From: Couret, Ivonne
To: Ralph, Melissa; Rihm, Roger
Subject: FYI - Spent Fuel booklet NUREG/BR 0292
Date: Monday, July 25, 2016 1:53:00 PM
Attachments: Spent Fuel Transport bro 6-2016 r7.pdf
Forms Nureg BR 0292.pdf

Negative consent - unless you see something blaringly wrong, we will move forward to print after NUREG/BR manuscript review. NMSS has approved. Ivonne

From: Couret, Ivonne
Sent: Monday, July 25, 2016 1:27 PM
To: Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Cc: Shannon, Valerie <Valerie.Shannon@nrc.gov>
Subject: FW: Spent Fuel booklet

Tojuna/Tina:
Attached is final approved NUREG/BR 0292 for your review. Thanks, Ivonne

NRC FORM 20 (2-1998)

U.S. NUCLEAR REGULATORY COMMISSION

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Ivonne Couret	OPA	(301) 415-8205	O-16D16	ivonne.couret@nrc.gov	05/02/2016

TITLE OF DOCUMENT: Safety of Spent Fuel Transportation - NUREG/BR-0292, Rev. 1

NUREG NO./FORM NO.: NUREG/BR-0292

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DOCUMENT SUBMITTED BY: Ivonne Couret — DATE: 6/27/16

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1 REPORT DESIGNATOR *(see instructions on page 2)*

2 TITLE AND SUBTITLE *(see instructions on page 2)*

Safety of Spent Fuel Transportation - NUREG/BR-0292, Rev. 1

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4.5 Does the manuscript contain Classified or Sensitive Unclassified Information?	☐	☑
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4.7 Will you publish a Federal Register notice of this publication's availability?	☐	☑
4.8 Will this manuscript require color printing or a specially designed cover?	☑	☐
4.9 Will this publication be posted to NRC's internal (staff use only) or public Web site?	Internal ☐	Public ☑

5. SIGNATURES *(see instructions on page 2)*

Name and Organization of Official	Office Telephone Number	Signature	Date
5.1 NRC Project Officer (required) — Printed Name & Office: Ivonne Couret, OPA	(301) 415-8205	Yvonne L Couret	6/27/16
5.2 NRC Information Services Branch (required, if applicable) — Printed Name & Office:			
5.3 NRC Patent Counsel (required, if applicable) — Printed Name & Office:			
5.4 Contractor, Grantee, or other organization (required, if applicable) — Printed Name & Office:			
5.5 NRC Public Affairs Reviewer (required, if applicable) — Printed Name & Office: Ivonne Couret, OPA	(301) 415-8205	Yvonne L Couret	6/27/16
5.6 NRC Official Authorizing Publication (required) — Printed Name & Office: Holly Harrington, OPA	(301) 415-8203	Holly Harrington	[illegible]

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste, and licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected States to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Cover Photos:

(Left) Transportable spent fuel storage casks sit on a storage pad. (Courtesy: Holtec International)

(Middle) Spent fuel transport cask arrives at Rancho Seco. (Courtesy: Areva)

(Right) Schematic of spent fuel transport cask. (Courtesy: Holtec International)

(Bottom) Spent fuel transport cask arrives on site.

Page 1 Photos:

(Left) Empty transportable spent fuel storage system arrives at Prairie Island. (Courtesy: Areva)

(Right) Transportable spent fuel storage system is readied for storage. (Courtesy: Areva)

(Bottom) Transport package is placed inside conveyance vehicle. (Courtesy: NAC International)

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely around the world.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments. However, the NRC does not control the timing or destination of spent fuel shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates that information against its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

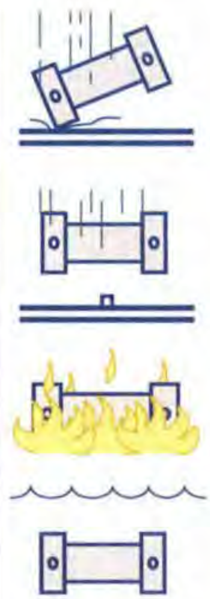
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

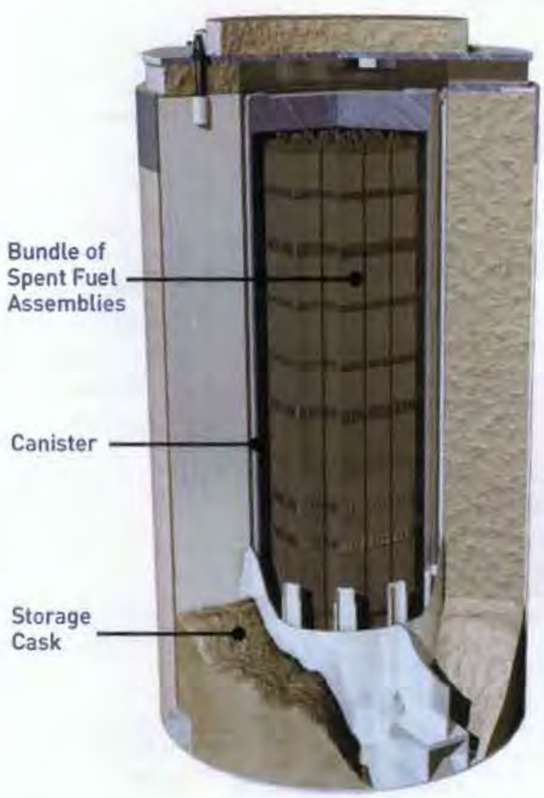
3. fire, and

4. water immersion.

Truck carries NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations when needed. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

NAC LWT spent fuel transport package is moved by crane. (Courtesy: NAC International)

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

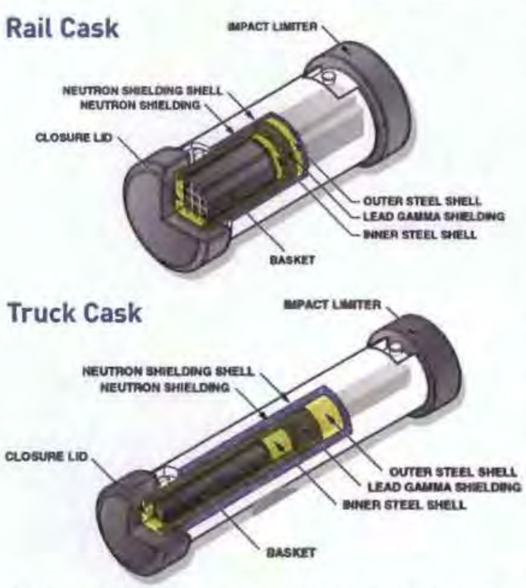
1. *http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf*
2. *http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/*
3. *http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf*
4. *http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf*

The risk assessment found:

Transportable spent fuel storage cask moves to storage pad.
(Courtesy: Holtec International)

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.



Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

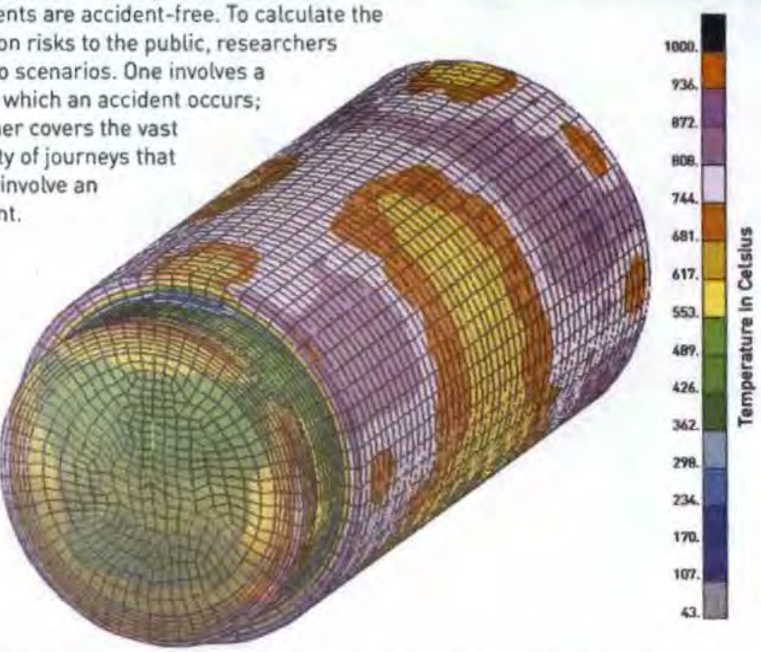
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a radioactive release in 99.99973% of those 5 accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand potential safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

@NRCgov

From:	Couret, Ivonne
To:	Grasty, Tojuana; Malone, Tina
Subject:	This is now Adjusted to output size - RE: Spent Fuel booklet
Date:	Thursday, July 28, 2016 12:42:00 PM
Attachments:	Spent Fuel Transport bro 7-16.pdf

Tojuana,
Here is the adjusted document. Ivonne

From: Raaum, Darrin
Sent: Thursday, July 28, 2016 11:24 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: RE: Adjustment to output size - RE: Spent Fuel booklet

Attached is the 8.5 x 11 Spent Fuel Transport brochure.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Couret, Ivonne
Sent: Tuesday, July 26, 2016 4:21 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>
Subject: FW: Adjustment to output size - RE: Spent Fuel booklet
Importance: High

This bites…let me know when we get the larger size item. Ivonne

From: Grasty, Tojuana
Sent: Tuesday, July 26, 2016 4:01 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>; Raaum, Darrin <Darrin.Raaum@nrc.gov>
Cc: Ferrell, Kimberly <Kimberly.Ferrell@nrc.gov>; Shannon, Valerie <Valerie.Shannon@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Subject: RE: Adjustment to output size - RE: Spent Fuel booklet
Importance: High

Ivonne,

Yes, I want the final of the document for publication—the size it will be printed.

Tojuana

From: Couret, Ivonne

Sent: Monday, July 25, 2016 2:55 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>; Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Cc: Shannon, Valerie <Valerie.Shannon@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>
Subject: RE: Adjustment to output size - RE: Spent Fuel booklet

Tojuana,
Can you review the document without the larger printout/design or shall we wait? Ivonne

---

From: Raaum, Darrin
Sent: Monday, July 25, 2016 2:05 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>; Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Cc: Shannon, Valerie <Valerie.Shannon@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>
Subject: RE: Adjustment to output size - RE: Spent Fuel booklet

That is going to require a complete redesign.
It will take some time. I will get to it later in the week.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

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Cc: Shannon, Valerie <Valerie.Shannon@nrc.gov>; Raaum, Darrin <Darrin.Raaum@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>
Subject: Adjustment to output size - RE: Spent Fuel booklet

Correction they want to make this larger size rather than the current 5.5" x 8' please make it 8.5 x 11 size. Thanks, Ivonne

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To: Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
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Tojuna/Tina:
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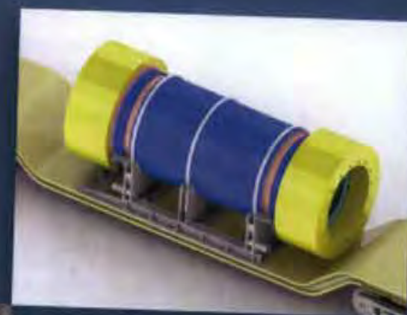
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation



The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste, and licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected States to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Cover Photos:

(Left) Transportable spent fuel storage casks sit on a storage pad. *(Courtesy: Holtec International)*

(Middle) Spent fuel transport cask arrives at Rancho Seco. *(Courtesy: Areva)*

(Right) Schematic of spent fuel transport cask. *(Courtesy: Holtec International)*

(Bottom) Spent fuel transport cask arrives on site.

Page 1 Photos:

(Left) Empty transportable spent fuel storage system arrives at Prairie Island. *(Courtesy: Areva)*

(Right) Transportable spent fuel storage system is readied for storage. *(Courtesy: Areva)*

(Bottom) Transport package is placed inside conveyance vehicle. *(Courtesy: NAC International)*

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely around the world.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments. However, the NRC does not control the timing or destination of spent fuel shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates that information against its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

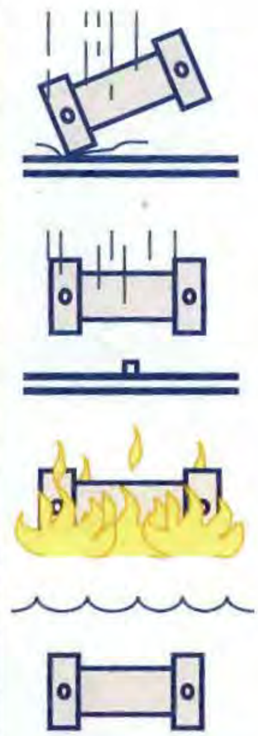
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding to protect anyone who might be near the cask during transport.



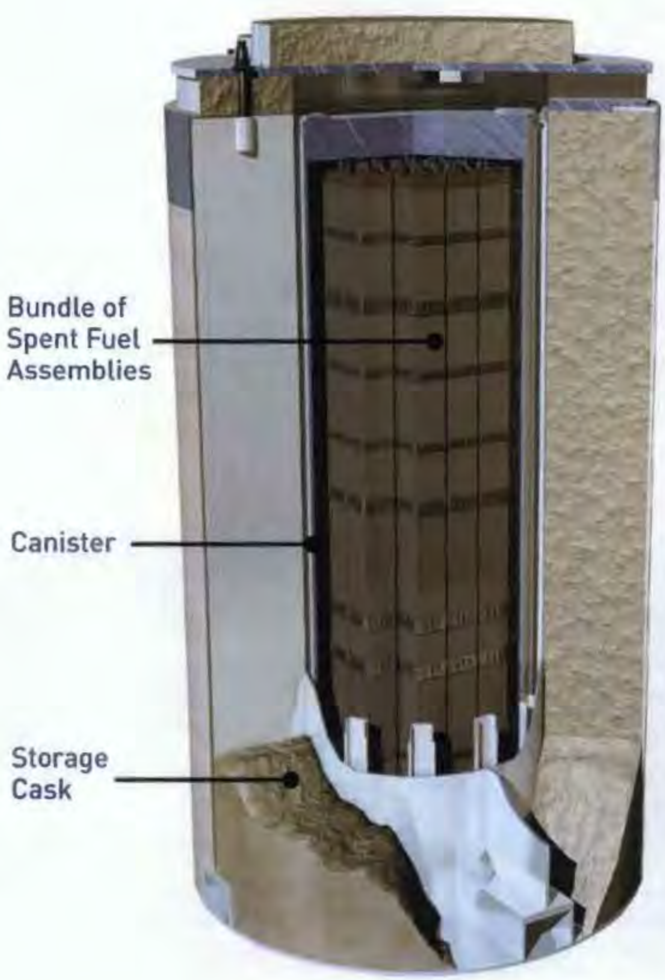
The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,
2. puncture impact,
3. fire, and
4. water immersion.

