRMAN RYAN: Okay.

MR. EASTON: Does that help?

CHAIRMAN RYAN: I'm still confused as to why but I understand what happened I think a little better. Thanks.

MR. EASTON: That's why I bring you.

CHAIRMAN RYAN: By the way just for the record, would you tell us who you are so that the court reporter doesn't have to run you down?

MR. BAJWA: Okay. I'm Chris Bajwa. I'm a thermal engineer with the Spent Fuel Project Office.

CHAIRMAN RYAN: Thanks a lot.

MR. EASTON: Remember we said you go over the temperature of the seals. So we did the exercise of what could get out. We don't think there's any breach in the fuel rods. So what we're talking about is prodded here to the outside of the fuel cladding. In order to get that out, you would have to have it come off the rods and you'd have to have it come out through a pathway like this which is about 15 or 18 inches of very tight clearances and your talking about CRUD, flaking off particles.

It would have to get out here where we believe we maintain a lot of metal to metal contact because of the high torquing of the bolts. There are very tight clearances. But this would be the pathway.

CHAIRMAN RYAN: These are pulled out of

the casks.

MR. EASTON: Yes.

CHAIRMAN RYAN: There's CRUD on the entire inside of the casks. It's not just coming off the fuel. Trust me.

MR. EASTON: Yeah.

CHAIRMAN RYAN: If you take a smear on the inside of a spent fuel cask, it will not be clean.

MR. EASTON: What this study looked at is just CRUD on the outside.

CHAIRMAN RYAN: Fuel only.

MR. EASTON: On the fuel only.

CHAIRMAN RYAN: Okay. Fair enough.

MEMBER WEINER: Is the CRUD a particulate? Is it high vapor pressure? Does it play out on the inside of the cask?

MR. EASTON: We looked at it in the form of particulate flakes and that sort of matter. That's just an illustration of a pathway that it would have to meet. We based on the calculation of what CRUD might get out on the methodology we used in 6672 and the security assessments and we predicted that at worst no more than about 3.5 curies of Cobalt 60 would get out. Most of the CRUD after about five years is Cobalt 60. So we based it on Cobalt 60.

CHAIRMAN RYAN: Really? No Manganese 54. No Iron. No nothing.

MR. EASTON: I didn't say no. Most and it's in the upper 90s of Cobalt 60.

CHAIRMAN RYAN: On total activity?

MR. EASTON: Yes, on activity. Yes. So rather than trying to capture every radionuclide, we based it using Cobalt 60.

CHAIRMAN RYAN: No assumption for anything from fission product inventory? Just CRUD.

MR. EASTON: Just CRUD. We don't think that there's a breach in cladding. That's what this is based on. And we would note that this is consistent with an analysis that we did in 1987, the Modal Study where we did a case study. We put in a very long fire and we got out, I think, the estimate there was no more than four times the regulatory limit which would be four times an A-2. But Cobalt 60 would be 40 curies. So back in the Modal Study in a very severe fire, they predicted that 30 to 40 curies may possibly escape. So this is not a new type of prediction.

Now we believe that when we did this analysis it was based on realistic values for CRUD. We took data that we could find that was available and it's based on this Sandia report, "Estimated CRUD Contribution to Shipping Cask Containment Requirements." And we took a limit. Ninety percent would be cleaner. We took that as the limit of what we used in this model. We didn't take the dirtiest rod.

CHAIRMAN RYAN: Why didn't you take the actual CRUD measurements from power plants that you were starting from?

MR. EASTON: The actual measurements from power plants, they give you a range. It's not one measurement.

CHAIRMAN RYAN: I understand that. There's a lot more to Cobalt 60 than CRUD.

MR. EASTON: We just --

CHAIRMAN RYAN: Nickel 63 for example. That's 100 year half life.

MR. EASTON: And what we did, these are estimates and for example, the data predicts that after five years, 92 percent of the CRUD is Cobalt 60 for PWR and for BWR --

CHAIRMAN RYAN: Ninety-two percent of the total number of curies or 92 percent on the basis of what's the most important to external dose?

MR. EASTON: Of activity.

CHAIRMAN RYAN: Curies?

MR. EASTON: Yes curies. And then this again comes out of this study that --

CHAIRMAN RYAN: But curie is not necessarily the basis of risk inside.

MR. EASTON: Like we said, we don't really think much if anything gets out but we tried to do an academic exercise if you will what gets out. We didn't do a detail of every radionuclide. We thought that since 92 percent of the activity for PWR is Cobalt 60 that we would base our calculations on it all being Cobalt 60 and BWR from the data we could gather, 98 percent after five years is Cobalt 60. So we assumed that all the activity was Cobalt 60.

CHAIRMAN RYAN: And I guess my other point is it would be nice to prove that it's important because Cobalt 60 is the main contributor to dose in some scenario. I don't know that that's true. It sounds like you don't know if that true either. You just assumed that based on the activity.

MR. EASTON: Yes, that's how that was done.

CHAIRMAN RYAN: Okay.

MR. EASTON: Okay. And that is a simplification. Some of the reasons we don't think much of anything will get out is it doesn't consider it a plugging of release pathways. Remember the long tortuous path. We still think that you have a lot of metal to metal contact from the high torquing of the lids. And the seal again does not go away. It's still a metal disk in there way above what the manufacturers guarantee but it's still an impediment.

Again what we did is we looked at the maximum seal temperature and assumed that that temperature was all the way around the cask. Remember the's a gradation. So we assumed that that was all the way over. We don't know for sure whether some of the temperatures at the bottom remain even below their rated temperature. We just assumed that all was at the maximum. That's basically what we did on the TN-68.

We looked at the LWT truck cask and this is two ways that it shipped usually on truck. Sometimes on truck, it has a personnel barrier. Sometimes it has an ISO container. When DOE did their shipments of return of foreign reactor fuel, it was always in an ISO container and to give you more detail, this is what it looks like inside an ISO container. So this is the model we chose to use because there were shipments actually being made.

Here the results were again you were about 280 degrees under the cladding burst temperature. We don't think that you get rupture of the cladding. You were way over the seal temperature. This has a Teflon seal and so you're way over the seal temperature. And again we did the exercise which is similar to the one we did for TN-68 to determine what you might get out in the way of CRUD.

Here is a schematic of what this looks like. It has a smaller lid, lesser number of bolts. The bolts are torqued to about 200 foot pounds on this cask. The other one is 800. This one is about 200 and this lid is I think about seven or eight inches minimum thickness. It might even be more.

So to get anything out, you'd have to again go through a pathway like this which is a very long pathway with very tight clearances and remember there's not much driving force inside the cask to get anything out. It's only volumetric expansion due to the heat up inside the cask. There's not much driving force.

MEMBER HINZE: To help me understand that diagram, could you tell me how the seal fails?

MR. EASTON: Okay. These are the seals and they are either one or two type. One is metallic which is spring loaded. They have a spring inside and how did they fail? I don't think we know exactly. All we know is that a manufacturer has done testing or has data to qualify these up to a certain temperature range.

Now you can get metallic seals that have been qualified at 800 degrees, 1500 degrees, the ones that have been tested. Once you get over the temperature, I believe you probably get some softening of the metal. But I don't think the metal melts or goes away. Some of these are elastomeric seals that may actually start to degrade, I guess, at high temperatures.

MEMBER HINZE: Did someone follow the testing by the manufacturer of the seals then to determine how they say they fail at 644 degrees? This is a very specific number. It sounds like they have a very quantitative way of determining the seal fails.

MR. EASTON: This is not the number at which they fail. I don't want to leave that impression. I think what the manufacturers do is say we have a seal and we have a bunch of applications. All these applications are below 650 degrees or whatever. So we're going to go out and test it to that range and we're going to sell people seals that say that we've tested them up to 650 degrees. They haven't taken it out to 900 to see if it necessarily fails.

Initially in the TN-68 when you talked to the manufacturers, they gave us a much higher number they thought it would hold a seal. But later when we tried to get them to do that in writing, they backed off to what they guaranteed. Is that true, Chris?

MR. BAJWA: Yes.

MR. EASTON: So it's not they cross a magic number they automatically fail. That's just the data that the manufacturer stands behind. Does that help?

MEMBER HINZE: Yes, it doesn't explain how it fails though. I think that's important.

MR. EASTON: A lot of these seals, I think have been tested to failure.

MEMBER WEINER: Yes.

MR. EASTON: I don't think they just actually tried to test them to failure.

MEMBER WEINER: Is there actually an impact limiter on that truck also? You haven't shown it.

MR. EASTON: This here is the impact limiter.

MEMBER WEINER: I see.

MR. EASTON: It's in white. Sorry. But this is the impact limiter. But again, what this is trying to say is any particle has to get out through here to get out. And again, I can't over emphasize. These seals the temperature we're using are the manufacturer's guaranteed temperatures. We don't really know what happens after they cross that line. We don't have the data. The manufacturers won't give us the data. They haven't been tested to failure.

Here we predicted that the amount based on Cobalt 60 only that we only get a fraction of curie again because you have a limited number of rods. You only have one fuel assembly.

Again, we think the same conservatisms apply. You have a very tight clearance and you're trying to get particles through clearances. We think a lot of plugging would occur if you tried to do that even if you had it available to get out. Metal to metal contact. These things are still torqued. Even though you don't know what happens to the seals, they are still tightly torqued. The bolts, there's still a lid and they are tightly torqued to the cask body. Again, we assume that the maximum temperature was the temperature of the seal all the way around.

This is summary. In summary form, we think that the HI-STAR nothing will get out. It has an inner canister. Again, we don't think that anything will get out but again the exercise says that if you're looking at CRUD and trying to do a bounding case, you get 0.3 curies for TN-68 and 0.002 curies of Cobalt, I'm sorry, and 60 for the LWT, 3.4 curies for TN-68 and then we have it in terms of A_2. A_2 is the number that all the transportation lovers go by and A_2 is the value above which you need an accident resistant package, below which you don't even an accident resistant package.

When you do a cask certification, the leak requirement after you've certified it to all the drop tests and that is that it release no more than an A_2 per week. Why is A_2 important? A_2 is based on dose models to provide protection for first responders. And A_2 provides protection against first responders with the margin built in. A fraction of an A_2 would give you more protection. So from this, we conclude that it really doesn't pose a significant danger from anything getting out of the cask to first responders let alone the public. Does everyone follow that?

We just tried to put this in a risk perspective. We did a study in 2000 6672 where we actually tried to put numbers, frequencies, the type of accidents. We used those numbers and the bottom line, I guess the bottom line is we ran through all the numbers and assumed the number of shipments to Yucca Mountain I think was 25,000 and the frequency of this type of fire per mile that we think that this has a probability of occurring once every 750,000 campaigns, not shipments. But if you had 750,000 Yucca Mountain campaigns this would happen once your particular cask would be in this type of fire.

Now a lot of people look at that and say wow. But when you think about it the Baltimore Tunnel fire did happen, but what is the probability that your spent fuel cask out of the billions of miles traveled on the rail by HAZMAT is going to be your spent fuel cask. That's the type of number this represents. Even given that low number, we don't think there's a consequence.

MEMBER WEINER: Did you look at the analogous number in terms of how many shipments of hazardous materials, shipments that go through the Howard Street Tunnel and so on or did you just look in terms of shipping campaigns to Yucca Mountain?

MR. EASTON: What we did is we took the frequency of a fire occurring per mile and we multiplied out the number of miles would be shipped in a Yucca Mountain campaign and we figured out how often. It's just a very simple number and we recognize that it could even been reduced further if you go to dedicated trains. Because if you have a dedicated, you don't necessarily have tank cars in the same thing.

Although tomorrow's presentation on the dedicated train study, I think if you read the study closely shows that there's not a big safety difference between types of train service. So we don't know how to really quantify this number very well but we think there will be a slight reduction.

The point being we think this type of accident is very infrequent. We think that if it occurred the way we modeled it you really don't get much release. The one thing I forgot to mention that I think is important for conservatism is what our models show is that most of the heat transferred in is from radiation from the tunnels like an oven and we don't assume there's any smoke there. We assume that it has a clear view of the tunnel surfaces and we think that over estimates the amount of radiation heat transfer into the cask.

CHAIRMAN RYAN: Your f mile is frequency

of severe fire accidents per mile. Per mile of what? Train travel in the U.S. total?

MR. EASTON: Yes, mile of train travel.

CHAIRMAN RYAN: And I'm sure it would still be a very small frequency but is that the right divisor? I would think you would want to divide by the number of miles on tracks on which spent fuel shipments would travel. My guess is that there's an awful lot of train miles that have absolutely nothing to do with Yucca Mountain one way or another or spent fuel shipments one way or another. Is that a fair assessment?

MR. EASTON: This is freight travel and you're right. There are different classes of tracks and spent fuel would be limited to the best classes of tracks.

CHAIRMAN RYAN: I guess I just don't know but it would seem to me that that would certainly change it from 750,000 Yucca Mountain to some smaller number.

MR. EASTON: It's a very small number and if you're off two orders of magnitude it's still a very small number.