Truck carries NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations when needed. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

NAC LWT spent fuel transport package is moved by crane. (Courtesy: NAC International)

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

1. *http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf*
2. *http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/*
3. *http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf*
4. *http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf*

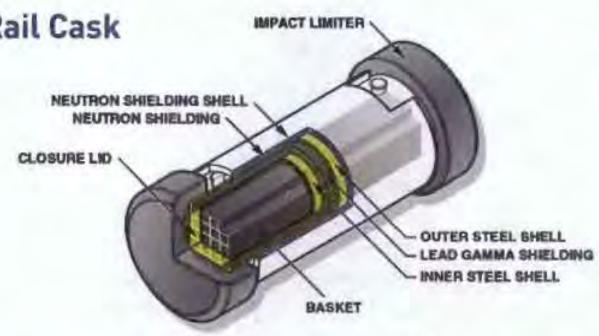
Transportable spent fuel storage cask moves to storage pad.
(Courtesy: Holtec International)

The risk assessment found:

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask



Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

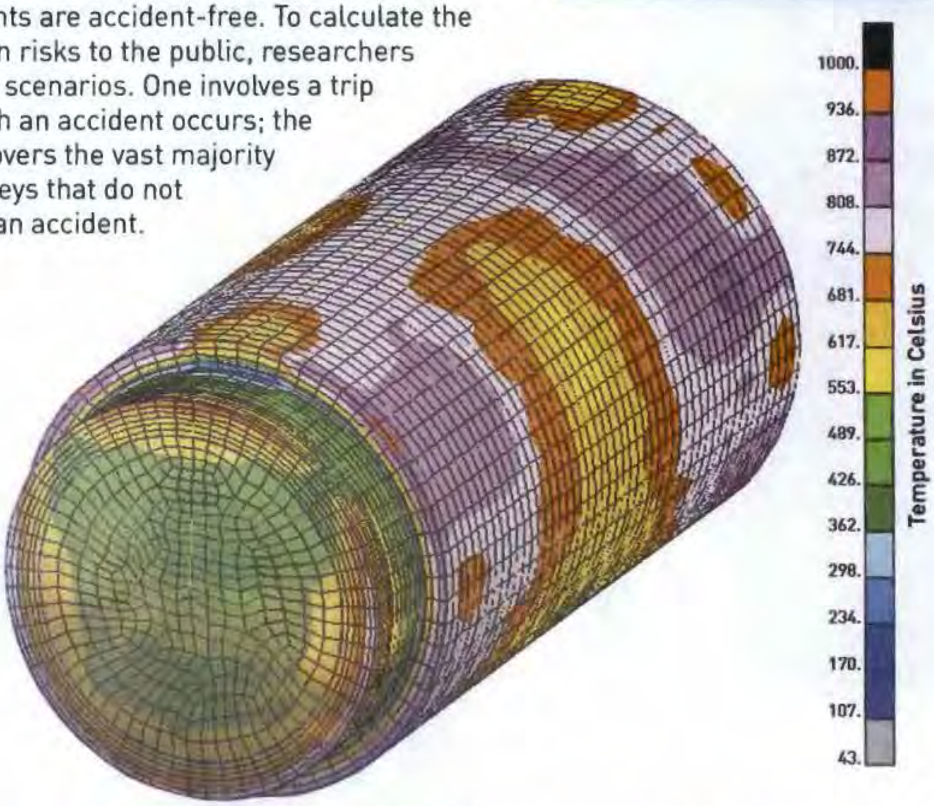
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a radioactive release in 99.99973% of those 5 accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand potential safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

@NRCgov

From:	Couret, Ivonne
To:	Raaum, Darrin
Subject:	RE: Adjustment to output size - RE: Spent Fuel booklet
Date:	Thursday, July 28, 2016 12:43:00 PM

Thanks Darrin!!! Ivonne

From: Raaum, Darrin
Sent: Thursday, July 28, 2016 11:24 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: RE: Adjustment to output size - RE: Spent Fuel booklet

Attached is the 8.5 x 11 Spent Fuel Transport brochure.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Couret, Ivonne
Sent: Tuesday, July 26, 2016 4:21 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>
Subject: FW: Adjustment to output size - RE: Spent Fuel booklet
Importance: High

This bites…let me know when we get the larger size item. Ivonne

From: Grasty, Tojuana
Sent: Tuesday, July 26, 2016 4:01 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>; Raaum, Darrin <Darrin.Raaum@nrc.gov>
Cc: Ferrell, Kimberly <Kimberly.Ferrell@nrc.gov>; Shannon, Valerie <Valerie.Shannon@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Subject: RE: Adjustment to output size - RE: Spent Fuel booklet
Importance: High

Ivonne,

Yes, I want the final of the document for publication—the size it will be printed.

Tojuana

From: Couret, Ivonne
Sent: Monday, July 25, 2016 2:55 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>; Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>;

Malone, Tina <Tina.Malone@nrc.gov>
Cc: Shannon, Valerie <Valerie.Shannon@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>
Subject: RE: Adjustment to output size - RE: Spent Fuel booklet

Tojuana,
Can you review the document without the larger printout/design or shall we wait? Ivonne

---

From: Raaum, Darrin
Sent: Monday, July 25, 2016 2:05 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>; Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Cc: Shannon, Valerie <Valerie.Shannon@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>
Subject: RE: Adjustment to output size - RE: Spent Fuel booklet

That is going to require a complete redesign.
It will take some time. I will get to it later in the week.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Couret, Ivonne
Sent: Monday, July 25, 2016 2:03 PM
To: Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Cc: Shannon, Valerie <Valerie.Shannon@nrc.gov>; Raaum, Darrin <Darrin.Raaum@nrc.gov>; Machalek, Woody <Woody.Machalek@nrc.gov>
Subject: Adjustment to output size - RE: Spent Fuel booklet

Correction they want to make this larger size rather than the current 5.5" x 8' please make it 8.5 x 11 size. Thanks, Ivonne

---

From: Couret, Ivonne
Sent: Monday, July 25, 2016 1:27 PM
To: Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Cc: Shannon, Valerie <Valerie.Shannon@nrc.gov>
Subject: FW: Spent Fuel booklet

Tojuna/Tina:
Attached is final approved NUREG/BR 0292 for your review. Thanks, Ivonne

From: Couret, Ivonne
To: Shannon, Valerie; WebContractor Resource
Subject: RE: Delivery Schedule for NUREG-BR-0292, Rev. 1 ML16237A133
Date: Monday, August 29, 2016 1:32:00 PM

Yes Replace it. Ivonne

From: Shannon, Valerie
Sent: Monday, August 29, 2016 8:28 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: FW: Delivery Schedule for NUREG-BR-0292, Rev. 1 ML16237A133

I will tell Jonathan to replace, correct?

From: WebContractor Resource
Sent: Friday, August 26, 2016 12:55 PM
To: Shannon, Valerie <Valerie.Shannon@nrc.gov>
Subject: RE: Delivery Schedule for NUREG-BR-0292, Rev. 1 ML16237A133

Good afternoon,

Should the current NUREG/BR-292 be kept or replace?
http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0292/

Thanks,
Jonathan D. Kramer
Web Team

From: Meyd, Donald
Sent: Wednesday, August 24, 2016 11:49 AM
To: WebWork Resource <WebWork.Resource@nrc.gov>
Cc: WebContractor Resource <WebContractor.Resource@nrc.gov>; Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>; Dickey, Karen <Karen.Dickey@nrc.gov>; Edmonds, Yvonne <Yvonne.Edmonds@nrc.gov>; Repetto, John <John.Repetto@nrc.gov>; Shannon, Valerie <Valerie.Shannon@nrc.gov>
Subject: FW: Delivery Schedule for NUREG-BR-0292, Rev. 1 ML16237A133

ATTN: NUREG Author/Coordinator,

By instruction in this e-mail, OIS Webwork.Resource will post your newly published NUREG(s) to the following NRC public Web site locations:

http://www.nrc.gov/reading-rm/doc-collections/nuregs/pubs/

AKA "Publications Available in the Agency wide Documents Access and Management System (ADAMS)"

AND

http://www.nrc.gov/reading-rm/doc-collections/nuregs/

AKA "NUREG-Series Publications" under the appropriate category of NUREG (e.g. staff reports, brochures, conference proceedings, international agreements, knowledge management).

ADM is not responsible for requesting that Webwork.Resource remove any outdated versions from the http://www.nrc.gov/reading-rm/doc-collections/nuregs site. Therefore, you will need to contact Webwork.Resource to remove the old NUREG version from this location.

Note: If you have any concerns regarding the instructions below, please "Respond To All" so that the respective parties can resolve any issues.

S

1) The document(s) below will be publicly released in ADAMS on Friday, 08/26/2016 and will be posted on the NRC external (public) web site once released.

NUREG/BR-0292, Rev. 1	Safety of Spent Fuel Transportation	August 2016	ML16237A133

2) Webwork.Resource: Please post at:

- http://www.nrc.gov/reading-rm/doc-collections/nuregs/pubs/ and
- http://www.nrc.gov/reading-rm/doc-collections/nuregs/

3) Printing: This document(s) has been processed and sent to a printing contractor. Delivery is currently scheduled to NRC by Friday, 08/26/2016. Distribution will commence once QA procedures are performed. Please remember that all deliveries now occur off-site, and this may affect the actual time in which you receive your document.

Regards,
Don

Donald J. Meyd
Senior Printing Specialist
Publications Branch
Division of Administrative Services
Office of Administration
(301) 415-1629
Email: Donald.Meyd@nrc.gov

From:	Couret, Ivonne
To:	Grasty, Tojuana
Cc:	Machalek, Woody
Subject:	Status of Nureg/BR-0292, Rev 2?
Date:	Thursday, August 18, 2016 1:43:00 PM

HI Tojuana,

Where are we with this NUREG review? The last thing I did was send the larger size file as a 8.5 x 11? Please let me know we would like to print and distribute. Thanks, Ivonne

Ivonne L. Couret

Public Affairs Officer

Office of Public Affairs

U.S. Nuclear Regulatory Commission

301-415-8205

Ivonne.couret@nrc.gov

NEW – Information Digest 2015-2016 now available online at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/

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From:	Couret, Ivonne
To:	Grasty, Tojuana
Cc:	Meyd, Donald; Malone, Tina; DISTRIBUTION Resource; Machalek, Woody
Subject:	Spent Fuel Transport final
Date:	Friday, August 19, 2016 10:17:00 AM
Attachments:	NUREG-0292_Spent Fuel Transport_rev1.pdf
Importance:	High

Here is the Revised NUREG-0292 with your two edits. We are ready then to post in ADAMS and have Duplications print 500 in-house. OPA (Val Shannon – O16-D4) will retain 100 copies when printed and distributed them appropriately. The rest will be remain in distribution. Ivonne

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Safety of Spent Fuel Transportation

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(Bottom) Transport package is placed inside conveyance vehicle. *(Courtesy: NAC International)*

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely around the world.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments. However, the NRC does not control the timing or destination of spent fuel shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates that information against its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

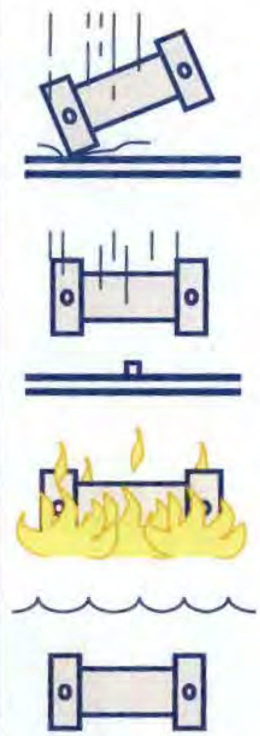
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

3. fire, and

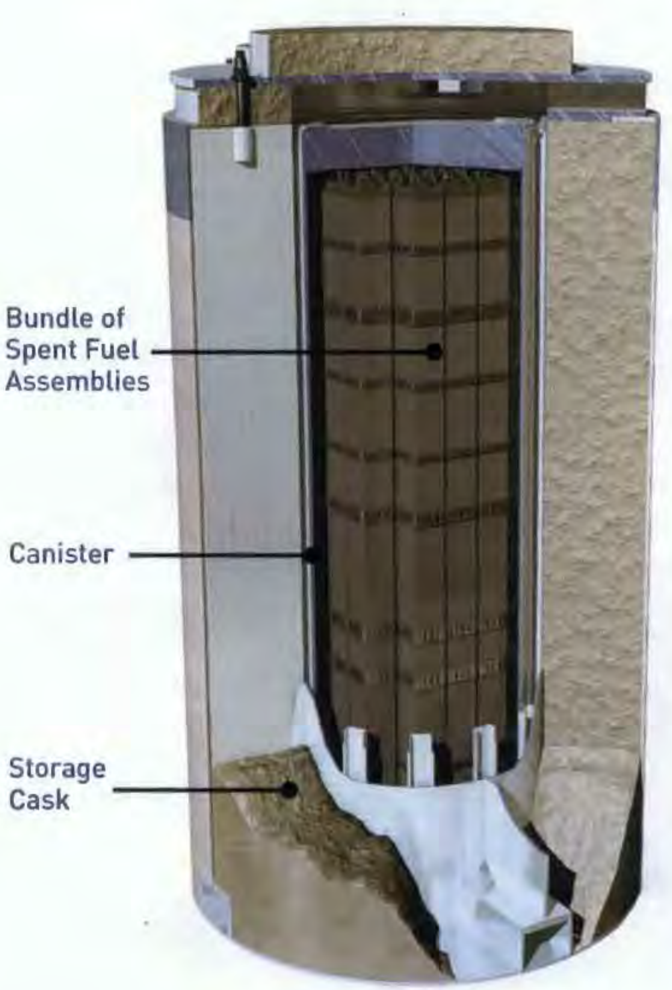
4. water immersion.

Truck carries NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations when needed. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.



A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

NAC LWT spent fuel transport package is moved by crane. *(Courtesy: NAC International)*

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

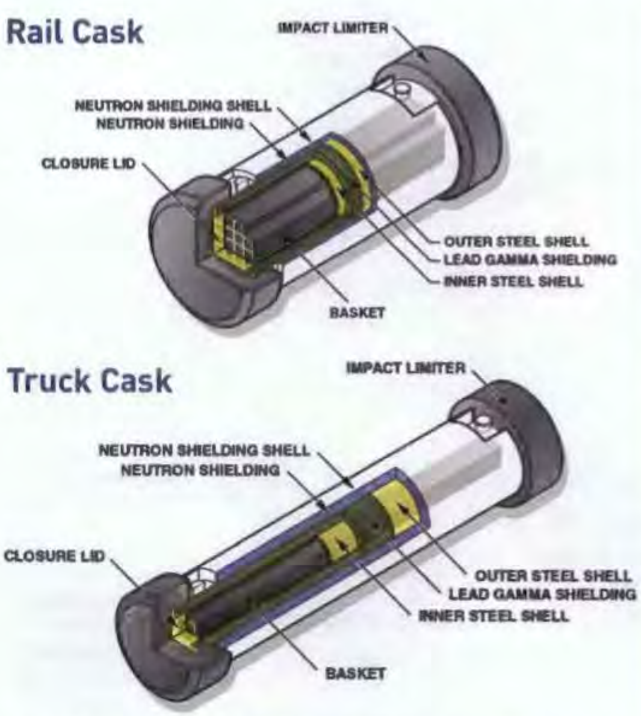
1. *http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf*
2. *http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/*
3. *http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf*
4. *http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf*

Transportable spent fuel storage cask moves to storage pad.
(Courtesy: Holtec International)

The risk assessment found:

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.



Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

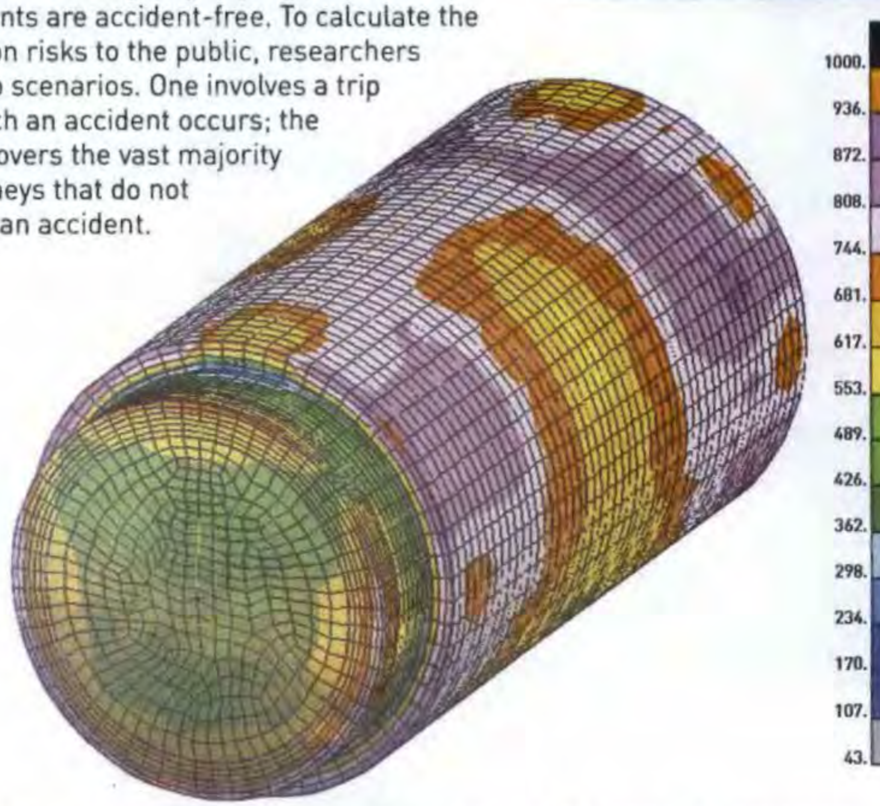
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a radioactive release in 99.99973% of those 5 accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand potential safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

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Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 1
August 2016

@NRCgov

From:	Couret, Ivonne
To:	Grasty, Tojuana
Cc:	GRAPHICS Resource; Malone, Tina; Shannon, Valerie
Subject:	RE: NUREG/BR-0292, R1
Date:	Monday, August 01, 2016 8:39:00 AM

Thanks, Ivonne

From: Grasty, Tojuana
Sent: Friday, July 29, 2016 5:49 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Cc: GRAPHICS Resource <GRAPHICS.Resource@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>; Shannon, Valerie <Valerie.Shannon@nrc.gov>
Subject: NUREG/BR-0292, R1
Importance: High

Hi Ivonne,

I reviewed the subject brochure. Please have Graphics change the revision to 1 and the date to July 2016 then resend the PDF file to me. Since the beginning of August is early next week, the report can still go out with a July date. I also need mailing labels with the name of the PAO in each region with (25 copies) beside each name. Include a label for Val Shannon (50 copies) and deliver the labels to my office. The remaining 350 copies will go to Distribution and older versions discarded.

Please do not include NRC Form 20 with future NUREG submissions. The Publication Analysts complete these forms and send them to the Printing Specialists electronically with the distribution listed at #3 on NRC Form 426.

Thanks,

Tojuana Fortune-Grasty
Senior NUREG Publications Analyst
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From: Conley, Maureen
To: Couret, Ivonne
Subject: Safety of Spent Fuel Transportation brochure FINAL.docx
Date: Tuesday, November 17, 2015 4:24:57 PM
Attachments: Safety of Spent Fuel Transportation brochure FINAL.docx

Here's the updated text, thanks Ivonne!

Safety of Spent Fuel Transportation

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

The NRC has three main functions:
1. To set standards and develop regulations;
2. To issue licenses for nuclear facilities and nuclear materials users; and
3. To inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage and permanent geologic disposal of used fuel.

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Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the U.S., and internationally, with the IAEA. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

What Is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:
• How does the NRC protect the public from radiation during transport?
• What is the likelihood one of these shipments will be involved in an accident?
• How well can the shipping containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 40 years.

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Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a "cask."

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Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, and physical testing of a scale model or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance through a public rulemaking process. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

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In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would have performed. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, Cal.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

• What can go wrong?
• How likely is it to occur?
• If something goes wrong, what are the consequences?

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.
Step 1. Experts determine what might happen.
• They gather historic records.
• They also put together data on how many spent fuel shipments are likely each year.
• They look at the rate of accidents for rail and highway shipments.
• They look at a large number of accidents that are credible.
• They also look at the effects of crash impact forces, fires or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.
• They gather data on how much spent fuel each container will carry.
• They analyze how the spent fuel might respond in a given type of accident.
• They calculate the temperature of the container and the spent fuel itself during a long-term fire.
This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by:
– Defining strict requirements for package design and performance
– Reviewing designs and independently checking a container's ability to meet accident conditions and
– Doing inspections to ensure casks are built, maintained and used properly.

• The NRC also looks at the risks involved in spent fuel shipments. The agency:
– Analyzes spent fuel transport records to fully understand any safety issues
– Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes and other factors, and
– Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:
• Coordinating with law enforcement agencies before the shipment
• Requiring advance notice to States, Indian tribes, and the NRC
• Using a communications center and other means to monitor shipments while in route
• Armed escorts, and
• Devices that allow drivers and escorts to shut the vehicle off

Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear
Regulatory
Commission
NUREG/BR-0292
March 2015

From: Couret, Ivonne
To: Raaum, Darrin
Cc: Conley, Maureen
Subject: Safety of Spent Fuel Transportation brochure FINAL no comments.docx
Date: Wednesday, June 01, 2016 8:58:00 AM
Attachments: Safety of Spent Fuel Transportation brochure FINAL no comments.docx

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Here is file with no comments or tracking. Ivonne

Safety of Spent Fuel Transportation

*The **U.S. Nuclear Regulatory Commission (NRC)** is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.*

*The **U.S. Department of Transportation (DOT)** coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected States to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.*

*The **U.S. Department of Energy (DOE)** is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.*

*The **International Atomic Energy Agency (IAEA)** is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.*

The NRC has three main functions:
1. To set standards and develop regulations
2. To issue licenses for nuclear facilities and nuclear materials users
3. To inspect facilities to ensure that NRC regulations are being met

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

What is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010, The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:
• How does the NRC protect the public from radiation during transport?
• What is the likelihood one of these shipments will be involved in an accident?
• How well can the shipping containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.

> The text under the cask drop graphic should read:
>
> The NRC requires spent fuel shipping casks to survive four tests in sequence: (1) free-drop impact, (2) puncture impact, (3) fire, and (4) water immersion.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance through a public rulemaking process. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents. But none of the shipments resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. These studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

The risk assessment found:

- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.
- There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.
- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982

[1] http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf
[2] http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/
[3] http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf
[4] http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf

Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

• What can go wrong?
• How likely is it to occur?
• If something goes wrong, what are the consequences?

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.
Step 1. Experts determine what might happen.
• They gather historic records.
• They also put together data on how many spent fuel shipments are likely each year.
• They look at the rate of accidents for rail and highway shipments.
• They look at a large number of accidents that are credible.
• They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.
• They gather data on how much spent fuel each container will carry.
• They analyze how the spent fuel might respond in a given type of accident.
• They calculate the temperature of the container and the spent fuel itself during a long-term fire.
This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

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Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- Coordinating with law enforcement agencies before the shipment
- Requiring advance notice to States, Indian tribes, and the NRC
- Using a communications center and other means to monitor shipments while in route
- Using armed escorts, and
- Using devices that allow drivers and escorts to shut the vehicle off

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear Regulatory Commission
NUREG/BR-0292
March 2015

From:	COURET, IVONNE L
To:	GRASTY, TOJUANA F; MALONE, TINA M; RAAUM, DARRIN L
Cc:	FERRELL, KIMBERLY M; CONLEY, MAUREEN E; MACHALEK, Woody U
Subject:	ON HOLD - REVIEW of NUREG/BR 0292 Revision Safety and Spent Fuel Transport r5
Date:	Monday, June 27, 2016 8:34:00 AM
Importance:	High

Tojuana, Tina, Darrin:
Despite the finalization, NMSS now wants to add more verbiage. I do apologize if you started to review this document. Please place this document on hold until we again re-finalize with program office. Thanks for all you do! Ivonne

From: COURET, IVONNE L
Sent: Friday, June 24, 2016 2:02 PM
To: Fortune Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Cc: Ferrell, Kimberly <Kimberly.Ferrell@nrc.gov>
Subject: NUREG/BR 0292 Revision Safety and Spent Fuel Transport r5

Tojuana and Tina:
I don't know if this is Revision 1 or 2. Attached is the brochure PDF and the related forms. Thanks in advance for your support on this project. Ivonne

Ivonne L. Couret
Public Affairs Officer
Office of Public Affairs
U.S. Nuclear Regulatory Commission
301-415-8205
Ivonne.couret@nrc.gov

NEW – Information Digest 2015-2016 now available online at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/

-

From: Couret, Ivonne
To: Machalek, Woody; Meyd, Donald
Cc: Ferrell, Kimberly
Subject: Problem with ADAMS PDF
Date: Wednesday, September 21, 2016 3:13:00 PM
Importance: High

There is a problem with the PDF in ADAMS for NUREG/BR 0292 is has pages of gibberish.

http://www.nrc.gov/docs/ML1623/ML16237A133.pdf

Ivonne L. Couret
Public Affairs Officer
Office of Public Affairs
U.S. Nuclear Regulatory Commission
301-415-8205
Ivonne.couret@nrc.gov

-

From:	Couret, Ivonne
To:	Fortune Grasty, Tojuana; Machalek, Woody; Baker, Johnnie; Meyd, Donald; Ferrell, Kimberly; Malone, Tina
Cc:	Shannon, Valerie; Harrington, Holly; West, Stephanie
Subject:	OPA_NUREG Spreadsheet_ Data Call
Date:	Monday, June 20, 2016 3:48:00 PM
Attachments:	NUREG Spreadsheet Data Call OPA June 20 2016.xlsx
Importance:	High

Attached is the OPA NUREG Data Call sheet for FY 16 and FY 17.
As per ADM directions, I have included the other generated pieces produced as part of the original NUREG under the NRC-designated term supplement.
Please let me know if you need further clarifications, I will be the OPA POC on these projects.
Thanks in advance for all your support. Ivonne

Ivonne L. Couret
Public Affairs Officer
Office of Public Affairs
U.S. Nuclear Regulatory Commission
301-415-8205
Ivonne.couret@nrc.gov

NEW – Information Digest 2015-2016 now available online at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/

Instructions: Use drop down menus for columns B, F, M and N

Remaining FY 2016 and FY 2017 NUREG Data Call

NUREG ID (If Known)	NUREG Type (use drop down list)	Full Title	OPA POC/Author (first and last name)	Author's E-mail Address	Author's Office (use drop down list)	# Pages	# Volumes	Expected Date to be Delivered to ADM for final manuscript review	Targeted Final Publication Date	Internal Drivers for Publication Due Date (Commission Driven, or Conferences, meetings, etc.)	External Drivers for Publication Due Date (OMB, etc.)	QTE Support Needed? (use drop down list)	Graphics Support Needed? (use drop down list)
NUREG-1350	Brochure/BR	NUREG-1350, Vol. 28 Information Digest	Ivonne Couret	ivonne.couret@nrc.gov	OPA	200	1	04/16/2016	08/30/2016	Out of date incorporate new information	IAEA General Conference	Yes	Yes
NUREG-1350	Brochure/BR	NUREG-1350, Vol. 28 Information Digest - Supplement - CD	Ivonne Couret	ivonne.couret@nrc.gov	OPA	1	1	04/16/2016	08/30/2016		Public Distribution	No	Yes
NUREG-1350	Brochure/BR	NUREG-1350, Vol. 28 Information Digest - Supplement - NRC AT A GLANCE	Ivonne Couret	ivonne.couret@nrc.gov	OPA	15	1	04/16/2016	08/30/2016		Public Distribution	No	Yes
NUREG-1350	Brochure/BR	NUREG-1350, Vol. 28 Information Digest - Supplement - Public Meeting Distribution	Ivonne Couret	ivonne.couret@nrc.gov	OPA	< 85	1	04/16/2016	08/30/2016		Public Distribution	No	Yes
NUREG/BR-0292	Brochure/BR	Safety of Spent Fuel Transportation	Ivonne Couret/ Maureen Conley	ivonne.couret@nrc.gov	OPA	8	1	05/02/2016	08/30/2016	Out of date incorporate new information		Yes	Yes
NUREG/BR-0010	Brochure/BR	Citizen's Guide to US NRC Information	Ivonne Couret/ Holly Harrington	ivonne.couret@nrc.gov	OPA	36	1	07/15/2016	11/11/2016	Out of date incorporate new information		Yes	Yes
NUREG/BR-0297	Brochure/BR	NRC Public Meetings	Ivonne Couret/ David McIntyre	ivonne.couret@nrc.gov	OPA	<10	1	06/01/2016	08/30/2016	Out of date incorporate new information	Public Distribution	Yes	Yes
NUREG/BR-0202	Brochure/BR	Guidelines for Interviews with the Media	Ivonne Couret/ Holly Harrington	ivonne.couret@nrc.gov	OPA	2	1	06/30/2016	09/19/2016	Out of date incorporate new information		Yes	Yes
NUREG/BR-0215	Brochure/BR	Public Involvement in the Nuclear Regulatory Process	Ivonne Couret/ Scott Burnell	ivonne.couret@nrc.gov	OPA	12	1	08/08/2016	12/15/2016	Out of date incorporate new information		Yes	Yes
NUREG/BR-0220	Brochure/BR	Public Petition Process	Ivonne Couret/ Scott Burnell	ivonne.couret@nrc.gov	OPA	2	1	08/08/2016	12/15/2016	Out of date incorporate new information for the public		Yes	Yes
NUREG/BR-0217	Brochure/BR	The Regulation and Use of Radioisotopes in Today's World	Ivonne Couret/ Maureen Conley	ivonne.couret@nrc.gov	OPA	34	1	01/30/2016	04/25/2017	Out of date incorporate new information		Yes	Yes
NUREG-1350	Brochure/BR	NUREG-1350, Vol. 29 Information Digest	Ivonne Couret/ Ivonne Couret	ivonne.couret@nrc.gov	OPA	<200	1	04/16/2017	08/24/2017	Update	IAEA General Conference	Yes	Yes
NUREG-1350	Brochure/BR	NUREG-1350, Vol. 29 Information Digest - Supplement - CD	Ivonne Couret	ivonne.couret@nrc.gov	OPA	1	1	04/16/2017	08/24/2017		Public Distribution	No	Yes
NUREG-1350	Brochure/BR	NUREG-1350, Vol. 29 Information Digest - Supplement - NRC AT A GLANCE	Ivonne Couret	ivonne.couret@nrc.gov	OPA	15	1	04/16/2017	08/24/2017		Public Distribution	No	Yes
NUREG-1350	Brochure/BR	NUREG-1350, Vol. 29 Information Digest - Supplement - Public Meeting Distribution	Ivonne Couret	ivonne.couret@nrc.gov	OPA	< 85	1	04/16/2017	08/24/2017		Public Distribution	No	Yes
Currently with Graphics													
Completed													
NUREG/BR-0099	Brochure/BR	U.S. Nuclear Regulatory Commission	Ivonne Couret	ivonne.couret@nrc.gov	OPA	2	1	05/31/2016	06/10/2016	Out of date incorporate new information for the public	Public Distribution	Yes	Yes