CHAIRMAN RYAN: Yeah, but you don't know it very well.

MR. EASTON: What?

CHAIRMAN RYAN: You don't know it.

MR. EASTON: Yes.

CHAIRMAN RYAN: I guess I just think that this looks an awful lot like an extreme bounding case and whenever you do an extreme bounding case, you mask potential understanding or insight in risk. It's something to think about.

MR. EASTON: Okay. And these last two slides are not actually in the Baltimore Tunnel fire study. They were extrapolated from 6672 which was our overall look at rail and highway accidents to try to give some risk perspective. The bottom line we don't think this type of accident happens very frequently and we think when it does happen the consequences are not very high. That's the conclusion we're drawing from the tunnel fire.

I guess I just went over these. Any consequences we would predict would come from CRUD and there are reasons why we believe even CRUD doesn't get out. But we did go through the exercise to predict what if any CRUD did get out. We think we bound it.

We did put out for public comment and we go comments from three parties, the State of Nevada and I think we have representatives here that might characterize them or correct me if I mischaracterize them. That's on the next page. We go them from two other parties, the Brotherhood of Locomotive Engineers and Trainmen who are primarily worried about loss of shielding because some of these have lead shielding and you do exceed that temperature.

What we believe is yes, if you exceed that temperature and get localized melting and if there's a pathway that that can drain out, you create an air gap which retards the flow in. However, we don't think that in this type of accident you'd get any breach to let out. So basically you'd get some liquefaction and then you would get resolidification. It would be come a solid in place.

MEMBER WEINER: If you have an impact that is combined with a high enough temperature to melt the lead, you do get gaps in the lead. You get voids.

MR. EASTON: Right.

MEMBER WEINER: And I would encourage you to consider that as well.

MR. EASTON: And you're quire correct. That was not part of this exercise, but it was part of 6672 where we looked at a whole range of accidents. This was just done as a case study of the Baltimore Tunnel fire which there was no impact.

We got comments from the Northeast High Level Radioactive Waste Transportation Project which is a group that represents gubernatorial appointees from the ten Northeast states that deal with transportation and they said can you consider a longer duration fire and can you consider a different horizontal and vertical location. They're saying that is it possible to have an accident where you could run up over that bumper car with the tank car and have the fire closer or somehow slide by and get the tank car closer. Of course, this was a single track tunnel. So that's part of it and there was no real impact.

And the State of Nevada and here you can help me if you want, guys, but some of their comments were to explain a relationship to NUREG-6672 as we understood it, explain a relationship to the Yucca Mountain FEIS and the Radioactive Waste Management Associate study I think done by Mr. Resnikow. To put this in context, they would like to see the analysis done for GA-4 truck cask which is one maybe DOE might use. They want to consider different horizontal and vertical positions for the cask, do an analysis where the cask is I think something like 15 feet away rather than 60 feet away, loss of shielding, effective higher burn-up fuel where you might get cladding breach and quantify modeling uncertainties. Now they had like two or three pages of comments and I just tried to summarize what I felt were the major ones and I don't know if I missed many or any or lots.

CHAIRMAN RYAN: We'll have member questions and then go around to the audience if that's all right, Ruth.

MEMBER WEINER: Sure. We'll do that. Are you going to respond to these, have a response document for these comments?

MR. EASTON: Yes, I think what we're planning on doing now is sending their comments out to the contractor and developing a response which could be presented either in a Q&A section in the back or resolved in changes to the text and this would be part of the final report, a list of the comments we got and either Q&A or that. We haven't decided exactly 100 percent what the format would be but these are our thoughts.

MEMBER WEINER: Questions. Start with Dr. Clarke.

MEMBER CLARKE: Just a quick question to clarify. Your analysis as reported in 6886 really focused on consequences. In other words, you assumed you had a fire and you used the input data from the

Baltimore Tunnel. You get to likelihood near the end of your presentation with 6672 and you're saying including an accident like the Baltimore Tunnel fire. Those were all tunnel fires for their analysis.

MR. EASTON: 6672 looked at severe fires.

MEMBER CLARKE: Severe fires.

MR. EASTON: All over the place.

MEMBER CLARKE: Which may have been in tunnels and not in tunnels.

MR. EASTON: And may not. So that number is for all severe fires. That's why we think the number is even lower than the one that we used.

MEMBER CLARKE: Okay.

MR. EASTON: Because that's a subset. And you're correct. This study the way it was fashioned was just to look at what happens. It didn't look at how frequent. So it's really not a risk study. It's just a what if consequence.

MEMBER CLARKE: But you're combining a likelihood study to the consequences.

MR. EASTON: But what I think to just present it as a consequence without giving some sort of risk.

MEMBER CLARKE: No, I have no --

MR. EASTON: So we pulled the information from another study.

MEMBER CLARKE: No problem with that. I just wanted to clarify the assumptions and the likelihood. Thank you.

MEMBER WEINER: Dr. Ryan.

CHAIRMAN RYAN: I guess I'll digest your report. Like Jim, I'm going to think about this notion of presenting what looks like an extreme bounding analysis to somehow make a comment on risk. Not to offer a pun but that's pretty risky and that's not to say I disagree or will disagree with the analysis itself. I'm just trying to put that into context. I don't know that that holds up over the longer haul. It's something to think about.

The other aspects of what's calculated and what's a model, I think I need to be a little clearer on that before I can offer you a thorough comment. But I'm a little concerned when I'm still not clear whether it was real data put into a model and used to extrapolate it to some new value and then switched to another model or it was all calculated data. How come one line that's calculated as dashed and one's -- But I need to understand that a little bit better. We're not going to get there today. It's sure something to think about.

The other point I'd make to you is that we did have a number of other presentations some months ago as you know, I'm sure, on the tunnel fire and had lots of participants in two separate meetings on these transportation related issues. So we sure have that information to think about as well. I've already asked the other questions I wanted to ask. Thank you.

MEMBER WEINER: Allen.

VICE CHAIRMAN CROFF: Once you're through with this report and you've done whatever you're going to do with the comments and there's a final report or whatever, is there a next step beyond this? Are you folks going to do something in addition? Is somebody going to consider this, your result, to make some decision? Where is this going?

MR. EASTON: Good question. I don't think that we would be taking any action like from a regulatory point of view based on the result of this report. I think we look at this report as sort of a case study that confirms our regulations and that there isn't any need to change them. I don't see us at this point making any changes. Is that what you're getting at?

VICE CHAIRMAN CROFF: I think so. Thanks.

MEMBER WEINER: Bill.

MEMBER HINZE: Just a couple of quick comments and questions. It seems to me that I would be much more happy with this document if there was some physical basis for it other than simply temperature modeling, what's happening to cause failure, etc. and I think that could be a much more of a certain view of what is really happening here and I would encourage you to at least think about that.

And I guess this really is a follow-up to, a more specific thing to follow up to Dr. Croff's question and that is for example in your view a cask that has undergone this kind of treatment and experience, is this cask going to be reused?

MR. EASTON: Reused?

MEMBER HINZE: Yes.

MR. EASTON: No.

MEMBER HINZE: Why not?

MR. EASTON: I think it would not be reused until you could demonstrate it was in the same condition as it was in the original use. What I mean by that is these casks, the design and use of them is controlled through a certificate. You have to meet that certificate. To reuse this cask, you would have to demonstrate that you meet the terms of that certificate before you reuse it. So if there's an lead melt or any bulging or there's any this or that damage, it would be hard to go back and say that you met that certainly without doing some remedial work or something like that.

MEMBER HINZE: So there is provision for going back and reevaluating the performance of a cask that has been involved in an accident.

MR. EASTON: Absolutely. Before you use a cask, it has to meet the condition of an NRC certificate.

MEMBER HINZE: I'm not familiar with 6672 but I gather that sort of thing is in 6672.

MR. EASTON: No, this is in the regulations.

MEMBER HINZE: And is there anything that came out of your study of the Baltimore fire which would suggest that you should revamp 6672?

MR. EASTON: No, we don't see anything that would. 6672 is a more generalized look at highway and railway accidents.

MEMBER HINZE: Right.

MR. EASTON: And we see this as a small subset and we don't see any reason to go back. There are some other reasons to go back and relook at parts of it, but not from the Baltimore Tunnel fire.

MEMBER HINZE: Do you envision going back and doing some modeling where the stacking of cars may have occurred and so that the cask is closer to the source of the heat?

MR. EASTON: That we haven't address that comment yet but I would mention that in 6672 we did do analysis where casks were directly in the fire and there is a case in 6672 where it was an engulfing fire long enough that you did get cladding failure and there is a prediction on what might be released in 6672. So I don't think that really revisiting that in the Baltimore Tunnel would really add to that necessarily.

MEMBER HINZE: Thank you.

MEMBER WEINER: I have a quick question and then I'm going to call on Mr. Halstead. My quick question is how do your temperature profiles compare to those that are in 6672 for the inner heat and the heat of the clad? Did you look at those comparisons at all? There's a chart at the end of one of the chapters in 6672.

MR. EASTON: I haven't done that direct comparison. All I know is there are more severe fires in 6672.

MEMBER WEINER: I was thinking mostly

about the length of time that it takes for the internal of the cask to reach the fire temperature.

MR. EASTON: Let me just say that in 6672 they looked at fully engulfing fires under the cask and if you burned off a whole rail tank car, that supports a fire for about six hours. So I want a fully engulfing fire of 12 hours, I have to have two tank cars burning in sequence at exactly under that cask, draining and burning in sequence or I have to have a pit deep enough to contain two tanks cars full of fuel and somehow have that cask sit above it. We'll looked at these type of issues about duration and where it's located in 6672.

PUBLIC COMMENT

MEMBER WEINER: I'm going to ask since we did a get a request for a representative of the State of Nevada to add something. Come up and use the microphone and identify yourself for the reporter.

MR. HALSTEAD: Thank you. I'm Bob Halstead, Transportation Advisor to the Nevada Agency for Nuclear Projects. We filled 17 summary comments on the report on December 30th. We are struggling to add the additional documentation we promised to add to those comments in the next couple of work weeks.

But I think it's fair to say that this

controversy is not going to be closed quickly. I see us working on this for another nine or 12 months because we want to replicate some of the modeling using particularly the expertise that we've supported the development of that University of Nevada Reno Department of Mechanical Engineering where Dr. Miles Griener has been conducting a number of simulations for us.

So what I'd like to do is quickly give you an overview of the comments that I expect will be in the cover letter that we send in a couple weeks with some more detailed comments. The first point is that four and a half years after this fire a lot of the facts are still in dispute. They will probably never be resolved and that's part of why we have this continuing controversy in spite of the fact that the NTSB, FEMA's fire division, the NRC and the State of Nevada have studied this. It's extraordinary that any accident event gets this kind of study.

The rail-tunnel safety issue is particularly important to us because of unique local conditions in Nevada and particularly since DOE has selected the Caliente corridor for Yucca Mountain rail access. We've now looked at the UP main lines into where that spur would originate and there are 14 tunnels within 50 miles of Caliente. It's an unusually mountainous area and no matter which way you approach that spur each rail shipment to Yucca Mountain would go through a minimum of six or seven tunnels within the State of Nevada alone.

And we haven't looked at this as a national phenomena but I think it underscores that fact that this is not a trivial issue. It's something that we want to pay attention to.

Our safety concerns are further added to by the fact that the Department of Energy has still refused to use dedicated trains for all spent fuel shipments to Yucca Mountain. They're still proposing to ship spent fuel and rail casks without welded canisters. And they're still proposing as a back-up plan to ship legal weight truck casks, most likely about 90 percent GA-4 with some other assortments of casks like the NAC-LWT on rail cars.

Now regarding fire itself, whatever the other disagreements may be, we all seem to be who have studied it in agreement that the hottest region of the fire burned approximately two to three hours at temperatures of about 1500 to 2000 degrees Fahrenheit or 800 to 1,000 degrees C, burned for another three or four hours at lower temperatures and then cooled down over one to three days. Looking at the particulars of that fire, we find that contrary to our thinking and some other people's thinking it was not a worst case tunnel fire because of the water main break at about three hours, because of the limited oxygen supply in the fire and as Earl pointed out, based on the fuel availability in the tanker, you could conceive of a six to seven hour fire at those higher temperatures.

But it was considerably more severe than the hypothetical accident that's assumed in the NRC regulations which is 1475 degrees F or about 100 degrees C for 30 minutes. So the hottest region of the Baltimore Tunnel fire burned considerably longer, four to six times longer and possibly 25 percent hotter. We don't know for sure.

Now the approach we've taken in examining this fire and its safety implications and understand we're assuming a hypothetical accident, the NRC is assuming a hypothetical accident, we've assumed that the casks should be subjected to the hottest region of the fire in addition to being subjected to the temperatures that would be expected some distance from the fire. Frankly, based on our own modeling, based on NUREG-CR-6672, which is some people at the table know we've been extremely critical of and in other cases we've been extremely supportive of those analyses, we would expect virtually all NRC-certified casks to fail significantly if they had been subjected to the hottest duration of that fire of its full duration.

I say potentially because there's on interesting possible exception and that is that the welded canister in the Holtec HI-STAR really provides such significant additional protection that we need more analysis. And of course, that was a point of contention in the report that we issued in November of 2001. We believe that the report significantly under estimates the potential radiological consequences then because it assumed that the cask would be at least 20 meters from the hottest region of the fire and moreover, even at that 20 meter distance we think there's a significant under estimation of the potential consequences to the NAC-LWT cask. That's the truck cask because it's assumed to be in an ISO shipping container and that's because there is no requirement that it be shipped that way. It's shipped that way generally for the convenience of international shippers for the research reactor fuel shipments and it does in our opinion provide some additional significant thermal insulation which in fact we would argue should be a requirement in the event that that truck cask is shipped that way.

Furthermore, even at 20 meters distance, we believe that the NUREG-CR-6886 report may have under estimated, may have significantly under estimated, the potential radiological consequences for all three casks because of some uncertainties in the NIST fire model, some uncertainties in the assumptions about how spent fuel cladding performs and whether there could possibly be any fission product released before the excepted burst rupture temperature of about 750 degrees C is reached, assumptions about the release pathways from the casks, Earl talked about those, we have some different opinions about them, and a number of other factors.

But these are things that we're going to have to study some more. I'm not confident telling you exactly how great the difference between our conclusions and the report is. I would like to conclude by saying that there are three areas where we think there are some important regulatory and policy implications and frankly, we think these are a lot more important than this very interesting academic debate we've been having for four and a half years and we'll continue to have for another year or so on what happened in the Baltimore Tunnel fire.

First of all, we think that dedicated trains should be required for all spent fuel shipments by rail. That's been our position for 15 years. We think it is a sound position. It's the position the railroad have had and we think it ought to be in regulation.

We think, secondly, the findings of this report suggest that when a steel lead, steel traditional legal weight truck cask like the NAC-LWT is shipped by rail, it's a good idea to have it in an ISO container even though that isn't required.

And it may be at the end of this study that we'll see the need for some additional administrative controls when rail shipments are made through tunnels. We're not prepared to say something definitive about that at this time. That's certainly one of the things we'll evaluate.

Policy implications for the NRC, separate from regulatory implications, we would really like to see the package performance study proposal for full scale testing reoriented to prioritize looking at fire testing and particularly to look at extra regulatory fire testing. We estimate that you could do a pretty thorough two to three hour fire test of a truck cask for somewhere in the neighborhood of $6 million to $10 million which is considerably less expensive than the full scale testing of the rail cask that's been proposed and frankly, we think it would go much more directly to the area of concern which is accidents involving long duration fires and that would be primarily to validate modeling but I think there are also some things we would learn about materials performance.

Certainly, a rail cask could be tested similarly but we probably would learn enough from full scale long duration testing of the truck cask to answer most of the questions about how a rail cask would perform in terms of our confidence in our models.

Finally, policy implications for DOE, I know that that probably is beyond what this group would be involved in but I'll just tell you what we have told DOE. We said all rails shipments should be made by dedicated train and further, based on this study we think DOE should not even consider using LWT casks on rail as a backup. They are talking about using GA-4 casks. Those would be shipped without an ISO enclosure and for a number of reasons, we think that's not advantageous.

But one important finding of this study that DOE should consider is this whatever we may disagree about there's some profound evidence here that a large rail cask like the Holtec with a welded canister is an awfully robust package and NRC regulations don't require a shipper to use the "safest" package based on extra regulatory accident assumptions. But as a policy matter particularly if DOE is going to move towards looking at the so-called clean facility handling packages and what we used to call an MPC and now we call it a TAD, there's probably an important policy reason for the extra safety.

Finally, I know that DOE is already doing some work to identify tunnels and other hazardous features along their routes and developing risk management measures. I think the findings of this report say that that's a very good way to approach route specific risk management. Thank you very much.

MEMBER WEINER: Are there other comments from anyone? Staff. Okay. Then I'll turn it back.

MEMBER HINZE: The Center?

MEMBER WEINER: Any comments from the CENTER?

MR. DUNN: We don't have any comments.

MEMBER WEINER: Thank you. Then I'll turn it back to the Chair.

CHAIRMAN RYAN: No, you won't.

MEMBER WEINER: I won't. All right.

CHAIRMAN RYAN: You're up.

MEMBER WEINER: I'm up.

CHAIRMAN RYAN: Thank you very much. We appreciate you being with us and your colleagues as well and thank you very much for your insights and thorough Q&A. John, do we need this part on the record or not?

MEMBER WEINER: No.

CHAIRMAN RYAN: Okay. I guess we'll conclude. Why don't we do this. Why don't we take a 15 minute break and reconvene at 2:30 p.m. and then we'll pick on the white paper on transportation and preliminary discussion and we'll close our record for the day here. Yes we will. Thanks very much. Off the record.

(Whereupon, at 2:15 p.m., the above-entitled matter was concluded.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Nuclear Waste 167th Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Eric Hendrixson
Official Reporter
Neal R. Gross & Co., Inc.

KENNY C. GUINN
Governor

STATE OF NEVADA

ROBERT R. LOUX
Executive Director

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December 30, 2005

Chief, Rules Review and Directives Branch
U.S. Nuclear Regulatory Commission
Mail Stop T6-D59
Washington, DC 20005-0001

RE: Comments on Draft Report, Spent Fuel Transportation Package Response to the Baltimore Tunnel Fire Scenario (NUREG/CR-6886, PNNL-15313)

Dear Sir/Madam:

The State of Nevada Agency for Nuclear Projects is submitting additional comments on NUREG/CR-6886. We previously submitted preliminary comments on this draft report via our letter to Mr. Allen Hansen, Spent Fuel Project Office, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, on October 27, 2005. We request that our October 2005 letter and attachments be incorporated into the current record of comments on NUREG/CR-6886.

We appreciate the 60-day extension of the original comment period. Due to the complexity of this report and the supporting documents, we have still not fully completed our reviews. In order to comply with the December 30, 2005, deadline, we are submitting the following summary comments. We intend to submit additional documentation, in support of each of these comments, in about 10 days.

1. The final version of NUREG/CR-6886 should include an expanded introductory section summarizing previous NRC studies of spent fuel shipping cask response to severe fire environments, including an explanation of the relationship between this report and NUREG/CR-6672 (SAND2000-0234).

2. The final version of NUREG/CR-6886 should include a more detailed discussion of the Nation Transportation Safety Board (NTSB) investigation of the Baltimore Tunnel Fire, including the NTSB safety recommendations (R-04-15 and -16, issued

January 5, 2005) and the NTSB decision not to issue an official report on the cause and history of the fire.

3. The final version of NUREG/CR-6886 should include a detailed discussion of the 2001 analysis of the Baltimore Tunnel Fire prepared by Radioactive Waste Management Associates for the State of Nevada.

4. The final version of NUREG/CR-6886 should include a detailed discussion of the 2002 analysis of the Baltimore Tunnel Fire prepared by the U.S. Department of Energy as part of the Final Environmental Impact Statement for Yucca Mountain (DOE/EIS-0250).

5. The final version of NUREG/CR-6886 should include side-by-side fire transient results and consequence analyses of the NAC LWT cask, with and without enclosure in an ISO container. (The discussion at page 7.17 implies that these analyses were performed, but they apparently were not reported.)

6. The final version of NUREG/CR-6886 should include an additional cask analysis, parallel to the approach described in Section 5, of a General Atomics GA-4 legal-weight truck cask, shipped on a rail car without enclosure in an ISO container.

7. The final version of NUREG/CR-6886 should include an additional thermal analysis for each of the four casks, parallel to the approach described in Section 5, assuming that the cask is located 5 meters (16 feet) from the fire center.

8. The final version of NUREG/CR-6886 should include an additional thermal analysis for each of the four casks, parallel to the approach described in Section 5, assuming that the cask is located within the hottest region of the fire.

9. The final version of NUREG/CR-6886 should include a reexamination of the potential for fuel cladding failure and release of radioactive materials, including fission products, at temperatures below the projected burst temperature of 1382°F (750°C) for Zircaloy cladding. (Additional attention should be given to the presence of older fuel with brittle and/or previously failed cladding.)

10. The final version of NUREG/CR-6886 should include a reexamination of the potential for fuel cladding failure and release of radioactive materials for higher burn-up fuels, specifically addressing the issues of radiation embrittlement, pellet degradation due to thermal cycling, and fission product buildup.

11. The final version of NUREG/CR-6886 should include a reexamination of the potential for release of radioactive materials for fuel assemblies with higher levels of CRUD activity (e.g., BWR assemblies with surface concentration up to150 $\mu Ci/cm^2$).

12. The final version of NUREG/CR-6886 should include a reexamination of the mechanisms for seal failure and release of radioactive materials, including seal failure long before maximum seal temperatures are reached, bolt failure, and pressure-induced blowout of failed seals.

13. The final version of NUREG/CR-6886 should include a reexamination of the role of the HI-STAR 100 train carriage and cask restraints regarding heat shielding and heat conduction.

14. The final version of NUREG/CR-6886 should include a discussion of the emergency response implications, and cask recovery implications, of the predicted damage to the neutron shielding for all three considered casks, and the loss of gamma shielding for the NAC LWT.

15. The final version of NUREG/CR-6886 should include a reexamination of the uncertainties associated with the NIST FDS simulations of gas and wall temperatures 20-30 meters from the fire center. (These issues include the construction and benchmarking of the FDS code, selection of the conductivity value for the tunnel bricks, and potential inconsistencies with the materials analyses.)

16. The final version of NUREG/CR-6886 should include a comprehensive analysis of uncertainties in the following factors, and how these uncertainties might affect the results of the consequence assessment: fire size, location, and duration; gas and wall temperatures from the NIST FDS simulations; CNRWA metallurgical analyses; uncertainties in the package models; seal and cladding temperature limits; and heat transfer models for the neutron shield (including gap radiation in charred solid, and boiling heat transfer in liquid) and impact limiters.

17. The final version of NUREG/CR-6886 should include a discussion of any peer reviews conducted for this report, and any peer reviews conducted for two of the major supporting studies, NUREG/CR-6793 (NIST) and NUREG/CR-6799 (CNWRA).

Thank you for your consideration.

Sincerely,

Robert R. Loux
Executive Director

RRL/cs
cc Governor Guinn
Nevada Congressional Delegation
Earl Easton, NRC

Performance of Spent Fuel Transportation Casks in Environments similar to the Baltimore Tunnel Fire

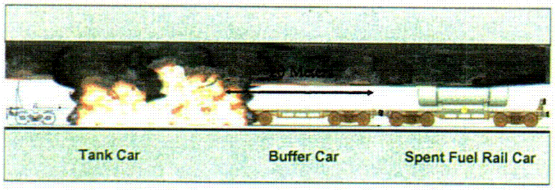
167th Meeting of the
Advisory Committee for Nuclear Waste
Rockville, Maryland
January 11, 2006

Earl Easton
Spent Fuel Project Office
U.S. Nuclear Regulatory Commission

Purpose of the Tunnel Fire Study

- To determine how three representative spent fuel cask designs certified by the NRC might have responded in an accident such as the Baltimore Tunnel Fire.

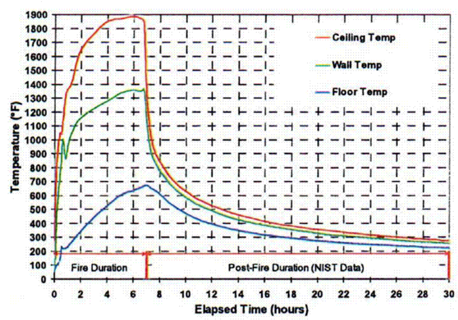
Assumptions Used to Define the Tunnel Fire Environment



- Casks located one rail car length from fire source.
- Duration of fire – seven hours; 23-hour cool down.
- Temperature profiles developed by National Institute of Standards and Technology (NIST).