From: Conley, Maureen
To: Couret, Ivonne
Subject: FW: AREVA Inc. (TN) Type B Packagings
Date: Thursday, January 21, 2016 3:58:00 PM

These are interesting – they are "transportable storage casks," which means they serve both functions. So while these are being readied for storage, we can use them (with a notation to that effect) in the transport brochure.

From: Saverot, Pierre
Sent: Thursday, January 21, 2016 3:50 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: AREVA Inc. (TN) Type B Packagings

Maureen,

Attached are pictures of the following AREVA Inc. (TN) **Type B** Packagings (spent fuel):

1. CoC 9293, TN-68 at Peach Bottom entering the ISFSI
2. CoC 9313, TN-40 at Prairie Island.

This is the last of the pictures for TN . Holtec will be next…..

Pierre

From:	Couret, Ivonne
To:	Conley, Maureen
Subject:	FW: Files Attached: NUREG Text - Spent Fuel Transport brochure
Date:	Thursday, December 10, 2015 11:17:12 AM
Attachments:	Spent Fuel Transport bro r1 edited.pdf Summary of Comments on Spent Fuel Transport bro r1 edited.pdf

Here is attachment with comments. Ivonne

From: QTE Resource
Sent: Wednesday, December 09, 2015 12:25 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: RE: Files Attached: NUREG Text - Spent Fuel Transport brochure

Ivonne,

Attached are the files for the spent fuel transport NUREG.

Regards,
Caroline

From: Couret, Ivonne
Sent: Wednesday, December 09, 2015 10:06 AM
To: QTE Resource
Subject: RE: Files Attached: NUREG Text - Spent Fuel Transport brochure

Caroline,
You sent the comments for a different document, the PAR. Please send item for Spent Fuel Transport. Ivonne

From: QTE Resource
Sent: Tuesday, December 08, 2015 10:02 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Cc: QTE Resource <QTE.Resource@nrc.gov>
Subject: Files Attached: NUREG Text - Spent Fuel Transport brochure

Ivonne,

Attached is the pdf with editing comments. As usual, the comments are color coded:

Yellow: mechanical comments that can be accepted without review
Pink: comments that require author disposition
Red: comments that should be addressed before publishing

Also attached is the summary of comments file.

Please let us know if you have any questions, comments, or feedback.

Regards,
Caroline

From: Couret, Ivonne
Sent: Monday, November 30, 2015 2:57 PM
To: QTE Resource
Subject: Please review Updated NUREG Text - Spent Fuel Transport brochure
Importance: High

From: Raaum, Darrin
Sent: Monday, November 30, 2015 10:06 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: R1 Spent Fuel Transport brochure

Ivonne,

Attached is the first draft of the Spent Fuel Transport brochure.
The first two pages are cover concepts.
Let me know if you have any changes / corrections.

Darrin Raaum | Graphic Designer Contractor for USNRC
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U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient and realistic.

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. [redacted] Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

The NRC has three main functions:

1. *To set standards and develop regulations;*
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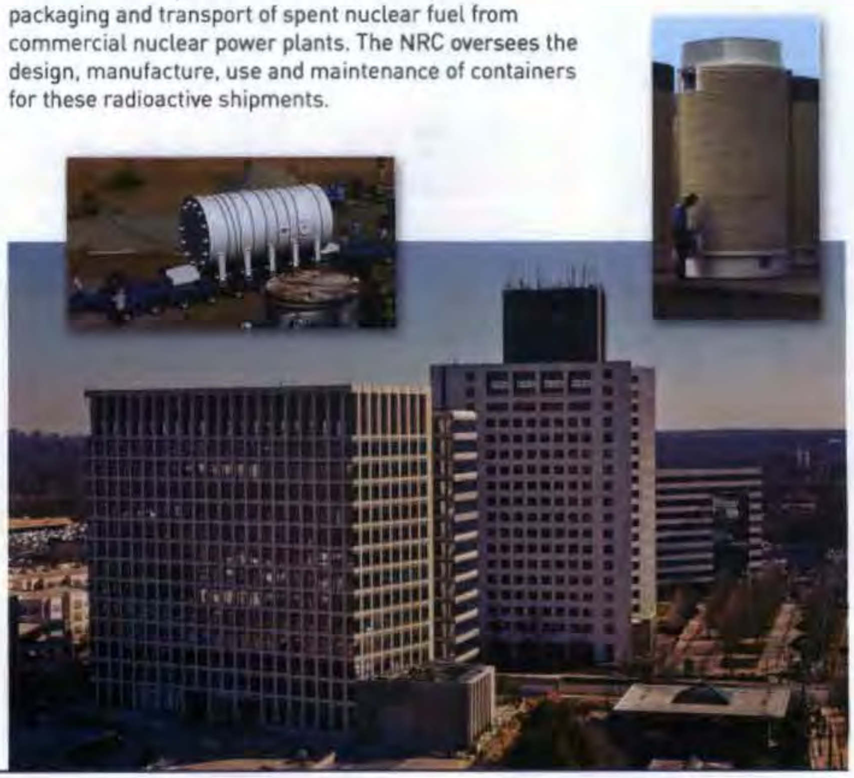


What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

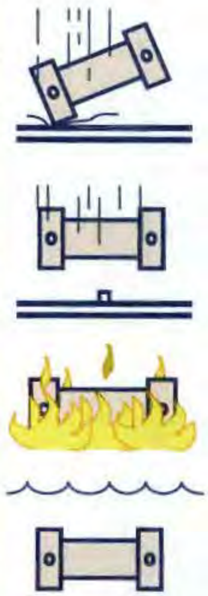
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a "cask."

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents [redacted] these containers must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials five to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.



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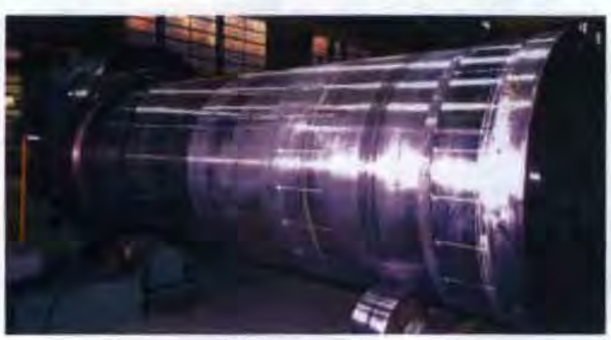


Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, and physical testing of a scale model or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance through a public rulemaking process. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

In a 1977 study, the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987 and 2000, the NRC looked more closely how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. These studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. The risk assessment found:

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year**

- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident**

- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would have performed. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, Cal.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask

Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

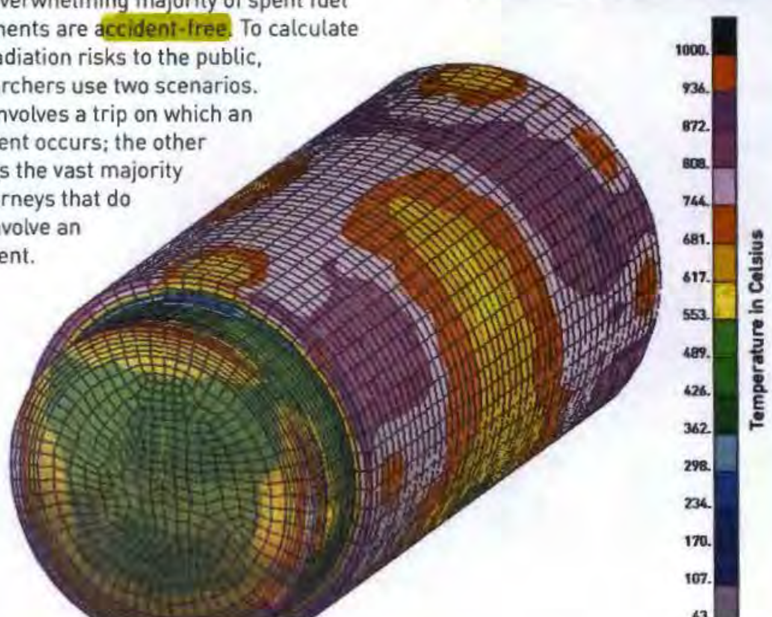
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions and
  - Doing inspections to ensure casks are built, maintained and used properly.
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes and other factors, and
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Armed escorts, and**
- **Devices that allow drivers and escorts to shut the vehicle off**

Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
March 2015

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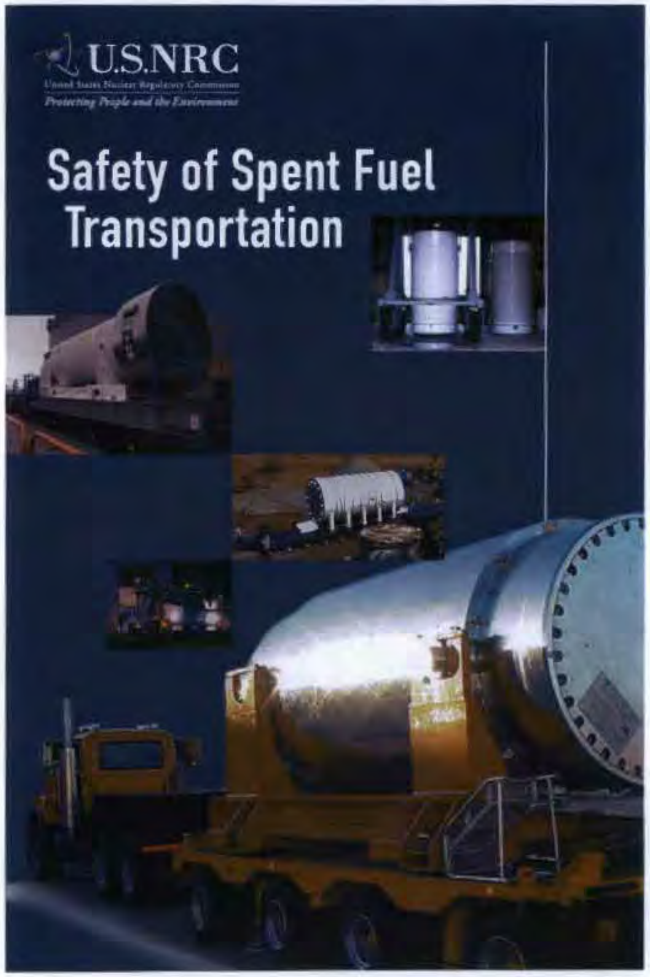

Summary of Comments on Spent Fuel Transport_bro_r1_edited.pdf

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The logos are not readily identifiable as belonging to the agencies to casual readers. Suggest calling out the agency name more clearly in each paragraph. For example by bolding the agency name in the first line or making the name blue.

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Capital S in States (GPO Style Manual)

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add a comma after "routes, an is..."

~~The~~ Nuclear Regulatory Commission

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Page: 1

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add "U.S." The U.S. Nuclear Regulatory Commission

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Please add captions explaining what these photos are showing.

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Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

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Page: 2

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Delete quotes around spent fuel

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add comma after "rocks."

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Change to active voice if possible. For example: Once Congress approves a central location for the storage or disposal of spent nuclear fuel, licensees would transport their spent fuel there from sites around the country.

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change "U.S." to "United States"

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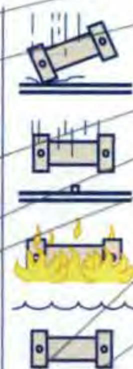

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remove the quotation marks around cask.

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lowercase: certificate of compliance

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Add a label/caption for the whole thing. Example: Cross section of a spent fuel storage and transportation cask.

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Change to "U.S. Department of Transportation"

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Change "U.S." to United States

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Add a caption describing what is shown in this picture.

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- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident**
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In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would have performed. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, Cal.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask

Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

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Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
change "would have performed" to "would perform."

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
change "Cal" to "CA" and keep on one line "Oakland, CA; and..."

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*

Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

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Change "U.S." to "United States"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "fires,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete hyphen: accident free.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
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- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

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use a nonbreaking hyphen. "long-term"

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The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions and
  - Doing inspections to ensure casks are built, maintained and used properly.
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes and other factors, and
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Armed escorts, and**
- **Devices that allow drivers and escorts to shut the vehicle off**

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Change "U.S." to "United States"

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For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
March 2015

This page contains no comments

From:	Conley, Maureen
To:	McIntyre, David
Subject:	FW: two questions for you`
Date:	Wednesday, January 20, 2016 11:03:00 AM
Attachments:	DOE Idaho ISFSI Ltr.pdf

Fyi, Michele's answer…

From: Sampson, Michele
Sent: Wednesday, January 20, 2016 10:52 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: two questions for you`

Good thing you followed up as I seem to have completely dropped the ball on asking the vendors for pics. I'll do that today.

You remember correctly, the TMI-2 ISFSI is in operation. The other Idaho ISFSI (formerly known as Foster-Wheeler) has never been put into operation. Just for fun, I've attached a letter from DOE which has a definitive statement to that effect from DOE to get them out of the annual fee.