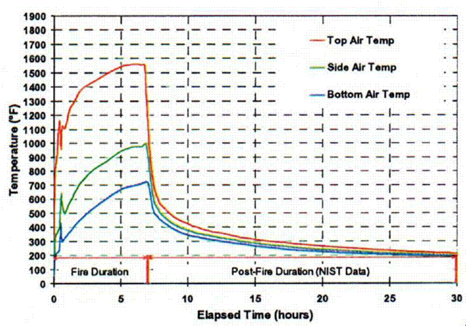
C01

Temperature of Tunnel Surfaces at Cask Location



4

Ambient Tunnel Air Temperatures at Cask Location



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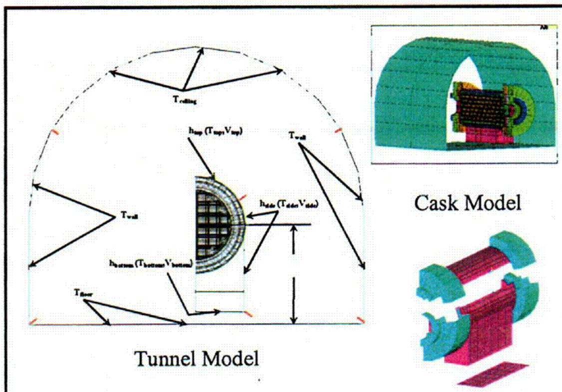
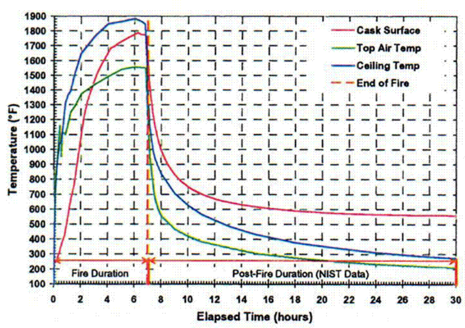


6

C02

Maximum Surface Temperatures for the TN-68 Cask compared to NIST Boundary Condition Temperatures

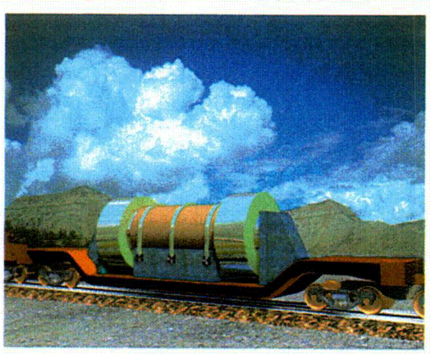


7

Spent Fuel Transport Casks Analyzed in Baltimore Tunnel Fire Study

	Typical Transport Mode	Loaded Weight, lbs	Contents	Cask Closure Design Features
HI-STAR 100 (cask on rail car)	Rail	277,300	68 BWR 32 PWR	Bolted Lid with O-rings, Inner Welded Canister
TN-68 (cask on rail car)	Rail	260,400	68 BWR	Bolted Lid with O-rings
NAC-LWT (cask in ISO container on rail car)	Truck	52,000	1 PWR	Bolted Lid with O-rings

8



HI-STAR – 100 Rail Cask (conceptual image)

9

C03

Key Results for HI STAR-100 Rail Cask

Inner Canister remains intact

→ No release from cask

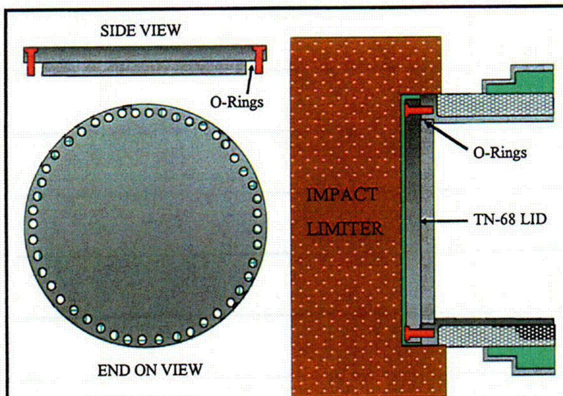
Peak Fuel Cladding Temperature	Cladding Burst Temperature	Temperature Margin
884° F	1382° F	498° F

→ No release from spent fuel rods

Peak Temperature In Seal Region	Outer Seal Temperature Limit	Inner Seal Temperature Limit
1177° F	1200° F Metallic	1200° F Metallic

→ No release from cask

10



TN-68 LID

11

Key Results for TN-68 Rail Cask

Peak Cladding Temperature	Cladding Burst Temperature	Temperature Margin
845° F	1382° F	537° F

→ No release from spent fuel rods

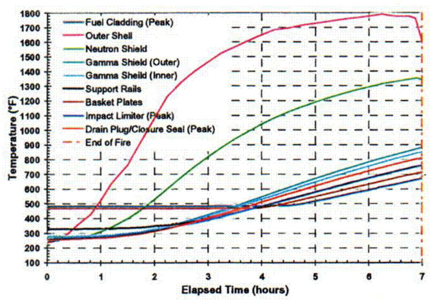
Peak Temperature In Seal Region	Outer Seal Temperature Limit	Inner Seal Temperature Limit
811° F	644° F Metallic	644° F Metallic

→ Minor release of CRUD possible

12

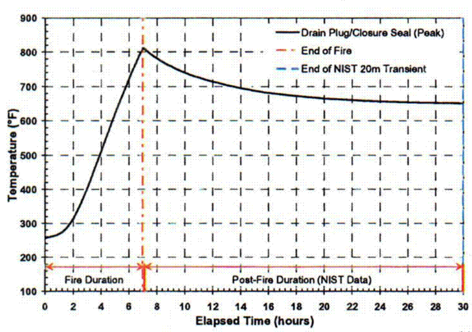
C04

Maximum Temperature Histories for TN-68 Package Components



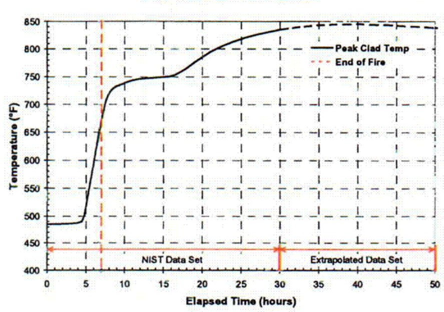
13

Closure/Port Seal Temperature for the TN-68 Cask



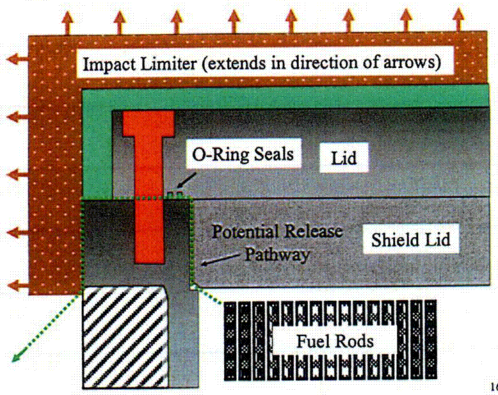
14

Peak Fuel Cladding Temperature For the TN-68 Cask



15

C05



16

Staff Estimation of Possible CRUD Release from the TN-68 Rail Cask in a Baltimore Tunnel Fire Type Accident

- Staff calculation based on methodology used in NUREG/CR-6672 and Security Assessments.
- Amount released less than 3.4 Curies of Co^{60}
- Estimate consistent with release estimate in Modal Study (1987) for Livingston Fire Analysis.

17

Realistic Conservatism in Release Estimates

- Realistic Assumptions
  - Based on realistic values for CRUD on BWR rods, not highest values.
- Conservatisms
  - Does not consider plugging of release pathways.
  - No credit for metal to metal contact between lid and cask.
  - No credit given for seals in regions where the seals remain below their rated service temperature, i.e., total area of seals were considered to be at the peak seal temperature.

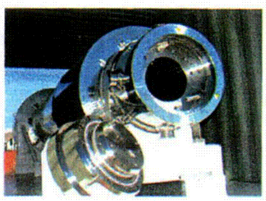
18

NAC-LWT Truck Cask

Below:
NAC-LWT with personnel barrier

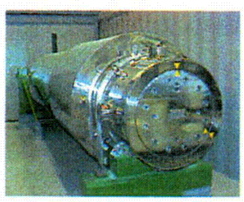
Above:
NAC-LWT in ISO container

Right:
NAC-LWT rail shipment in ISO containers, configuration that is analyzed in study.



Left:
NAC-LWT with lid removed. Note stepped configuration of Lid. Impact limiter affixed to bottom end.

Right:
NAC-LWT inside ISO Container. Lid bolted in place. Impact limiters not in place.



Key Results for NAC-LWT Truck Cask shipped by Rail in an ISO Container

Peak Cladding Temperature	Cladding Burst Temperature	Temperature Margin
1099° F	1382° F	283° F

→ No release from spent fuel rods

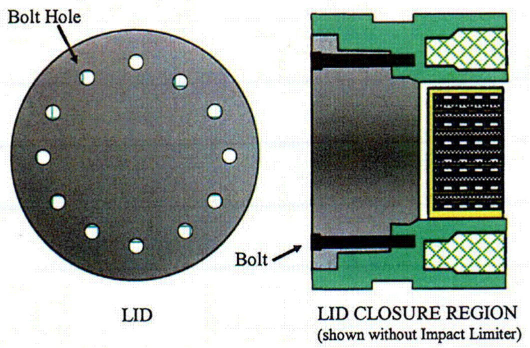
Peak Temperature In Seal Region	Outer Seal Temperature Limit	Inner Seal Temperature Limit
1350° F	735° F Teflon	800° F Metallic

→ Minor release of CRUD possible

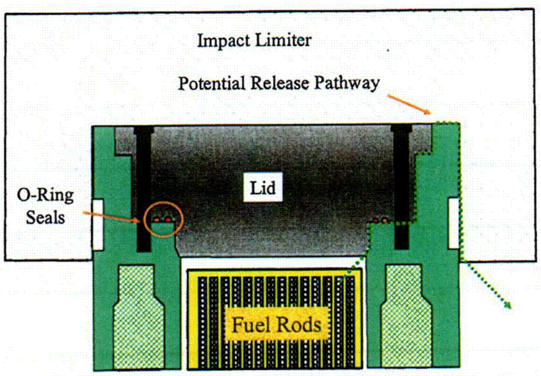
CRUD is a thin layer of corrosion that sometimes forms on a fuel rod when the surface oxidizes.

C017

NAC-LWT Truck Cask



22



NAC-LWT LID CLOSURE REGION

23

Staff Estimation of Possible CRUD Release from the NAC-LWT Truck Cask in a Baltimore Tunnel Fire Type Accident

- Staff calculation based on methodology used in NUREG/CR-6672 and Security Assessments.
- Amount released less than 0.02 Curies of Co^{60}

24

C08

Realistic Conservatism in Release Estimates

- Realistic Assumptions
  - Based on realistic values for CRUD on PWR rods, not highest values.
- Conservatisms
  - Does not consider plugging of release pathways.
  - No credit for metal to metal contact between lid and cask.
  - No credit given for seals in regions where the seals remain below their rated service temperature, i.e., total area of seals were considered to be at the peak seal temperature.

Summary of Key Results

	Potential Releases (calculated)	Comments	Number of A_2's released[1]
HI-STAR 100	None.	Releases prevented by Inner Canister	0
TN-68	3.4 Ci of Co^{60}	Release due to Crud. Cladding remains intact.	0.3
NAC-LWT	0.02 Ci of Co^{60}	Release due to Crud. Cladding remains intact.	.002

[1] The potential releases of radioactive material from all three casks are well below the internationally accepted safety standard of an A_2 quantity per week. The A_2 quantity per week is based on limiting potential exposures to first responders and the public following a severe transportation accident to no more than the occupational dose of 100 mrem. This limit represents approximately 25 percent of the normal background dose of 400 mrem/yr.

Risk Perspective

- NUREG/CR – 6672 predicts that severe fire accidents, including an accident like BTF, will occur once every 4.8×10^{12} miles.
  - The frequency stated is for a class of accidents that would include BTF; however, BTF is extreme (duration) within that class – probability of cask in BTF-type accident is significantly less than that stated (for the entire class of severe fire accidents)
  - Operational considerations further limit frequency; e.g., spent fuel rail shipments not permitted in BT; use of dedicated trains.
- By comparison, a rough estimate of the total rail shipment miles for a proposed repository campaign is about 6.4×10^6 miles (3200 rail shipments at an average distance of 2000 miles).

Risk Perspective (continued)

- Frequency (F) of a BTF type event:

$$F = F_{mile} M_{campaign} R$$

where, F_{mile} = frequency of severe fire accidents per mile
$M_{campaign}$ = miles per shipping campaign
R = factor based on operational restrictions

- F = 1.3×10^{-6} R events/shipping campaign or one event every 750,000 shipping campaigns.

Conclusions

- The response of three different cask designs indicate that spent fuel would not be released in a Baltimore Tunnel Fire-type accident.
- Any release of radioactive material, such as CRUD, would be extremely small and pose no significant danger to the public or first responders.

Conclusions

- Although the Baltimore Tunnel Fire was a real world event, the chance that a spent fuel cask would be involved in this type of accident is extremely low.

Comments Received on the BTF Study

- Northeast High-Level Radioactive Waste Transportation Project
  - -- Consider longer fire duration.
  - -- Consider different horizontal and vertical position of cask.
- Brotherhood of Locomotive Engineers and Trainmen
  - -- Loss of shielding during accidents not considered in study.

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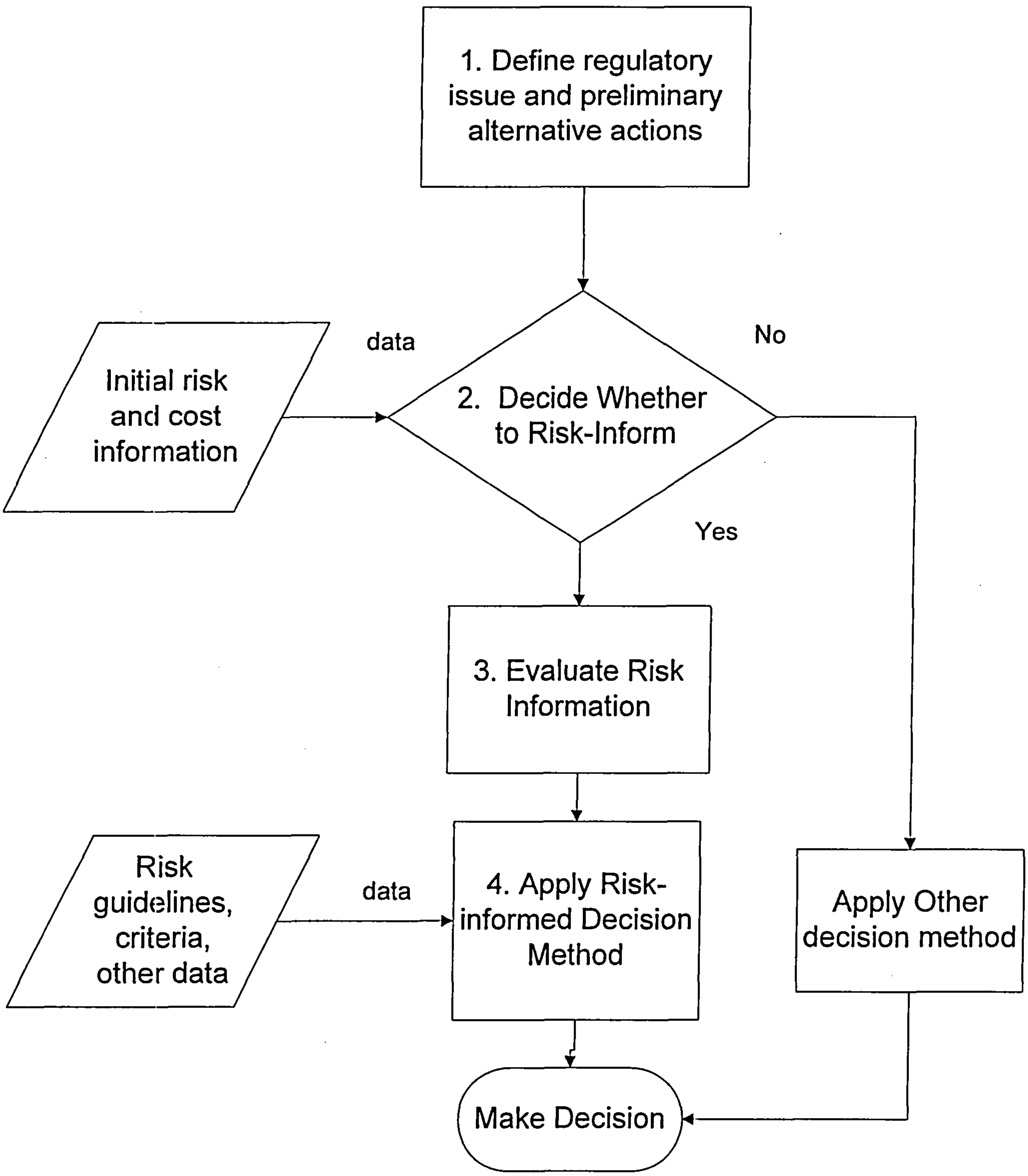
Comments Received on the BTF Study

- State of Nevada
  - Explain relationship to NUREG-6672, DOE Yucca Mountain FEIS and RWMA study.
  - Expand analysis to include the GA-4 truck cask.
  - Consider different horizontal and vertical positions for cask, longer fire durations, loss of shielding, and effect of higher burnup and more contaminated fuel.
  - Quantify modeling uncertainties.

32


1. Define regulatory issue and preliminary alternative actions
Initial risk and cost information
data
2. Decide Whether to Risk-Inform
No
Yes
3. Evaluate Risk Information
Risk guidelines, criteria, other data
data
4. Apply Risk-informed Decision Method
Apply Other decision method
Make Decision

Waste Package Fabrication: Process and Effects

Aladar Csontos, Ph.D
U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Division of High-Level Waste Repository Safety
Technical Review Directorate

January 10, 2005

167th Advisory Committee on Nuclear Waste Meeting

Presentation Outline

I. Outline
II. Objectives
III. Background
IV. Fabrication Process
V. Fabrication Effects
VI. Summary

Objectives

- To present the staff's current understanding and observations regarding the design, fabrication, and assembly of the 21-PWR Uncanistered Fuel (UCF) prototype waste package.
- To present an overview of the effects of potential fabrication processes on the phase stability and corrosion and mechanical behaviors of Alloy 22.

Background

Waste package (WP) fabrication and assembly processes may affect the long-term performance of the WP in the potential repository.

Potential
Fabrication Processes:

- Fabrication Specifications:
  - Design
  - Codes & Standards
- Prototype Assembly

Potential
Fabrication Effects:

- Phase Stability
- Corrosion Behavior
- Mechanical Behavior

UNITED STATES NUCLEAR REGULATORY COMMISSION

Potential Fabrication Process:

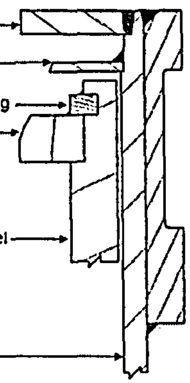
- Fabrication Specifications:
  - –Design
  - –Codes & Standards
- Prototype Assembly

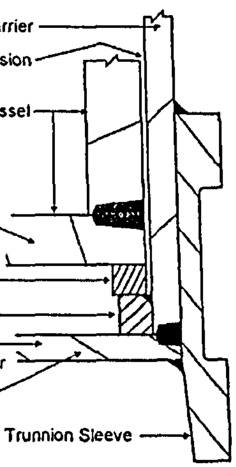
Fabrication Process: 21-PWR UCF WP Design

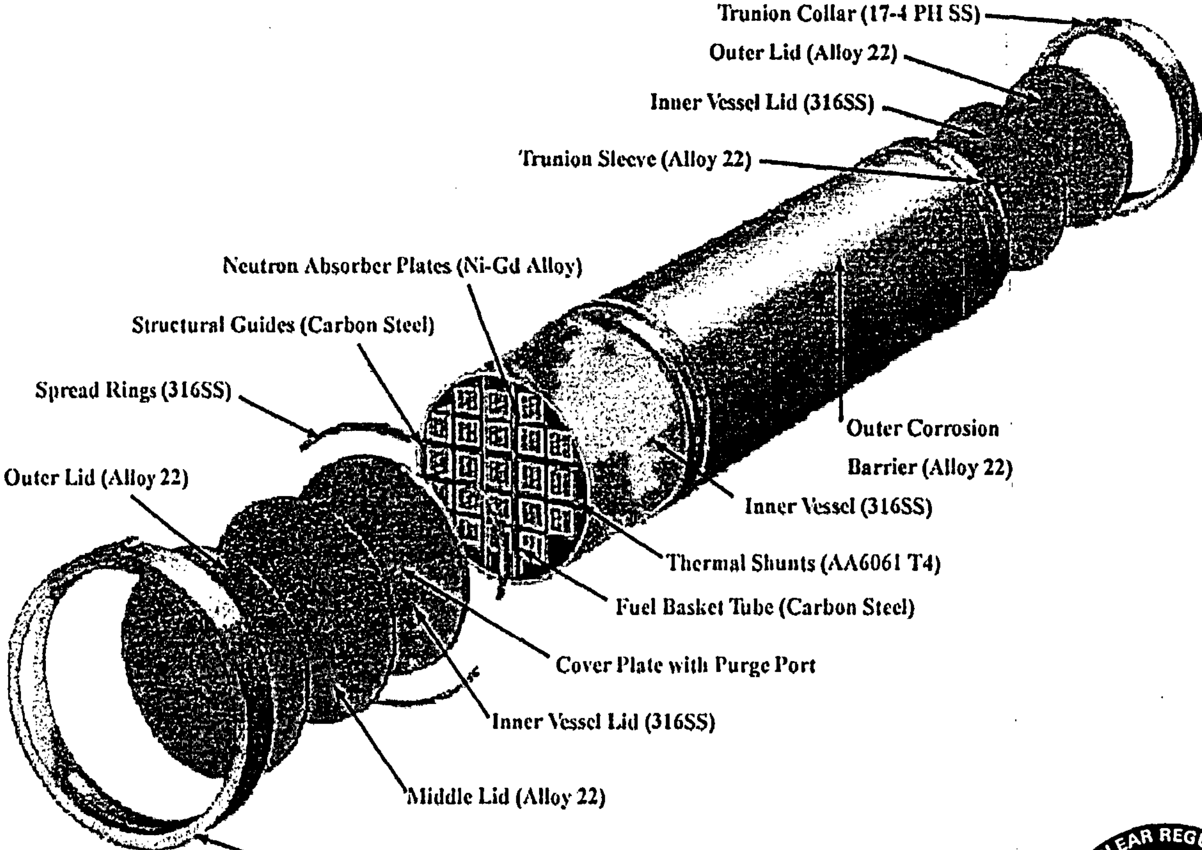
Overall Dimensions:
Length: 16ft 7in
Diameter: 5ft 7¼in

SS316 Thickness:
Initial: 2⅞in (7.3cm)
Final$_{(min)}$: 2in (5cm)

Alloy 22 Thickness:
Initial: 1⅛in (3cm)
Final$_{(min)}$: ¾in (2cm)







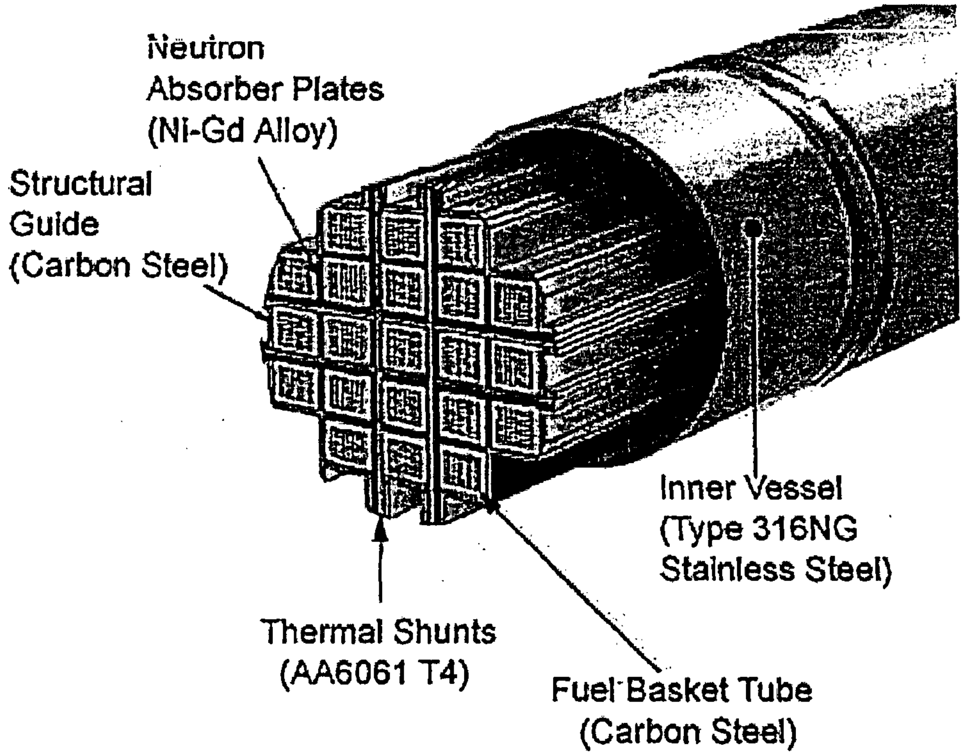
Fabrication Process: Codes & Standards

- DOE plans to use the ASME Boiler & Pressure Vessel Code (BPVC), Section III, Division 1 to fabricate the WP inner vessel and outer barrier.
- ASME BPVC Section III takes into account load stresses, but does not cover deterioration that may occur in service as a result of radiation effects, corrosion, erosion, or instability of materials.
- ASME BPVC Section III does state that the design should allow for loss of thickness if corrosion will be an issue.

Fabrication Process: Codes & Standards

- Waste Package Inner Vessel:
  - Built to ASME Section III, Division 1, Subsection NC.
  - Will be N-stamped.
- Waste Package Outer Barrier:
  - Fabricated to meet relevant portions of the ASME Section III, Division 1, Subsections NB and NC requirements with enhancements as detailed by DOE.
  - DOE may use portions of the code since the code was never intended to be used to design or fabricate components with the long-term service requirements of the Alloy 22 WP outer barrier.
  - Hence, the WP outer barrier will not be N-stamped.