As for the fuel …. My understanding is that the Foster Wheeler site was intended to store fuel from the shutdown Peach Bottom and Shippingport reactors, along with some other TRIGA fuel. At least some of the fuel is already at DOE ID. I believe that all of the Shippingport fuel and Peach Bottom 1 fuel was already shipped there (it isn't still at either reactor site). I've never really looked into it, but my understanding is that DOE was working out a waste management plan with the state of ID and the Foster Wheeler ISFSI was some part of that agreement. However, DOE failed to meet some waste processing goals/requirements, and the state took them to court and somehow the ISFSI is in some permanent limbo. The ISFSI was not central to the state's issues, I think it is just a secondary casualty of the lawsuit/agreement.

FYI – I'll soon be your neighbor again. I'm moving over to OEDO Feb. 1st.

Thanks,
Michele Sampson
Division of Spent Fuel Management
301-415-7493

From: Conley, Maureen
Sent: Wednesday, January 20, 2016 10:13 AM
To: Sampson, Michele <Michele.Sampson@nrc.gov>
Subject: two questions for you`

Hi, Michele. Am I remembering correctly that DOE only built one of the two NRC-licensed Isfsis in Idaho? TMI-2 is operating, but not the Idaho spent fuel facility? (and if that's correct, where are they storing research reactor fuel?)

Also – I'm wondering whether you had any luck getting images out of the cask vendors for that brochure. No rush, just following up.

Thanks,

Maureen Conley
NRC Office of Public Affairs
301-415-8202

Hudson, Sharon

From:	Wylie, Maureen
Sent:	Thursday, June 04, 2015 11:08 AM
To:	Barbara Gusack; Grancorvitz, Teresa
Cc:	Muessle, Mary; Hudson, Sharon
Subject:	Fwd: Annual Fee Payments for Nuclear Regulatory Commission License No. SNM-2512 Idaho Spent Fuel Facility Independent Spent Fuel Storage Installation (EM-FMDP-15-029)
Attachments:	EM-FMDP-15-029 Annual Fee Payments for NRC License No. SNM-2512 ISFSI.pdf

Ticket action as appropriate

From: "Kaiser, Nancy A" <kaisernа@id.doe.gov>
Subject: Annual Fee Payments for Nuclear Regulatory Commission License No. SNM-2512 Idaho Spent Fuel Facility Independent Spent Fuel Storage Installation (EM-FMDP-15-029)
Date: 04 June 2015 08:56
To: "Wylie, Maureen" <Maureen.Wylie@nrc.gov>
Cc: "Allen, William" <William.Allen@nrc.gov>, "Hall, Gregory G" <gregory.hall@icp.doe.gov>, "CWI Correspondence Control" <CWICorrespondenceControl@icp.doe.gov>

This correspondence is sent electronically only. Hard copy is available upon request. Hard copy will be sent to Maureen Wylie.

[illegible] Kaiser
Secretary [illegible]
Department of Energy
Idaho [illegible] Office
[illegible] Avenue
Idaho Falls [illegible] 83415

[illegible]
[illegible]

From:	Couret, Ivonne
To:	GRAPHICS Resource; Machalek, Woody
Cc:	Conley, Maureen
Subject:	New Project Update NUREG
Date:	Tuesday, November 17, 2015 4:30:29 PM
Attachments:	BR0292_ML031140098.pdf Safety of Spent Fuel Transportation brochure FINAL.docx

Woody,

New project from OPA.

We would like to update/or new fresh layout of this NUREG 0292 from 2003 to current new approved text found in the word file.

So let's discuss tomorrow this project and The Student Corner on next steps.

Thanks for all you do. Ivonne

Ivonne L. Couret

Public Affairs Officer

Office of Public Affairs

U.S. Nuclear Regulatory Commission

301-415-8205

Ivonne.couret@nrc.gov

NEW – Information Digest 2015-2016 now available online at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/

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Safety of Spent Fuel Transportation

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

The NRC has three main functions:
1. To set standards and develop regulations;
2. To issue licenses for nuclear facilities and nuclear materials users; and
3. To inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient and realistic

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the U.S., and internationally, with the IAEA. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

What is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:
• How does the NRC protect the public from radiation during transport?
• What is the likelihood one of these shipments will be involved in an accident?
• How well can the shipping containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a "cask."

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these containers must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials five to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, and physical testing of a scale model or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance through a public rulemaking process. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

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Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk. NRC studies show this risk is low. As a part of its safety effort. the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

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NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs. an accident might be severe enough to cause a radioactive release.

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• Armed escorts, and
• Devices that allow drivers and escorts to shut the vehicle off

Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:
Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear Regulatory Commission
NUREG/BR-0292
March 2015

From:	COURET, IVONNE L
To:	Grasty, Tojuana; Malone, Tina; Raaum, Darrin
Cc:	Ferrell, Kimberly; Conley, Maureen; Machalek, Woody
Subject:	ON HOLD - REVIEW of NUREG/BR 0292 Revision Safety and Spent Fuel Transport r5
Date:	Monday, June 27, 2016 8:35:00 AM
Importance:	High

Tojuana, Tina, Darrin:
Despite the finalization, NMSS now wants to add more verbiage. I do apologize if you started to review this document. Please place this document on hold until we again re-finalize with program office. Thanks for all you do! Ivonne

From: COURET, IVONNE L
Sent: Friday, June 24, 2016 2:02 PM
To: Fortune Grasty, Tojuana <Tojuana.FortuneGrasty@nrc.gov>; Malone, Tina <Tina.Malone@nrc.gov>
Cc: Ferrell, Kimberly <Kimberly.Ferrell@nrc.gov>
Subject: NUREG/BR 0292 Revision Safety and Spent Fuel Transport r5

Tojuana and Tina:
I don't know if this is Revision 1 or 2. Attached is the brochure PDF and the related forms. Thanks in advance for your support on this project. Ivonne

Ivonne L. Couret
Public Affairs Officer
Office of Public Affairs
U.S. Nuclear Regulatory Commission
301-415-8205
Ivonne.couret@nrc.gov

NEW – Information Digest 2015-2016 now available online at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/

-

From:	Couret, Ivonne
To:	Conley, Maureen
Subject:	QTE Suggested changes for NUREG Text - Spent Fuel Transport brochure
Date:	Wednesday, December 09, 2015 10:08:57 AM
Attachments:	Spent Fuel Transport_bro_r1_edited.pdf

Maureen,
Can you accept or reject changes suggested by QTE. Thanks, Ivonne

From: QTE Resource
Sent: Tuesday, December 08, 2015 10:02 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Cc: QTE Resource <QTE.Resource@nrc.gov>
Subject: Files Attached: NUREG Text - Spent Fuel Transport brochure

Ivonne,

Attached is the pdf with editing comments. As usual, the comments are color coded:

Yellow: mechanical comments that can be accepted without review
Pink: comments that require author disposition
Red: comments that should be addressed before publishing

Also attached is the summary of comments file.

Please let us know if you have any questions, comments, or feedback.

Regards,
Caroline

From: Couret, Ivonne
Sent: Monday, November 30, 2015 2:57 PM
To: QTE Resource
Subject: Please review Updated NUREG Text - Spent Fuel Transport brochure
Importance: High

From: Raaum, Darrin
Sent: Monday, November 30, 2015 10:06 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: R1 Spent Fuel Transport brochure

Ivonne,

Attached is the first draft of the Spent Fuel Transport brochure.
The first two pages are cover concepts.
Let me know if you have any changes / corrections.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage and permanent geologic disposal of used fuel.

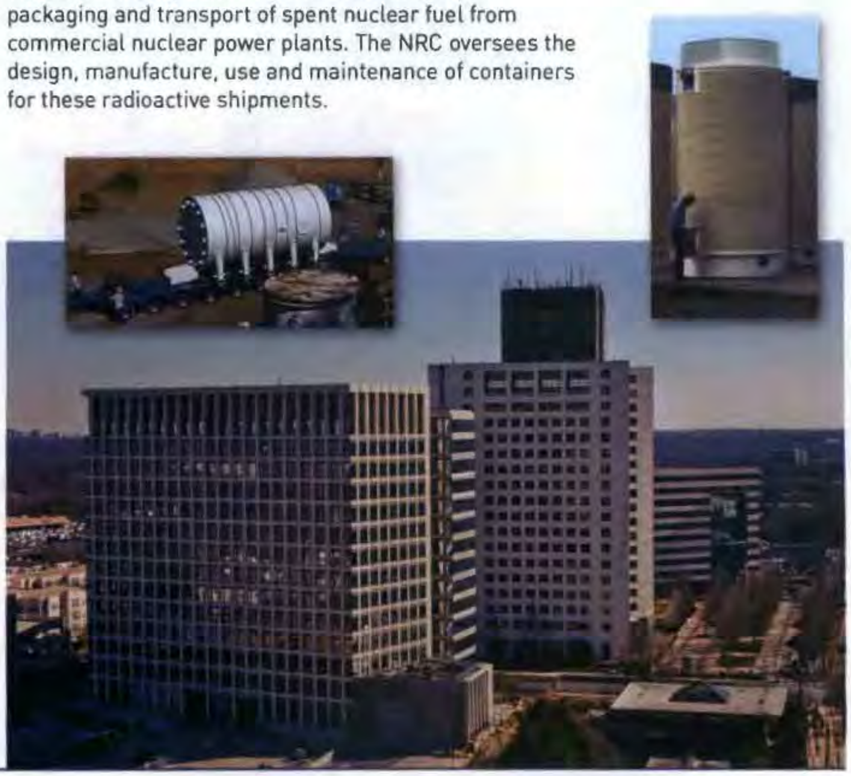
The NRC works to protect public health and safety, the environment and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient and realistic.

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. [redacted] Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

The NRC has three main functions:

1. *To set standards and develop regulations;*
2. *To issue licenses for nuclear facilities and nuclear materials users; and*
3. *To inspect facilities to ensure that NRC regulations are being met.*



What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as **"spent fuel."** It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

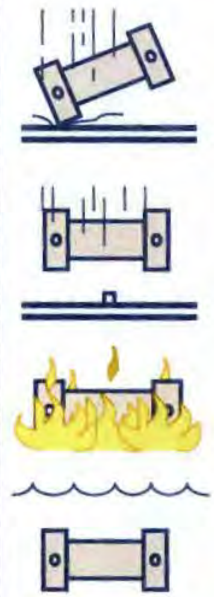
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a "cask."

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents [redacted] these containers must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials five to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

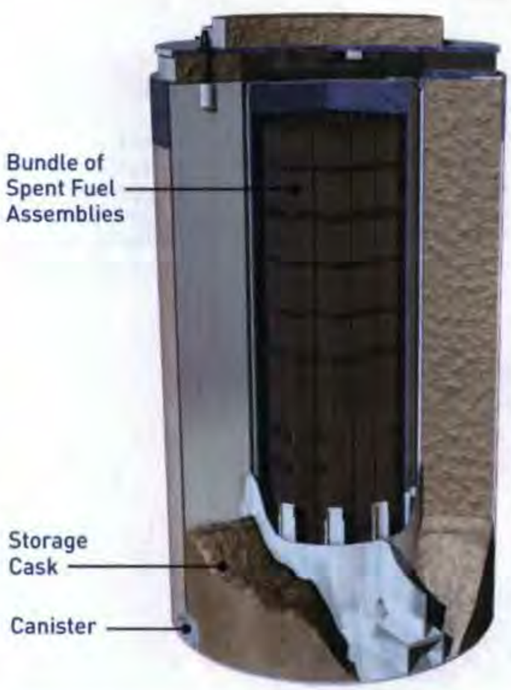
Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.



[redacted] *fire, and water immersion tests are considered in sequence to determine their cumulative effects on a given package.*

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, and physical testing of a scale model or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance through a public rulemaking process. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

In a 1977 study, the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987 and 2000, the NRC looked more closely how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. These studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

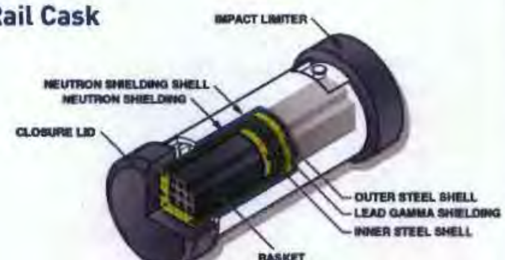
The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. The risk assessment found:

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would have performed. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, Cal.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask



Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

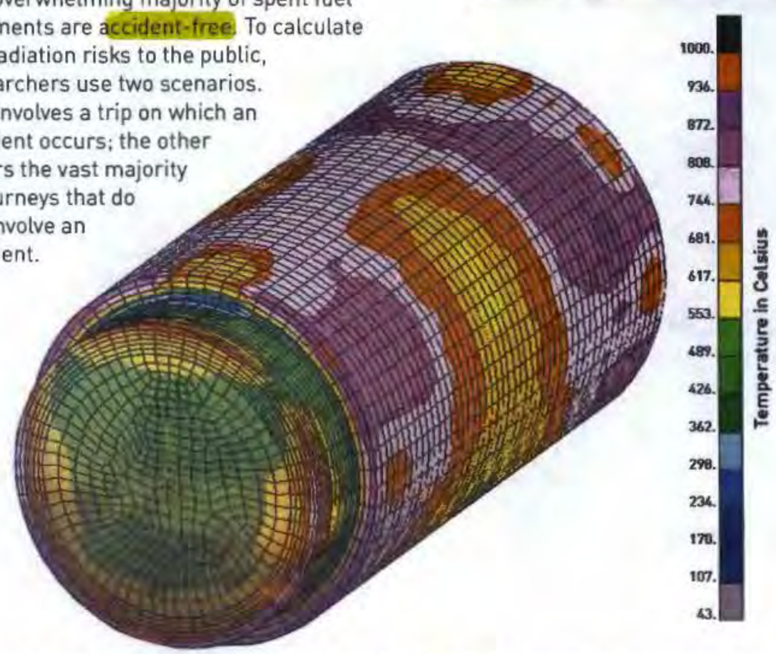
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions and
  - Doing inspections to ensure casks are built, maintained and used properly.
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes and other factors, and
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Armed escorts, and**
- **Devices that allow drivers and escorts to shut the vehicle off**

[redacted]

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
March 2015

@NRCgov

From: Couret, Ivonne
To: Conley, Maureen
Subject: RE: AREVA (TN) Pictures of Transportation Casks
Date: Thursday, January 21, 2016 3:47:22 PM

WooHoo do we have okay to cure will provide AREVA credit. Ivonne

---

From: Conley, Maureen
Sent: Thursday, January 21, 2016 3:46 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: FW: AREVA (TN) Pictures of Transportation Casks

The first of (hopefully) many batches of pics for the transport brochure… (NOTE: this is all FRESH fuel, not spent)

From: Saverot, Pierre
Sent: Thursday, January 21, 2016 3:44 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: AREVA (TN) Pictures of Transportation Casks

Maureen,

Attached are pictures of the following AREVA Inc. (TN) Fresh Fuel Packagings:

CoC 9217 (Docket 71-9217) ANF-250
CoC 9248 (Docket 71-9248) SP1, SP2, SP3

These pictures were taken at AREVA Inc.'s Horn Rapids Road Facility in Richland, WA.