Fabrication Process: Codes & Standards

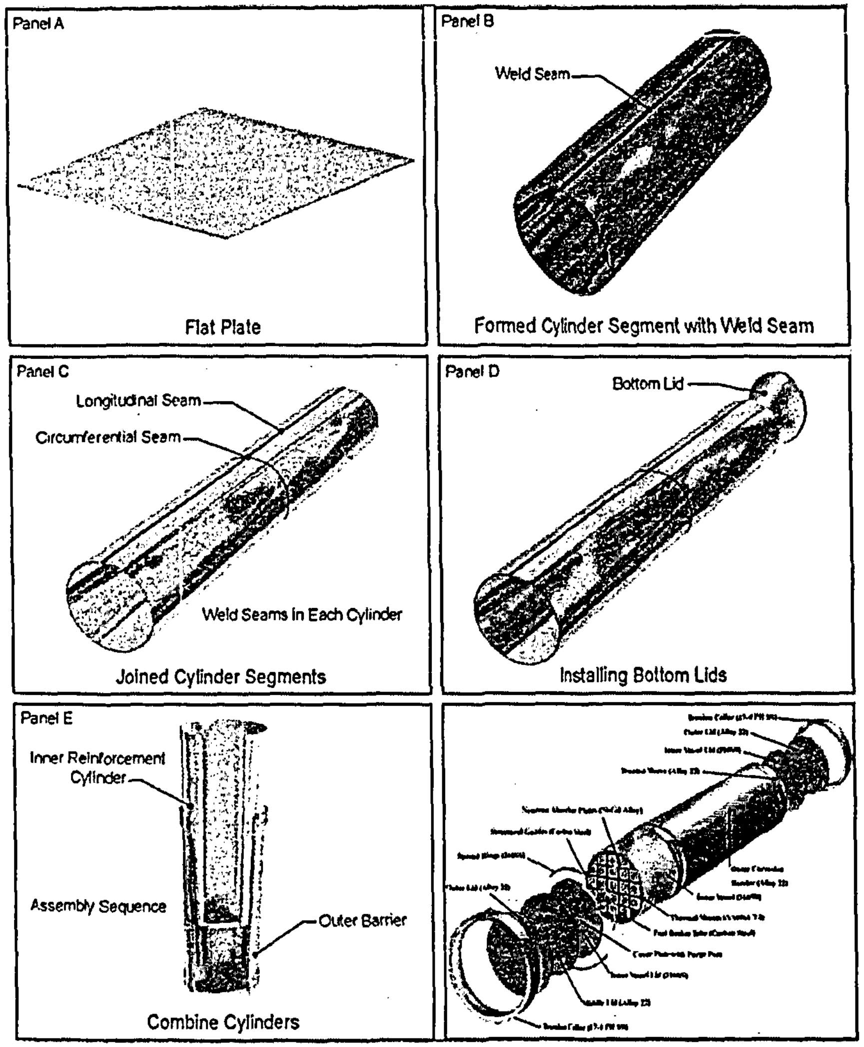


- Waste Package Basket Assembly:
  - Fabricated using guidance from ASME Section III, Division 1, Subsection NF.

Fabrication Process: Prototype Assembly

- Joseph Oat Corporation, Inc. (JOC) won the initial contract to fabricate the first full scale 21-PWR UCF prototype WP with basket assembly.
- Schedule of 15 WP prototypes by 2009*.
- DOE is trying to develop a pool of qualified vendors*.
- Purpose of the JOC visits is to better understand the fabrication process and the potential implications for WP postclosure performance.

Fabrication Process: Prototype Assembly

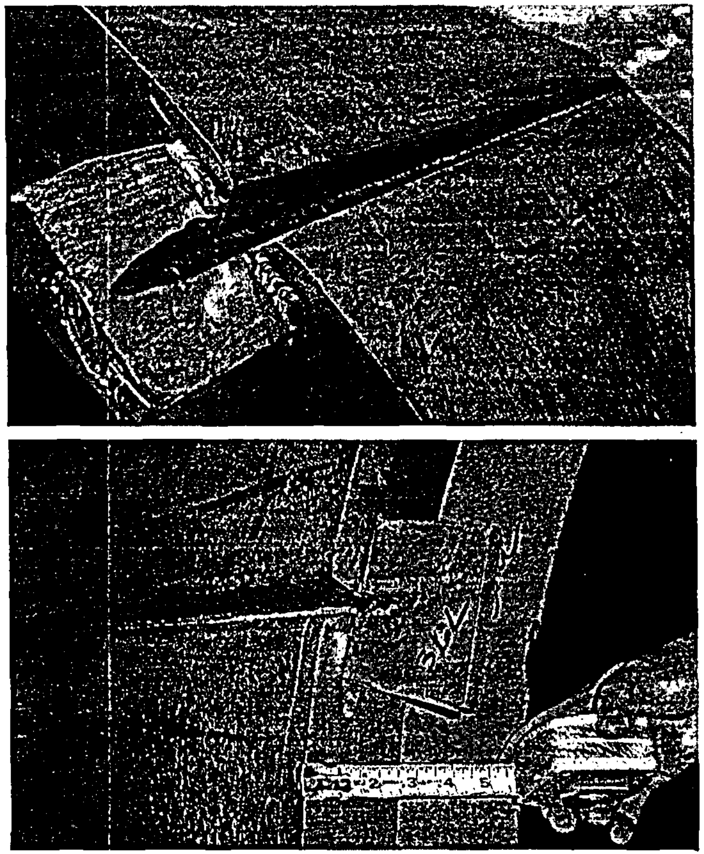


- Fabricator Operations:
  - 316NG & Alloy 22 plates
  - Roll plates into cylinders
  - Weld/Inspect longitudinal seams
  - Machine & fit shells
  - Weld/Inspect circumferential seams
  - Machine & fit bottom lid to shell
  - Weld/Inspect bottom lid to shell
  - Weld trunion (outer barrier)
  - Solution anneal & quench (outer barrier)
- Field Operations:
  - Sleeve inner & outer cylinder
  - Weld/Inspect top lids to shell
  - Laser peen or burnish top lid weld

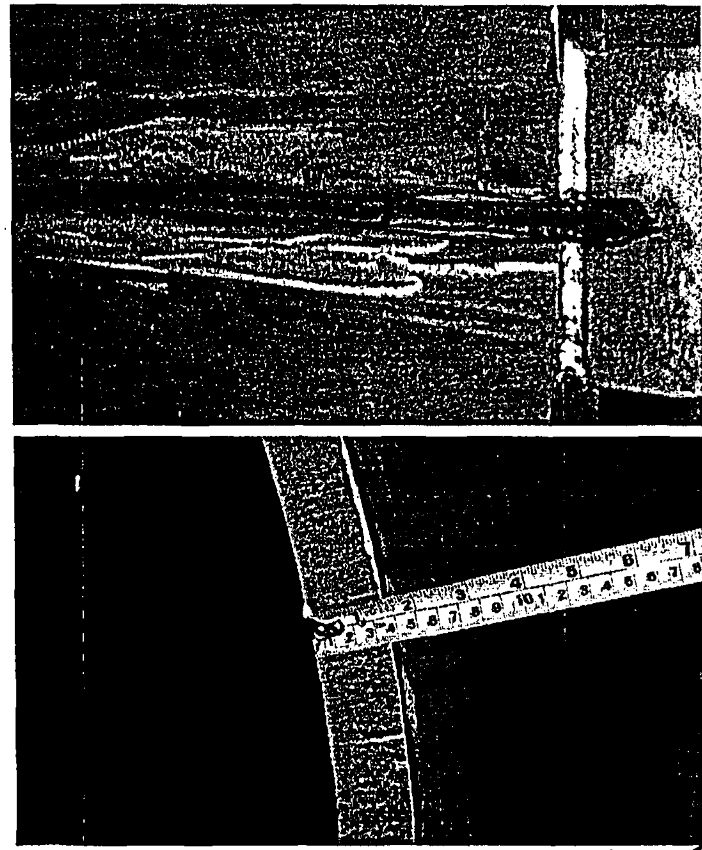
Fabrication Process: Prototype Assembly

Longitudinal Weld Preparation

316SS Inner Vessel (SAW)

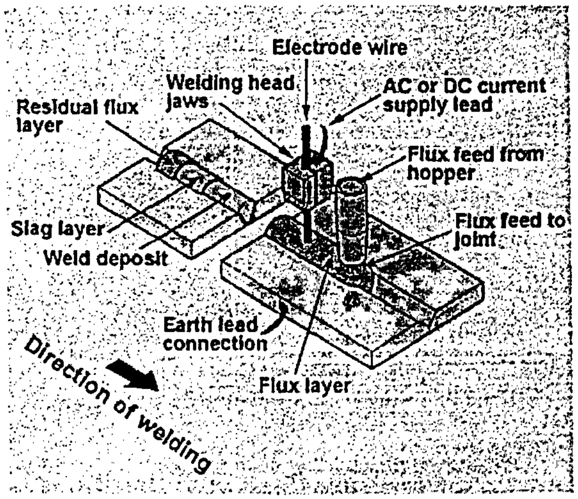


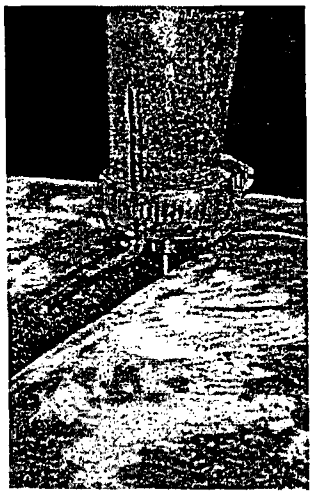
Alloy 22 Outer Barrier (GTAW)

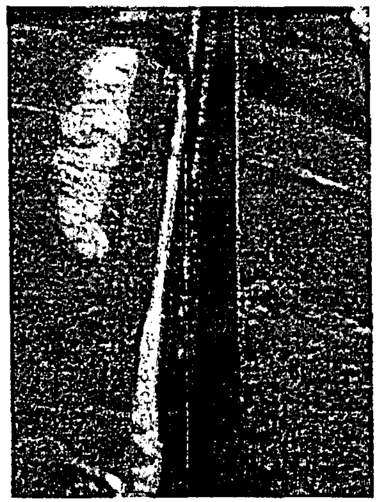


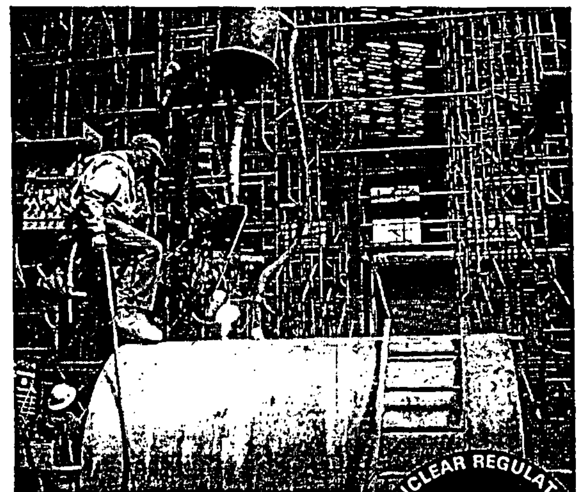
Fabrication Process: Prototype Assembly

- Submerged Arc Welding (SAW) involves the formation of an arc between a continuously-fed bare wire electrode and plate.
- The process uses a flux to generate protective gases, hence, a shielding gas is not required like in Gas Tungsten Arc Welding.
- SAW was employed to weld the 316NG inner vessel longitudinal and circumferential joints.



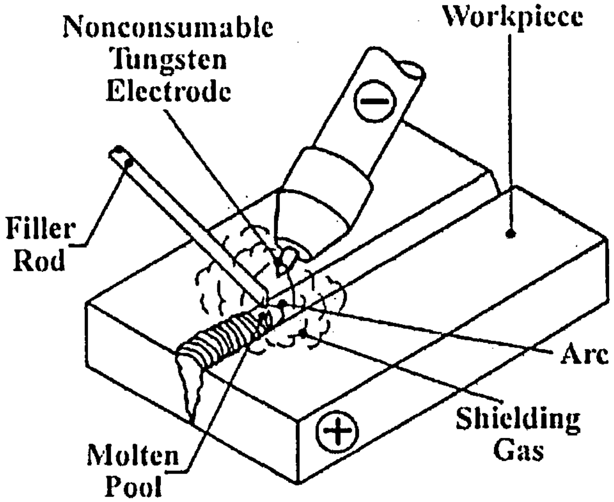


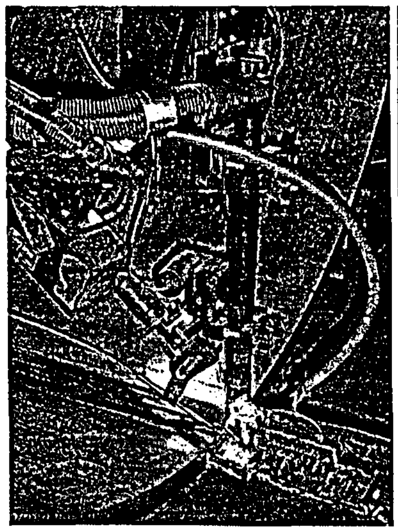




Fabrication Process: Prototype Assembly

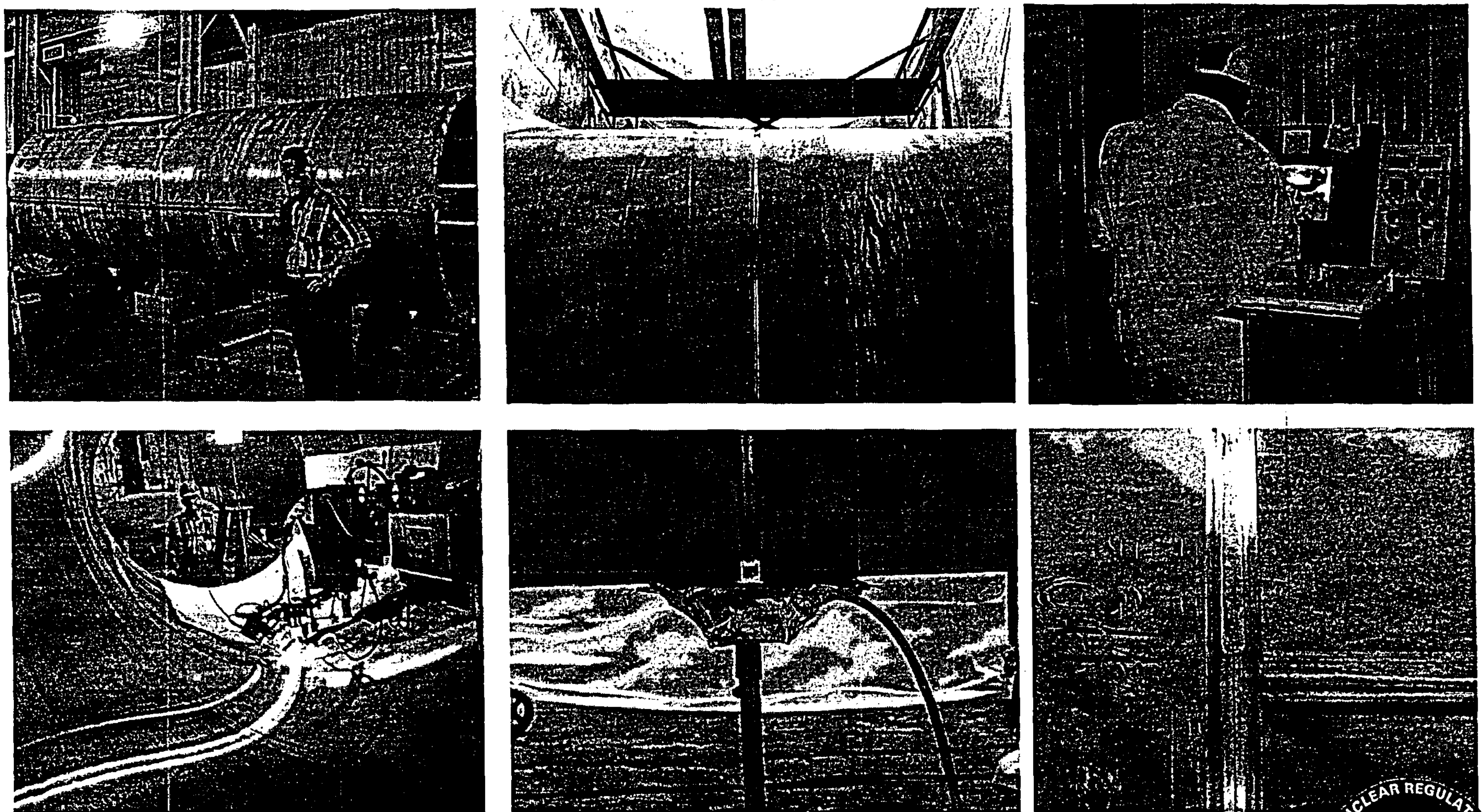
- Gas Tungsten Arc Welding (GTAW) involves the formation of an arc between a nonconsumable tungsten electrode and plate.
- GTAW uses a gas to shield the weld, usually argon or helium.
- GTAW welds are typically of high quality and relatively clean.
- GTAW was employed to weld the Alloy 22 outer barrier longitudinal and circumferential joints.





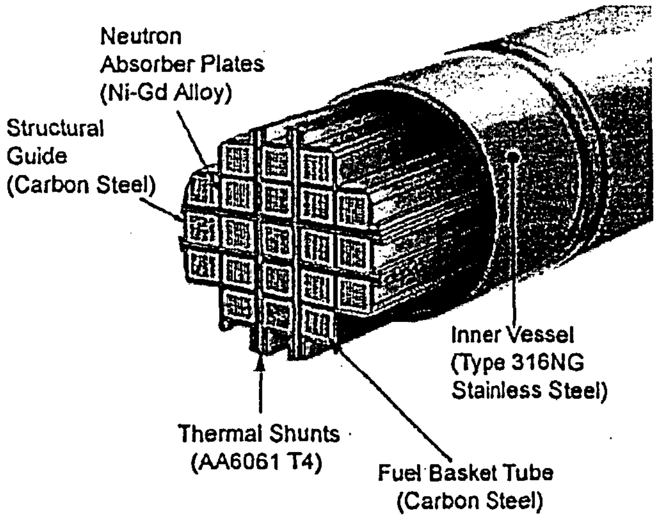
Fabrication Process: Prototype Assembly

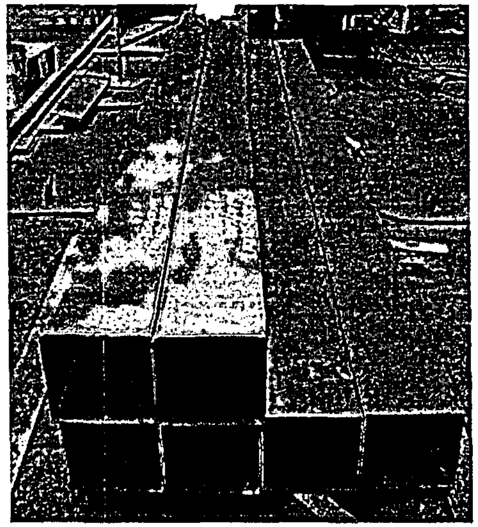
Circumferential Weld Preparation and Welding

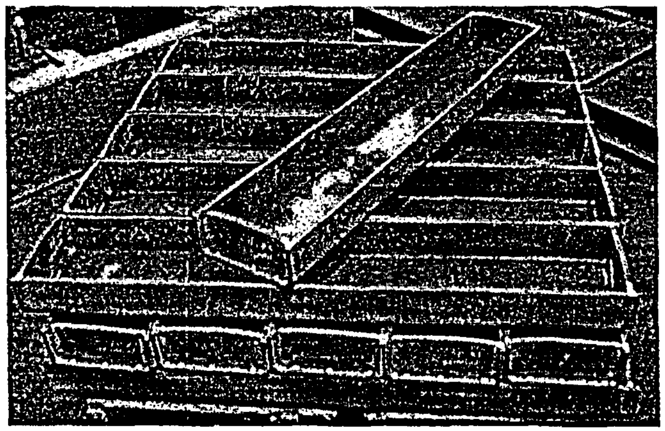


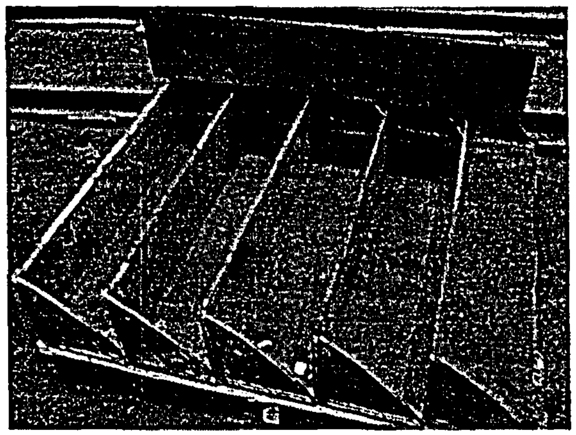
Fabrication Process: Prototype Assembly

Basket Assembly









Potential Fabrication Effects (WP Outer Barrier)

- Phase Stability
- Corrosion Behavior
- Mechanical Behavior

Fabrication Effects: Phase Stability

- Mill-annealed Alloy 22 is a single phase solid solution alloy.
- WP fabrication processes, however, can produce secondary phases that could affect the long-term corrosion and mechanical performance of the Alloy 22 WP outer barrier.
- Hence, the effect of fabrication processes on WP corrosion and mechanical performance needs to be considered.
- For example, short-term exposures at high temperatures during welding and solution annealing warrant additional consideration.

Fabrication Effects: Phase Stability

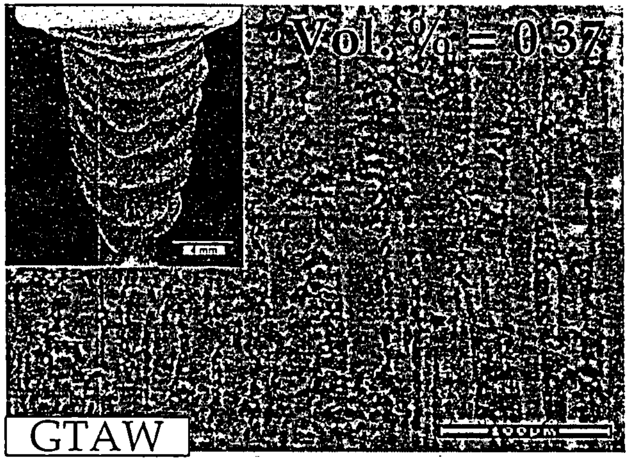
Solution Anneal & Quench after Welding:

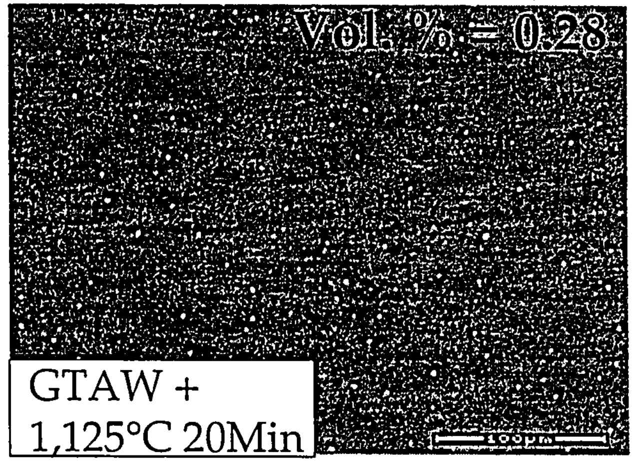
- A solution anneal is a high temperature heat treatment designed to:
  - Homogenize the alloy, i.e. dissolve secondary phases
  - Mitigate residual stresses developed during fabrication.
- A rapid quench after the solution anneal should:
  - Prevent the formation of secondary phases
  - Develop compressive stresses on the Alloy 22 surface.
- DOE plans to solution anneal at 1,150°C (soak time not specified) followed by an immediate water quench.
- NRC studies indicate that solution anneals between 1,125 – 1,300°C did not completely dissolve secondary phases*.

*1) Y.-M. Pan and D.S. Dunn, TMS MS&T Conference 2005, Pittsburgh, PA, 09/26/05
2) CNWRA 2004-01: Effect of Fabrication Processes on Material Stability – Characterization & Corrosion

Fabrication Effects: Phase Stability

Solution Anneal & Quench after Welding:

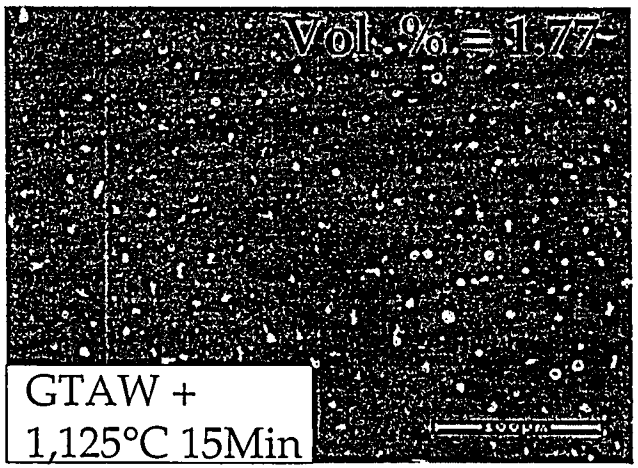


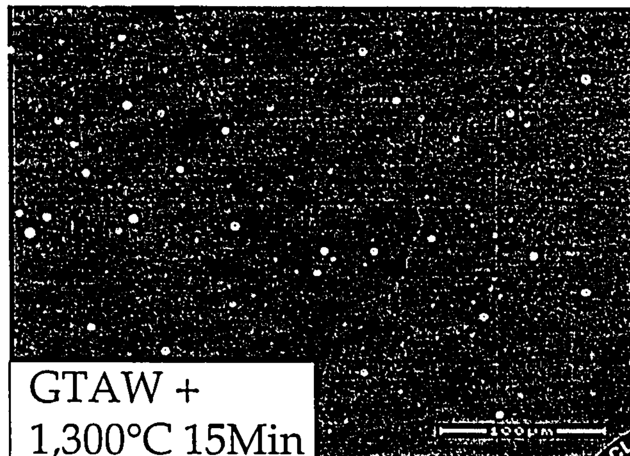


Alloy Heat 1

Heat to Heat Variability

Alloy Heat 2





1) Y.-M. Pan and D.S. Dunn, TMS MS&T Conference 2005, Pittsburgh, PA, 09/26/05

2) CNWRA 2004-01, Effect of Fabrication Processes on Material Stability – Characterization & Corrosion

Fabrication Effects: Corrosion Behavior

- NRC independently studied the effect of fabrication processes on:
  - General Corrosion:
    - » Thermally aged or welded plate has 3 to 5 times the general corrosion rates of mill-annealed Alloy 22.
  - Localized Corrosion:
    - » Fabrication processes reduced the localized corrosion resistance of Alloy 22 welds.
    - » Solution annealing improved the localized corrosion resistance of Alloy 22 welds.
  - Stress Corrosion Cracking:
    - » Fabrication processes did not increase the susceptibility to stress corrosion cracking.