More to come.

Pierre

From:	Hsia, Anthony
To:	Conley, Maureen
Subject:	RE: BROCHURE!!!!
Date:	Thursday, July 21, 2016 3:57:13 PM

Even if we do not have a new printed version of the brochure, I can give them a draft on 7/26.

From: Conley, Maureen
Sent: Thursday, July 21, 2016 3:50 PM
To: Hsia, Anthony <Anthony.Hsia@nrc.gov>
Subject: RE: BROCHURE!!!!

Ok, thanks Tony!

From: Hsia, Anthony
Sent: Thursday, July 21, 2016 3:43 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: BROCHURE!!!!

They are coming here. It is the PIIC tribal council president Shelley Buck and the executive assistant to the tribal council Heather Westra to attend the Commission stakeholders meeting and I have scheduled a meeting with MSTR and PIIC form 1 to 2 pm on 7/26. Will send you the scheduler in case you are interested in attending.

From: Conley, Maureen
Sent: Thursday, July 21, 2016 3:37 PM
To: Hsia, Anthony <Anthony.Hsia@nrc.gov>
Subject: RE: BROCHURE!!!!

Are they coming here, or are NRC folks going there?

From: Hsia, Anthony
Sent: Thursday, July 21, 2016 3:23 PM
To: Lombard, Mark <Mark.Lombard@nrc.gov>; Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: BROCHURE!!!!

For the 7/26 meeting with PIIC, is there a version of the "Safety of Spent Fuel Transportation" brochure I can hand to the visitors? If not, I could give them the old version NUREG/BR-0292.

Tony

From: Lombard, Mark
Sent: Friday, July 15, 2016 2:40 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>; Hsia, Anthony <Anthony.Hsia@nrc.gov>
Subject: RE: BROCHURE!!!!

Sorry for the delay. Your recommended wording is awesome.

From: Conley, Maureen
Sent: Tuesday, July 12, 2016 5:36 PM
To: Lombard, Mark <Mark.Lombard@nrc.gov>; Hsia, Anthony <Anthony.Hsia@nrc.gov>
Subject: RE: BROCHURE!!!!

Hi guys. Just wanted to follow up on the brochure. I've made the edits Mark sent but I think we still need to nail down the language in the "accident scenario" section. I like Mark's suggested context but not being a mint julep drinker (I prefer gin thanks) I'm not sure I can relate (!)

So I'd like to propose the following for that section, please let me know if you have any comments (including about alternate beverages one might consume in the shower on the 4th of July) and I'll move the brochure into production:

NRC studies show that the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a radioactive release in 99.99973% of those 5 accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

Thanks!
Maureen

From: Lombard, Mark D
Sent: Tuesday, June 28, 2016 1:48 PM
To: CONLEY, MAUREEN E <Maureen.Conley@nrc.gov>; Hsia, Anthony H <Anthony.Hsia@nrc.gov>
Subject: RE: BROCHURE!!!!

I like it but perhaps you can put the probability in context like "you have a better chance of being hit by a meteor while in the shower at midnight on the fourth of July while drinking a mint julip."

-------- Original Message --------
From: "CONLEY, MAUREEN E" <Maureen.Conley@nrc.gov>
Date: Mon, June 27, 2016 3:19 PM -0400
To: "Lombard, Mark D" <Mark.Lombard@nrc.gov>, "Hsia, Anthony H" <Anthony.Hsia@nrc.gov>
Subject: RE: BROCHURE!!!!

P.S. Along similar lines –

- Page 8, third paragraph – can we characterize the large release and it consequences? Again, looking to put in in the "not worry" box.

The blog post on the risk study states,

- There is a 1 in 1 billion chance that radioactive material would be released in an accident
- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm

I propose we just use that language, in sentence form, and blend with what we have in the brochure:

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

Does that work?

Maureen

From: CONLEY, MAUREEN E
Sent: Monday, June 27, 2016 12:00 PM
To: Lombard, Mark D <Mark.Lombard@nrc.gov>; Hsia, Anthony H <Anthony.Hsia@nrc.gov>
Subject: RE: BROCHURE!!!!

Thanks for these edits, Mark (especially the missed typos!)

RE: Page 8, first paragraph – "Fewer than 1 in 100 accidents will be more severe than the design standards" I don't think they will be more severe than the HAC standards, will they? Just thinking how we can keep it in the "not worry" box.

In looking at that graphic from the risk study – it appears the figure should be 99.95% of accidents will not exceed the design requirements. Of those, 99.99973% will not lead to a release or loss of shielding.

The first line of the paragraph is, "NRC studies show that the likelihood of an accident is low."

Can we reword that paragraph to read:

NRC studies show that the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a release in 99.99973% of those accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

[then we go on to talk about how we estimate the risk)

Here's the link to the risk study, see figure PS-8, p. xxxvi
http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf

Please let me know your thoughts on that alternate wording. Also, Tony, if you have any additional comments, please let me know.

Maureen

From: Lombard, Mark D
Sent: Friday, June 24, 2016 5:25 PM
To: CONLEY, MAUREEN E <Maureen.Conley@nrc.gov>; Hsia, Anthony H <Anthony.Hsia@nrc.gov>
Subject: RE: BROCHURE!!!!

Sounds good. A few comments on the current draft:

- Page 1, third paragraph, add "around the world" to the end of the last sentence
- Page 1, last paragraph, last sentence, and elsewhere, Include commas per the NRC Style Guide
- Page 4, first paragraph – we don't always do confirmatory calcs
- Page 4, second paragraph – transportation CoCs do not go through rulemaking, only storage CoCs
- Page 5, fifth paragraph, third sentence – delete one of the "boths"
- Page 8, first paragraph – "fewer than 1 in 100 accidents will be more severe than the design standards" I don't think they will be more severe than the HAC standards, will they? Just thinking how we can keep it in the "not worry" box.
- Page 8, third paragraph – can we characterize the large release and it consequences? Again, looking to put in in the "not worry" box.
- Page 9, second bullet, first sub-bullet – change to "…fully understand potential safety issues"

From: CONLEY, MAUREEN E
Sent: Friday, June 24, 2016 3:48 PM
To: Lombard, Mark D <Mark.Lombard@nrc.gov>; Hsia, Anthony H <Anthony.Hsia@nrc.gov>
Subject: BROCHURE!!!!

Just to follow up on our meeting from yesterday…We made the change to the text that we discussed. I conferred with my management on the graphic idea and the decision was made to stick with the spent fuel cask cut-away (reason being, if we introduce the subject of dose, it gets very complicated and can be used against us, whereas the existing image is very non-offensive). So the brochure is moving through the Nureg process now. Y'all probably have a better idea than I do how long that takes, but I'll keep you posted.

That said, we did decide it would be worthwhile to have the dose graphics from the spent fuel risk study in our back pocket when/if transport actually is on the horizon and the mobile Chernobyl campaign gears up.

OPA will work with the graphics folks on this – we think we can package it a little differently and make it even more dramatic and clear. When we have something to share I'll bring it to our monthly meeting.

Thanks,

Maureen Conley
NRC Office of Public Affairs
301-415-8202

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste, and licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected States to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Cover Photos:

(Left) Transportable spent fuel storage casks sit on a storage pad. (Courtesy: Holtec International)

(Middle) Spent fuel transport cask arrives at Rancho Seco. (Courtesy: Areva)

(Right) Schematic of spent fuel transport cask. (Courtesy: Holtec International)

(Bottom) Spent fuel transport cask arrives on site.

Page 1 Photos:

(Left) Empty transportable spent fuel storage system arrives at Prairie Island. (Courtesy: Areva)

(Right) Transportable spent fuel storage system is readied for storage. (Courtesy: Areva)

(Bottom) Transport package is placed inside conveyance vehicle. (Courtesy: NAC International)

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates that information against its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

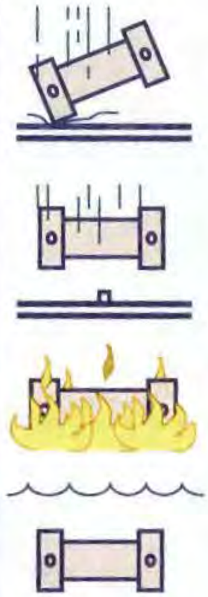
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

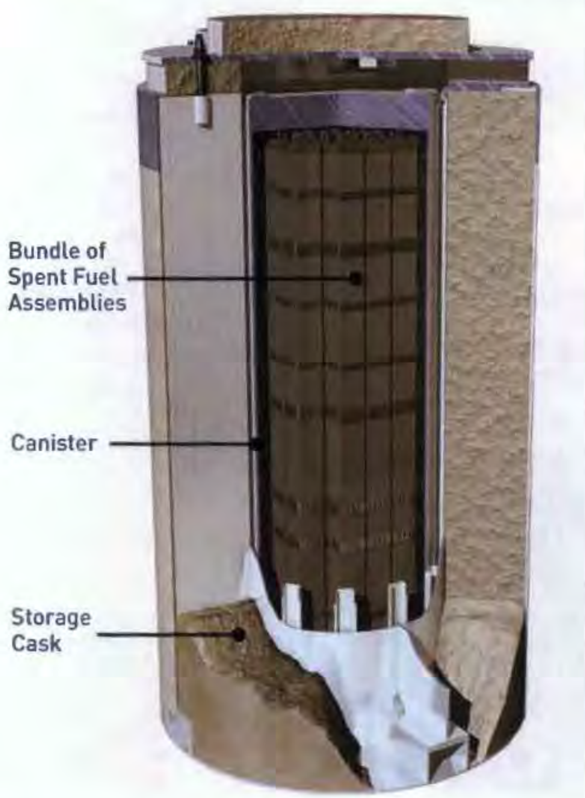
3. fire, and

4. water immersion.

Truck carries NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance through a public rulemaking process. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

NAC LWT spent fuel transport package is moved by crane. (Courtesy: NAC International)

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

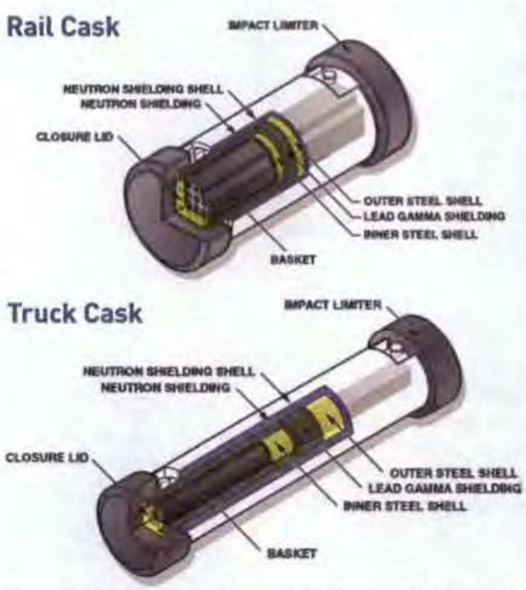
1. http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf
2. http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/
3. http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf
4. http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf

The risk assessment found:

Transportable spent fuel storage cask moves to storage pad.
(Courtesy: Holtec International)

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.



Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

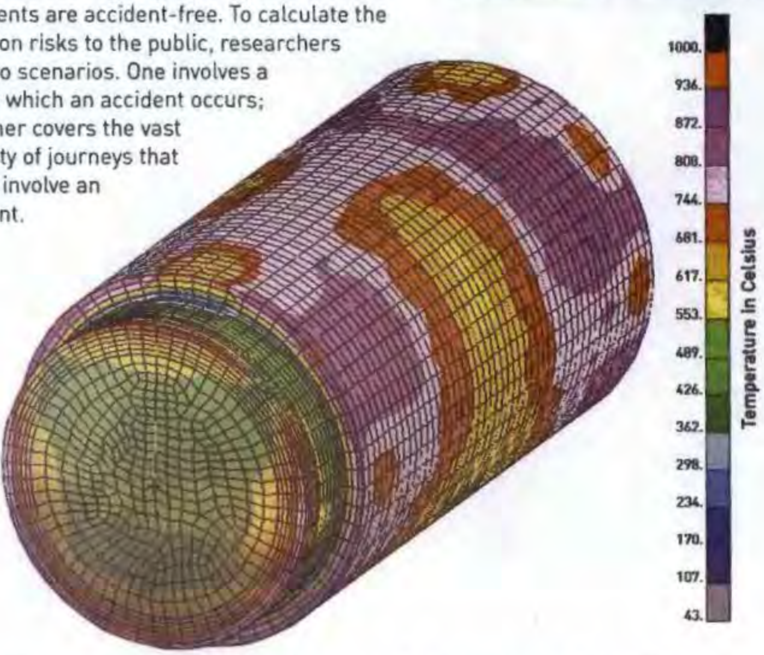
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1 billion.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

@NRCgov

From:	WHITE, BERNARD H
To:	CONLEY, MAUREEN E
Subject:	RE: FW: Safety and Spent Fuel Transport
Date:	Friday, June 24, 2016 2:20:22 PM

I have a million things going on right now, so you might want to ping me in a week or so to remind me that I have it.

Have a great weekend ☺

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: CONLEY, MAUREEN E
Sent: Friday, June 24, 2016 2:09 PM
To: WHITE, BERNARD H <Bernard.White@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport

No deadline. We'd just like to have a caption for it if we could. Don't strain yourself, it won't be the end of the world if we can't id it. But if you're up for the challenge I'd love to know the answer!

Thanks, Bernie!

From: WHITE, BERNARD H
Sent: Friday, June 24, 2016 2:05 PM
To: CONLEY, MAUREEN E <Maureen.Conley@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport

I will have to do some digging to find out. How soon do you need an answer?

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: CONLEY, MAUREEN E
Sent: Friday, June 24, 2016 2:05 PM
To: WHITE, BERNARD H <Bernard.White@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport

That's the one!

From: WHITE, BERNARD H
Sent: Friday, June 24, 2016 2:01 PM
To: CONLEY, MAUREEN E <Maureen.Conley@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport

I presume you are talking about the very large picture at the bottom, which covers the entire width of the page?

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: CONLEY, MAUREEN E
Sent: Friday, June 24, 2016 1:18 PM
To: WHITE, BERNARD H <Bernard.White@nrc.gov>
Subject: FW: FW: Safety and Spent Fuel Transport

Can you identify which transport package is pictured at the bottom of the cover page in the attached brochure?

From: Raaum, Darrin
Sent: Thursday, June 23, 2016 11:48 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Cc: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport

Maureen,

Attached is the latest version of the Spent Fuel Transport brochure.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Thursday, June 23, 2016 11:28 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>; Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport Word file

Looks good Darrin. A few more things, I'll swing by with a marked up copy. Please give a call if you have any questions.

Thanks,
Maureen
415-8202

From: Raaum, Darrin
Sent: Thursday, June 23, 2016 6:35 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Cc: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport Word file

Here is the latest.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Couret, Ivonne
Sent: Thursday, June 23, 2016 5:57 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: Fwd: FW: Safety and Spent Fuel Transport Word file

Darrin it appears we didn't get the latest up date emailed can you resend. Thanks. Ivonne

via Mobile phone

-------- Original Message --------
From: "Conley, Maureen" <Maureen.Conley@nrc.gov>
Date: Wed, June 22, 2016 5:20 PM -0400
To: "Couret, Ivonne" <Ivonne.Couret@nrc.gov>
Subject: FW: Safety and Spent Fuel Transport Word file

Hey, Ivonne. Sorry this took so long, but I finally dug into my email. I'm waiting on edits from Darrin. I met with him June 13 to go over the changes and don't see that he's sent me anything since.

Thanks,
Maureen

From: Raaum, Darrin
Sent: Monday, June 13, 2016 3:00 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>

Subject: RE: Safety and Spent Fuel Transport Word file

Sure.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Monday, June 13, 2016 2:55 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Hi, Darrin. Looks good, but I have a few edits. Is now a good time for me to bring them down?

Maureen

From: Raaum, Darrin
Sent: Monday, June 13, 2016 11:28 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Maureen,

Attached is the updated brochure.
Let me know if I missed anything.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Monday, June 13, 2016 8:36 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Perfect, thanks!

From: Raaum, Darrin
Sent: Monday, June 13, 2016 8:36 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

That works, I'm flexible on time. I'll see you after your meeting, whenever that is.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Monday, June 13, 2016 8:32 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

No worries. I have a 9:00 meeting this morning that could go to 10:00 or could break up earlier. Ok if I come by when it's over? Or if you want a definite time, say 10:30?

Maureen

From: Raaum, Darrin
Sent: Monday, June 13, 2016 7:14 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Maureen,

Sorry I was not able to reply earlier. I was not available on Friday afternoon.
I am in all day today and tomorrow if you would like to come down.
Let me know what time works for you.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Friday, June 10, 2016 1:49 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Hey, Darrin. Are you in today? How late will you be here? I have a meeting at 2:00 but could come down after to talk about a few minor tweaks to the report if that works for you.

Please let me know. Thanks!
Maureen

From: Raaum, Darrin
Sent: Wednesday, June 08, 2016 11:13 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Cc: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

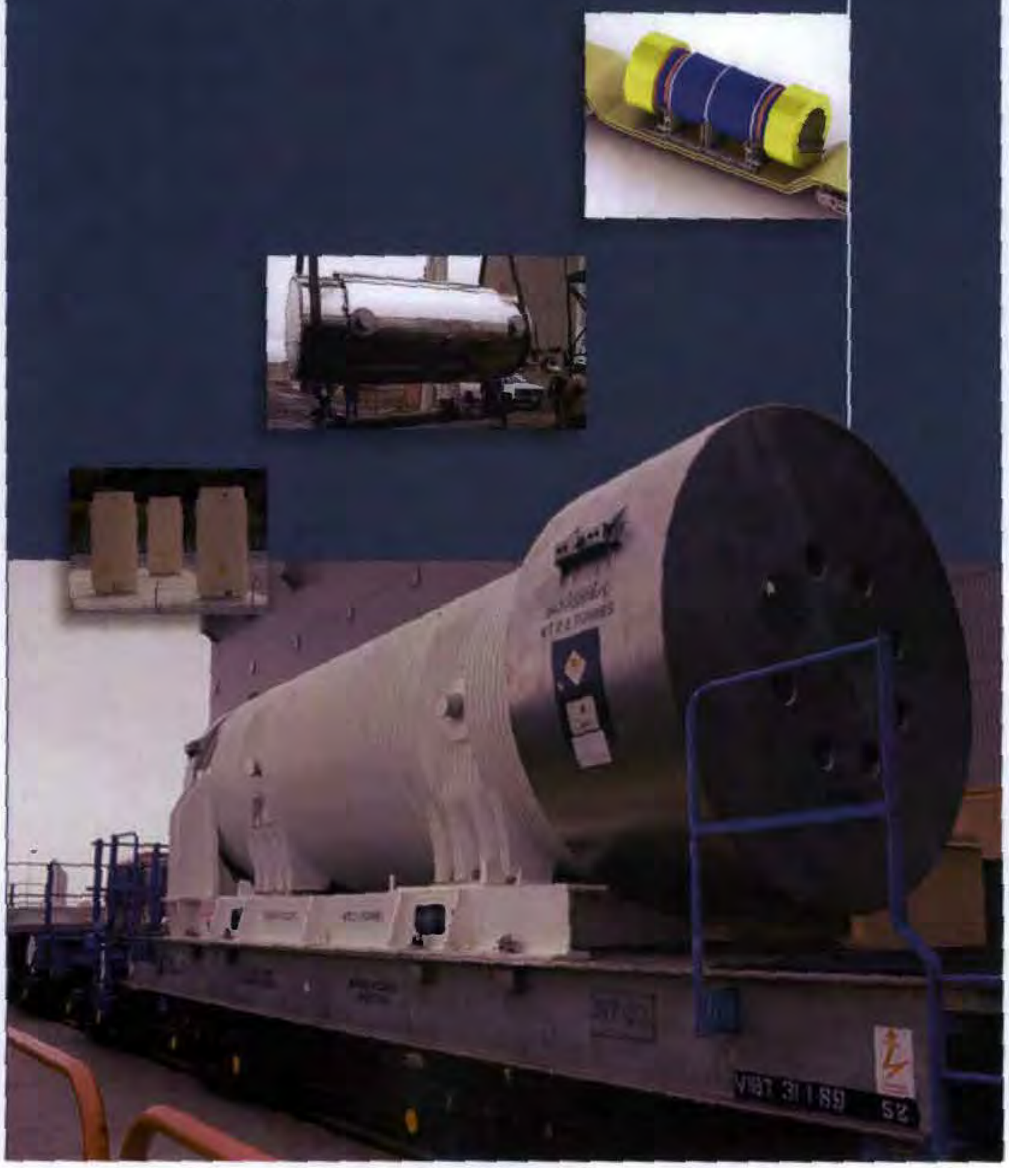
Attached is the first draft of the revised Spent Fuel Transport booklet.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation



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Cover Photos:

(Left) Transportable spent fuel storage casks sit on a storage pad. (Courtesy: Holtec International)

(Middle) Spent fuel transport cask arrives at Rancho Seco. (Courtesy: Areva)

(Right) Schematic of spent fuel transport cask. (Courtesy: Holtec International)

(Bottom) Spent fuel transport cask arrives on site.

Page 1 Photos:

(Left) Transportable spent fuel storage system is readied for storage. (Courtesy: Areva)

(Right) Empty transportable spent fuel storage system at Prairie Island. (Courtesy: Areva)

(Bottom) Transport package is placed inside conveyance vehicle. (Courtesy: NAC International)

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates that information against its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

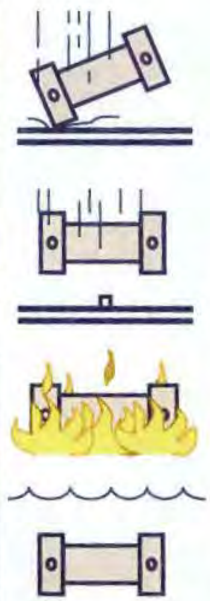
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

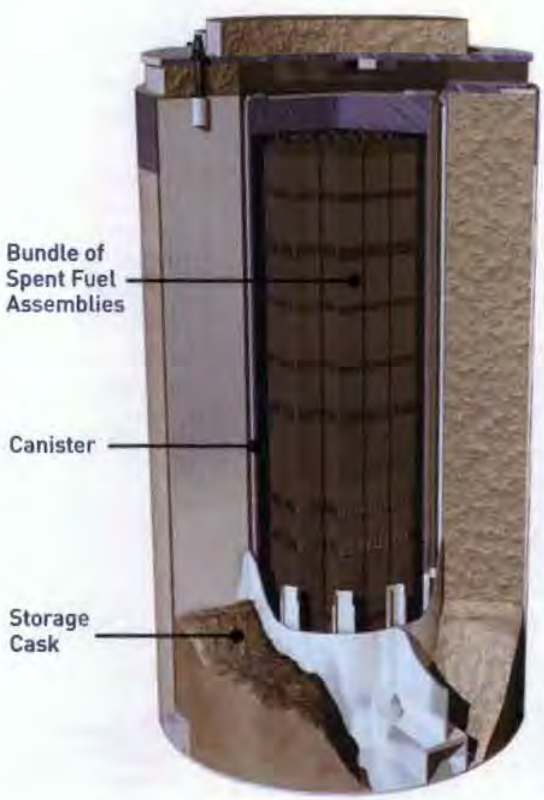
3. fire, and

4. water immersion.

Truck carryies NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance through a public rulemaking process. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

NACLWT spent fuel transport package is moved by crane. *(Courtesy: NAC International)*

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

1. *http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf*
2. *http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/*
3. *http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf*
4. *http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf*

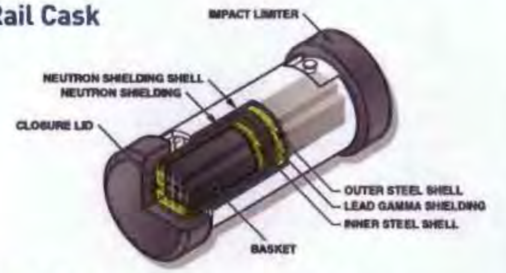
The risk assessment found:

Spent fuel storage cask moves to storage pad. *(Courtesy: Holtec International)*

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask



Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

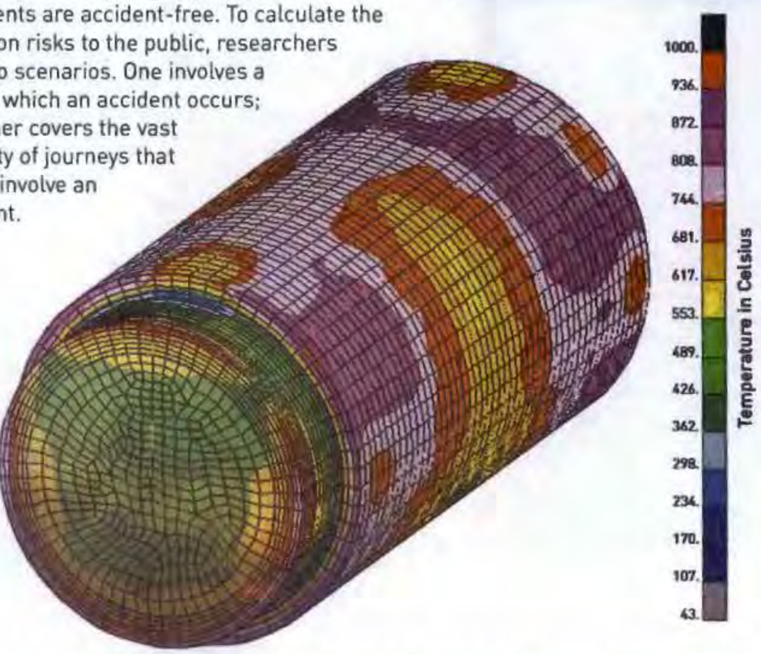
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1 billion.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

@NRCgov

From: COURET, IVONNE L
To: Conley, Maureen
Subject: RE: FW: Safety and Spent Fuel Transport r5
Date: Monday, June 27, 2016 8:37:54 AM

WTF

From: CONLEY, MAUREEN E
Sent: Friday, June 24, 2016 5:27 PM
To: RAAUM, DARRIN L <Darrin.Raaum@nrc.gov>; COURET, IVONNE L <Ivonne.Couret@nrc.gov>; GRASTY, TOJUANA F <Tojuana.FortuneGrasty@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport r5
Importance: High

Can we please put the brakes on this?!

NMSS has identified additional wording changes they would like to make. Will touch base on Monday.

From: RAAUM, DARRIN L
Sent: Friday, June 24, 2016 1:41 PM
To: COURET, IVONNE L <Ivonne.Couret@nrc.gov>
Cc: CONLEY, MAUREEN E <Maureen.Conley@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport r5

Attached is the current version of the Spent Fuel Transport brochure to send to Tojuana Fortune Grasty Tojuana.FortuneGrasty@nrc.gov.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Couret, Ivonne
Sent: Thursday, June 23, 2016 9:10 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Cc: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport Word file

Thanks for quick response. Ivonne

From: Raaum, Darrin
Sent: Thursday, June 23, 2016 6:35 AM

To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Cc: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: FW: Safety and Spent Fuel Transport Word file

Here is the latest.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Couret, Ivonne
Sent: Thursday, June 23, 2016 5:57 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: Fwd: FW: Safety and Spent Fuel Transport Word file

Darrin it appears we didn't get the latest up date emailed can you resend. Thanks. Ivonne

via Mobile phone

-------- Original Message --------
From: "Conley, Maureen" <Maureen.Conley@nrc.gov>
Date: Wed, June 22, 2016 5:20 PM -0400
To: "Couret, Ivonne" <Ivonne.Couret@nrc.gov>
Subject: FW: Safety and Spent Fuel Transport Word file

Hey, Ivonne. Sorry this took so long, but I finally dug into my email. I'm waiting on edits from Darrin. I met with him June 13 to go over the changes and don't see that he's sent me anything since.

Thanks,
Maureen

From: Raaum, Darrin
Sent: Monday, June 13, 2016 3:00 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Sure.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC

4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Monday, June 13, 2016 2:55 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Hi, Darrin. Looks good, but I have a few edits. Is now a good time for me to bring them down?

Maureen

From: Raaum, Darrin
Sent: Monday, June 13, 2016 11:28 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Maureen,

Attached is the updated brochure.
Let me know if I missed anything.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Monday, June 13, 2016 8:36 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Perfect, thanks!

From: Raaum, Darrin
Sent: Monday, June 13, 2016 8:36 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

That works, I'm flexible on time. I'll see you after your meeting, whenever that is.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Monday, June 13, 2016 8:32 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

No worries. I have a 9:00 meeting this morning that could go to 10:00 or could break up earlier. Ok if I come by when it's over? Or if you want a definite time, say 10:30?