Fabrication Effects: Mechanical Behavior

- The mechanical behavior of Alloy 22 is characterized by low yield strength, high ductility, and high toughness.
- Alloy 22 undergoes significant plastic deformation prior to ductile failure and has high toughness that resists fracture failure.
- Fabrication processes typically increase strength, but, reduce ductility and toughness.
- Welded and solution annealed Alloy 22, however, remains highly plastic by retaining significant ductility and toughness.
- Failure assessment diagrams indicate that fabrication processes do not change the overall mechanical behavior of Alloy 22 from ductile failure to brittle fracture.

Summary

- DOE plans to use the ASME BPVC, Section III, Division 1 as a guide to fabricate the WP.
- Fabrication and assembly of the 21-PWR UCF WP Prototype at JOC is ongoing.
- Effects of typical fabrication processes that may need consideration :
  - Solution annealing between 1,125 – 1,300°C did not completely dissolve secondary phases.
  - Welded Alloy 22 has general corrosion rates 3 to 5 times that of mill-annealed Alloy 22.
  - Fabrication processes did not increase the susceptibility of Alloy 22 to stress corrosion cracking.

Summary

- Effects of typical fabrication processes that may need consideration (continued):
  - Fabrication processes reduced the localized corrosion resistance of Alloy 22 welds.
  - Solution annealing improved the localized corrosion resistance of Alloy 22 welds.
  - Welded and solution annealed Alloy 22 retains significant ductility and toughness.
  - Fabrication processes do not change the overall mechanical behavior of Alloy 22 from ductile failure to brittle fracture.

Status of Risk-Informed Regulation in the Office of Nuclear Material Safety and Safeguards

Presentation to the ACNW

Dennis Damon
NMSS Spent Fuel Project Office
January 10, 2006

Outline of Briefing

- Summarize SECY-04-0182, Status of Risk-Informed Regulation in NMSS
- Summarize the SRM to SECY-04-0182
- Summarize the guidance document, Risk-Informed Decision-Making for Nuclear Material and Waste Applications
- Describe what the document added to existing guidance, and options for improvement
- Success would be: ACNW finds the added guidance acceptable

SECY-04-0182, Status of Risk-Informed Regulation in NMSS

- Gave background and a status report
- Described a systematic risk-informing process for trial use
- Stated: no separate risk-informing funding starting in FY2005
- Stated: NMSS will continue its commitment to risk-inform activities... in individual programs that are budgeted

SRM to SECY-04-0182

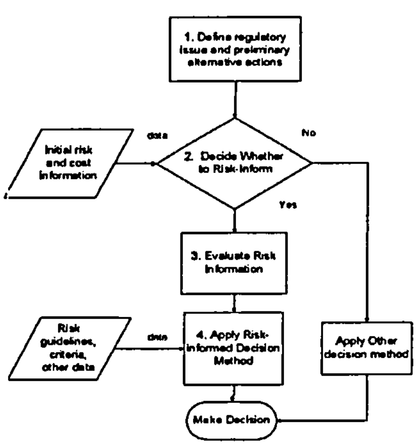
- "The Commission has approved the staff's plan to continue applying risk-informed methods..."
- "The staff should implement management controls to ensure that negligible values used as screening levels do not become default ALARA levels or used in any way as regulatory limits."
- "The staff should ensure that valuable resources are never applied to lower a risk that is already considered to be negligible."
- "the staff should consider ways to apply a risk-informed approach to the front end of the inspection program.."

Guidance Document: Risk-Informed Decision-Making for Nuclear Material and Waste Applications

- Overall 4 step risk-informing framework
- Specific decision algorithms for:
  - Imposing new requirements
  - Changing existing requirements
- Existing guidance for the above two situations included use of quantitative accident risk for reactors (cdf, lerf) not applicable to NMSS

Guidance Document: Risk-Informed Decision-Making for Nuclear Material and Waste Applications

- Thus this document provides guidance on use of quantitative accident risk using metrics applicable to NMSS
- Provides guidance for NMSS analogous to that in NUREG-BR-0058 (imposing requirements) and Reg. Guide 1.174 (relaxations) for reactors



4. Risk-Informed Decision Methods

- Two specific risk-informing decision algorithms are provided in the guidance:
  - #1 Imposing new safety requirements
  - #2 Changing or exempting from existing requirements
- Specific methods for risk-informing other possible regulatory activities are not provided, such as:
  - Licensing review
  - Areas on which inspections should focus

Risk-Informed Decision Methods

- Risk-informing involves considering factors in addition to risk in making decisions
- Factors include: defense-in-depth, safety margins, environmental protection, security, etc.
- Underlying principles of the two decision algorithms are the same:
  - First all factors must be in an acceptable range, including risk to individuals
  - Then optimization may be helpful in achieving further improvements

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Risk-Informed Decision Methods

- The guidance document has brief discussions of some factors, then refers the reader to the NRC Regulatory Analysis Handbook and other existing guidance.
- Use of routine and chronic doses are addressed in existing regulations and guidance
- The document supplements existing guidance by addressing accident risk to individuals
- That is: probabilities x consequences

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3 Regions of Individual Risk

- Consideration of risk to individuals is based on concept of 3 regions: unacceptable, tolerable, and negligible
- Unacceptable is a level of risk to individuals that should be prohibited and prevented.
- Tolerable means individual risk is not unacceptable. But the principle of optimization may indicate that further societal risk reduction is desirable.
- Negligible individual risk is a reference level for screening proposed regulatory actions, but not a strict floor.

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3 Regions of Individual Risk

Unacceptable Risk

Tolerable Risk

--- Guidelines (QHG)

Negligible Risk

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3 Regions of Individual Risk

- Same concept applies for routine exposures and accident risk to individuals
- For routine exposures, Part 20 annual limits, and other regulations, support avoidance of unacceptable risk to individuals (high risk)
- Quantitative Health Guidelines are negligible accident risk (low risk)

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Use of Guidelines 1

Decision algorithm for changing or exempting from existing requirement:

- risk may increase to unacceptable level
- Table 4.1 provides logic for evaluating acceptability, but...
- The QHGs are for the negligible level, not the unacceptable level
- If risk is below QHGs, then OK

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Use of Guidelines 2

Decision algorithm for new requirements:

- There are many reasons for new regulatory requirements: security, environmental protection, defense-in-depth, information to provide confidence, reducing individual risk, etc.
- Table 4.2 says that new requirements for the sole purpose of reducing individual accident risk are not recommended if the reduction is negligible relative to the QHGs

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Base Option for QHGs

- QHG1: Pr(acute fatality, public) 5E-7 /yr
- QHG2: Pr(latent fatality, worker) 2E-6 /yr
- QHG3: Pr(injury, public) 1E-6 /yr
- QHG4: Pr(acute fatality, worker) 1E-6 /yr
- QHG5: Pr(latent fatality, worker) 1E-5 /yr
- QHG6: Pr(injury, worker) 5E-6 /yr

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Base Option Guidelines

- The Base Option Guidelines are expressed in following units: probability of deterministic fatality or injury per year
- Values for public QHGs are the same as reactor QHOs
- Worker accident risk is important in NMSS, hence QHGs 4, 5, and 6 were added for worker accident risk
- Injury guidelines added for completeness

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Quantitative Health Guidelines

- Base Option QHGs are to be compared to realistic expectation value of health effect to individuals.
- That is they are the sum over all accident scenarios of frequency times dose times conversion factor to health effect.
- Previous ACNW feedback was to express QHGs as dose
- Risk Task Group devised 3 options

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Draft Risk Guideline - Option 1

- Consequence vs. Likelihood Histogram (ICRP 64)
- Example dividing QHG2=2E-6 among dose intervals:

Dose Range	Frequency (per year)
< 0.1 rem	1E-2
0.1 to 1 rem	1E-3
1 to 10 rem	1E-4
10 rem to 100 rem	1E-5
> 100 rem	5E-7

- This option avoids the use of dose-to-health-effects conversion; but is more constraining to meet.

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Draft Risk Guideline - Option 2

- A single negligible risk guideline that is an expectation value of annual dose for workers and public, say 1 mrem/yr
- To calculate, add acute and latent fatality risk to individual from all scenarios.
- Requires converting acutely fatal doses, e.g. 2000 rads, to some dose level for equivalency to stochastic exposure scenarios.
- 1 mrem/yr x 5E-4 fatal cancer / rem = 5E-7 risk of fatality/yr
- This option is simple and would avoid forward dose to health effect conversion. Users may have difficulty with the concept of acute fatality reverse conversion.
- Single guideline gives more flexibility than multiple guidelines.

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Draft Risk Guideline – Option 3

- Express guidelines for stochastic health effects in expectation value of annual dose
- Express guidelines for deterministic effects in frequency
- Avoids conversion of dose to probability of latent fatality

QHG1:	Public risk of acute fatality	5E-7 /yr
QHG2:	Public risk of latent cancer fatality	4E-3 rem/yr
QHG3:	Public risk of serious injury	1E-6 /yr
QHG4:	Worker risk of acute fatality	1E-6 /yr
QHG5:	Worker risk of latent cancer fatality	2.5E-2 rem/yr
QHG6:	Worker risk of serious injury	5E-6 /yr

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Other Options for QHGs

- There are other ways to define such guidelines.
- Simplify; combine negligible level QHGs for workers and public
- Drop injury risk QHGs
- See Appendix I for other options and issues

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Quantitative Health Guidelines

- The accident risk calculated for comparison to guidelines the is risk to individuals. In practice, similar to an RMEI, but realistic.
- The guidance directs the user to existing NRC guidelines on value-impact analysis; for further optimization.
- Guidelines are used as a screening tool for staff when setting requirements

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Trial Applications

Some lessons from trial applications:

- Cases exist where worker and public individual risk are affected in opposite directions.
- Value-Impact analysis is useful in identifying risk-risk tradeoffs.
- Defense-in-Depth and other factors can be more important than risk.
- Risk is difficult to quantify in certain areas
- What about non-radiological versus radiological risk tradeoffs?

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Potential Future Initiatives

- Risk-Informing licensing review guidance in additional areas
- Guidance on risk-Informing the focus of inspections in additional areas (per SRM)
- Sharing risk-informing experiences through staff training, etc.

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IN CONCLUSION

- The guidance document, "Risk-Informed Decision-Making for Nuclear Material and Waste Applications" is available to staff for use in risk-informing changes to requirements on a trial basis.
- It is a living document; to be changed as a result of experience.
- Other types of risk-informing have been and are being done.

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Back Up

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NMSS Quantitative Health Guidelines

- Individual Public Acute (QHG 1): 5E-7 /yr
- Individual Public Latent (QHG 2): 2E-6 /yr
- Individual Public Injury (QHG 3): 1E-6 /yr

- Individual Worker Acute (QHG 4): 1E-6 /yr
- Individual Worker Latent (QHG 5): 1E-5 /yr
- Individual Worker Injury (QHG 6): 5E-6 /yr

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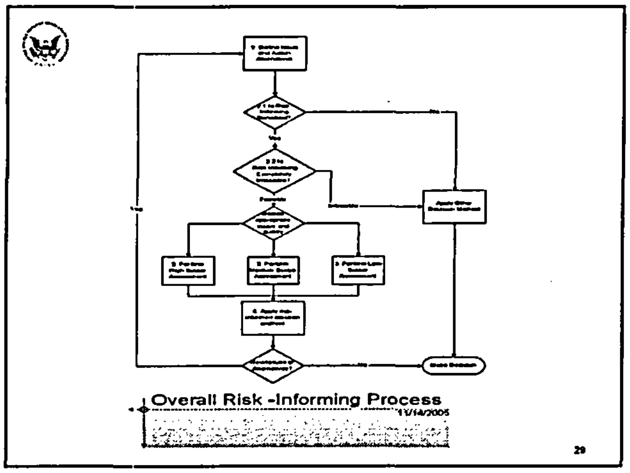
Overall Risk -Informing Process
11/14/2005
29