Maureen

From: Raaum, Darrin
Sent: Monday, June 13, 2016 7:14 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Maureen,

Sorry I was not able to reply earlier. I was not available on Friday afternoon.
I am in all day today and tomorrow if you would like to come down.
Let me know what time works for you.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Friday, June 10, 2016 1:49 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Hey, Darrin. Are you in today? How late will you be here? I have a meeting at 2:00 but could come down after to talk about a few minor tweaks to the report if that works for you.

Please let me know. Thanks!
Maureen

From: Raaum, Darrin
Sent: Wednesday, June 08, 2016 11:13 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Cc: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport Word file

Attached is the first draft of the revised Spent Fuel Transport booklet.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste, and licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected States to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Cover Photos:

(Left) Transportable spent fuel storage casks sit on a storage pad. *(Courtesy: Holtec International)*

(Middle) Spent fuel transport cask arrives at Rancho Seco. *(Courtesy: Areva)*

(Right) Schematic of spent fuel transport cask. *(Courtesy: Holtec International)*

(Bottom) Spent fuel transport cask arrives on site.

Page 1 Photos:

(Left) Empty transportable spent fuel storage system arrives at Prairie Island. *(Courtesy: Areva)*

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This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments. However, the NRC does not control the timing or destination of spent fuel shipments.

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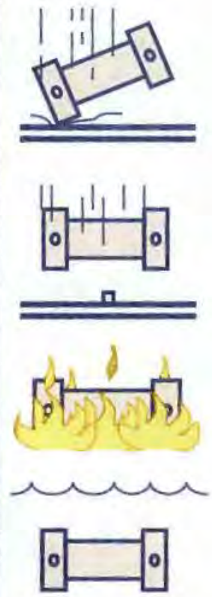
The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

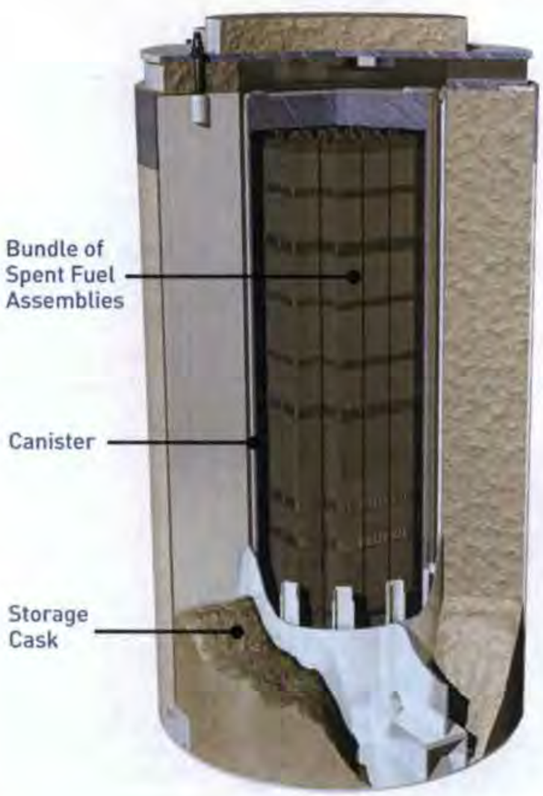
3. fire, and

4. water immersion.

Truck carries NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance through a public rulemaking process. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

NAC LWT spent fuel transport package is moved by crane. (Courtesy: NAC International)

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

1. http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf
2. http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/
3. http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf
4. http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf

The risk assessment found:

Transportable spent fuel storage cask moves to storage pad.
(Courtesy: Holtec International)

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask

Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

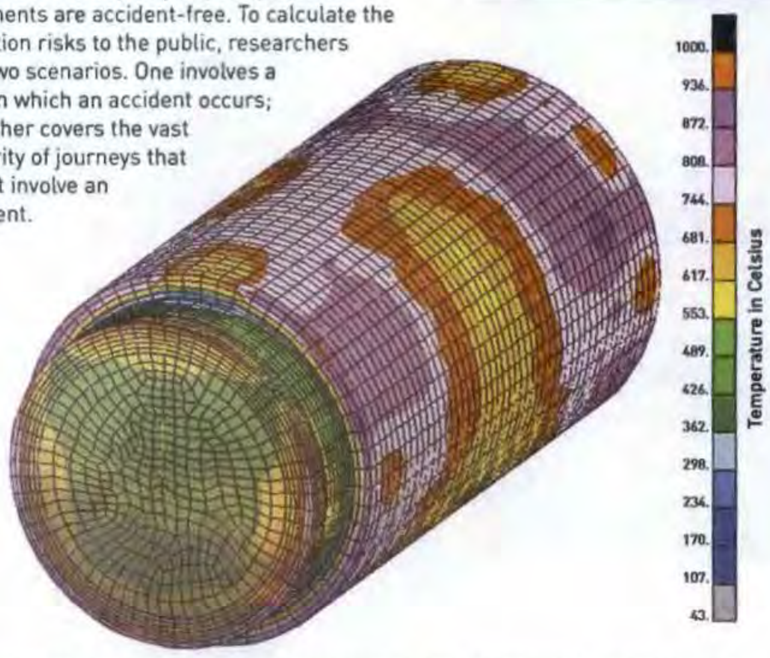
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1 billion.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

@NRCgov

From:	Couret, Ivonne
To:	Conley, Maureen
Subject:	RE: Files Attached: NUREG Text - Spent Fuel Transport brochure
Date:	Friday, December 18, 2015 10:18:47 AM

You can print out and mark it ...since it is a NUREG so we would loose the battle on that...not a backgrounder or PRelease.

-------- Original Message --------
From: "Conley, Maureen" <Maureen.Conley@nrc.gov>
Date: Fri, December 18, 2015 9:27 AM -0500
To: "Couret, Ivonne" <Ivonne.Couret@nrc.gov>
Subject: RE: Files Attached: NUREG Text - Spent Fuel Transport brochure

Hey, Ivonne. What's the process for resolving these comments? Should I print out the summary of comments and somehow note the ones I want to accept, or is there a file somewhere I should work in directly?

Also – I may need to talk with Holly about this, but there are a number of suggested changes that are based on GPO style and go against OPA style. Who wins?

Thanks,
Maureen

From: Couret, Ivonne
Sent: Thursday, December 10, 2015 11:17 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: FW: Files Attached: NUREG Text - Spent Fuel Transport brochure

Here is attachment with comments. Ivonne

From: QTE Resource
Sent: Wednesday, December 09, 2015 12:25 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: RE: Files Attached: NUREG Text - Spent Fuel Transport brochure

Ivonne,

Attached are the files for the spent fuel transport NUREG.

Regards,
Caroline

From: Couret, Ivonne
Sent: Wednesday, December 09, 2015 10:06 AM
To: QTE Resource
Subject: RE: Files Attached: NUREG Text - Spent Fuel Transport brochure

Caroline,
You sent the comments for a different document, the PAR. Please send item for Spent Fuel Transport. Ivonne

---

From: QTE Resource
Sent: Tuesday, December 08, 2015 10:02 PM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Cc: QTE Resource <QTE.Resource@nrc.gov>
Subject: Files Attached: NUREG Text - Spent Fuel Transport brochure

Ivonne,

Attached is the pdf with editing comments. As usual, the comments are color coded:

Yellow: mechanical comments that can be accepted without review
Pink: comments that require author disposition
Red: comments that should be addressed before publishing

Also attached is the summary of comments file.

Please let us know if you have any questions, comments, or feedback.

Regards,
Caroline

From: Couret, Ivonne
Sent: Monday, November 30, 2015 2:57 PM
To: QTE Resource
Subject: Please review Updated NUREG Text - Spent Fuel Transport brochure
Importance: High

From: Raaum, Darrin
Sent: Monday, November 30, 2015 10:06 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: R1 Spent Fuel Transport brochure

Ivonne,

Attached is the first draft of the Spent Fuel Transport brochure.
The first two pages are cover concepts.
Let me know if you have any changes / corrections.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From:	Pstrak, David
To:	Conley, Maureen
Subject:	RE: In case you missed it
Date:	Monday, September 12, 2016 9:17:28 AM

Thank you.

Mr. Halstead continues to push for full-scale testing of packages. He had similar comments related to the DSFM Fire Study Compendium (NUREG/CR-7209).

D.

From: Conley, Maureen
Sent: Monday, September 12, 2016 8:53 AM
To: Pstrak, David <David.Pstrak@nrc.gov>
Subject: RE: In case you missed it

Hi, David. It is publicly available now. Here's a link:

http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0292/

Thanks for sharing that Pahrump Valley Times story. I had seen it, and in fact communicated with the reporter last week because two of us responded to her emails and her initial story said she didn't hear back from us. She's since changed that.

Cheers,
Maureen

From: Pstrak, David
Sent: Monday, September 12, 2016 8:00 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: In case you missed it

Maureen – I had a question from DOE related to the updated NUREG/BR-0292.

Specifically, they want to know when this document will be publicly available.

While I believe that it is already, I wanted to ensure I provide an accurate response. Please advise.

Also, in case you missed it, here is an article that appeared in the Pahrump Valley Times related to this updated brochure. Select the first link for details.

Thanks –

David

NEWS

Nevada Opponents Of Yucca Project Criticize NRC Brochure Update.

The Pahrump (NV) Valley Times (9/7, Sokolova, 24K) reports that some Nevada officials and Yucca opponents are concerned at an NRC update to a "brochure on the safety of spent fuel transportation" because they fear it could "encourage new public relations efforts by the nuclear industry and proponents of the Yucca Mountain repository." The NRC publication titled, "The safety of spent fuel transportation" has drawn the ire of Nevada Agency for Nuclear Projects Director Robert Halstead, who "said Nevada staff and contractors are preparing a commentary on the publication focusing on several points." Among the points, Halstead contends that the new brochure "continues to misrepresent NRC cask accident performance criteria and the lack of full-scale cask testing requirements." It also "continues to misrepresent the most recent NRC transportation risk reports and does not address the consequences of successful terrorism and sabotage events." More news at http://www.bulletinintelligence.com/nrc/

From:	Saverot, Pierre
To:	Conley, Maureen
Subject:	RE: Pictures of Transportation Casks
Date:	Thursday, January 21, 2016 9:31:21 AM

You will have as many as you need.. (b)(5)

Even pictures of fresh fuel transport packages (even if this NUREG is on spent fuel transport) such as

CoC 9217 ANF-250
CoC 9248 SP1, SP2, SP3
CoC 9301 TNF-XI
CoC 9319 MAP 12/MAP 13

The pictures were taken at AREVA Inc.'s fuel processing facility, Horn Rapid Road, in Richland, WA.

You will decide !!

(b)(5)

From: Conley, Maureen
Sent: Thursday, January 21, 2016 9:20 AM
To: Saverot, Pierre
Subject: RE: Pictures of Transportation Casks

Awesome, thank you!

From: Saverot, Pierre
Sent: Wednesday, January 20, 2016 4:07 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Pictures of Transportation Casks

I will email you TN cask pictures by the end of the day tomorrow. Holtec casks soon after, TN first...

Pierre

From: Conley, Maureen
Sent: Wednesday, January 20, 2016 11:39 AM
To: Saverot, Pierre
Subject: RE: Pictures of Transportation Casks

Thank you, Pierre!

From: Saverot, Pierre
Sent: Wednesday, January 20, 2016 11:09 AM
To: Sampson, Michele <Michele.Sampson@nrc.gov>; White, Bernard <Bernard.White@nrc.gov>
Cc: Conley, Maureen <Maureen.Conley@nrc.gov>

Subject: RE: Pictures of Transportation Casks

Michele,

I am on it. No worry. It will be done and I am asking both AREVA TN and Holtec.

[redacted]

Pierre

From: Sampson, Michele
Sent: Wednesday, January 20, 2016 11:07 AM
To: White, Bernard; Saverot, Pierre
Cc: Conley, Maureen
Subject: Pictures of Transportation Casks

Bernie and Pierre,
Maureen is working on an update to NUREG/BR-0292. Because there is not any current large-scale commercial spent fuel shipping in the US, there are not a lot of transport package pictures. Would you reach out to your vendors, NAC, Holtec and AREVA-TN to see if they have any pictures of their current transportation package designs that they would voluntarily provide for us to consider using in the brochure update. If they could identify which package it is and where the picture was taken (i.e., photograph of NAC-LWT taken at public meeting in Virginia; or empty HI-STAR storage and transportation package being transported to a utility for storage). I don't think we need super-precise details, but we need to be able to identify what the picture is and roughly how it is being used in the picture.

Please send Maureen whatever you get or let her know if the vendor doesn't have anything. You should also let the vendors know that we are asking all three – I don't want anyone to think they have an exclusive deal.

Thanks,
Michele Sampson
Division of Spent Fuel Management
301-415-7493

From: White, Bernard
To: Sampson, Michele
Cc: Conley, Maureen; Saverot, Pierre
Subject: RE: Pictures of Transportation Casks
Date: Wednesday, January 20, 2016 12:15:01 PM

I will give NAC a call shortly

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: Saverot, Pierre
Sent: Wednesday, January 20, 2016 11:09 AM
To: Sampson, Michele <Michele.Sampson@nrc.gov>; White, Bernard <Bernard.White@nrc.gov>
Cc: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Pictures of Transportation Casks

Michele,

I am on it. No worry. It will be done and I am asking both AREVA TN and Holtec.
[redacted] (b)(5)
Pierre

From: Sampson, Michele
Sent: Wednesday, January 20, 2016 11:07 AM
To: White, Bernard; Saverot, Pierre
Cc: Conley, Maureen
Subject: Pictures of Transportation Casks

Bernie and Pierre,
Maureen is working on an update to NUREG/BR-0292. Because there is not any current large-scale commercial spent fuel shipping in the US, there are not a lot of transport package pictures. Would you reach out to your vendors, NAC, Holtec and AREVA-TN to see if they have any pictures of their current transportation package designs that they would voluntarily provide for us to consider using in the brochure update. If they could identify which package it is and where the picture was taken (i.e., photograph of NAC-LWT taken at public meeting in Virginia; or empty HI-STAR storage and transportation package being transported to a utility for storage). I don't think we need super-precise details, but we need to be able to identify what the picture is and roughly how it is being used in the picture.

Please send Maureen whatever you get or let her know if the vendor doesn't have anything. You should also let the vendors know that we are asking all three – I don't want anyone to think they have an exclusive deal.

Thanks,
Michele Sampson

Division of Spent Fuel Management
301-415-7493

From:	Conley, Maureen
To:	White, Bernard
Subject:	RE: Pictures of Transportation Casks
Date:	Friday, February 05, 2016 1:06:00 PM

Hey, Bernie. We would gladly take anything they can give us. (You might let them know that we received a couple dozen photos from Areva – generate a little healthy competition!)

Thanks,
Maureen

From: White, Bernard
Sent: Friday, February 05, 2016 12:03 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Pictures of Transportation Casks

Maureen,

I talked with NAC regarding this effort and they didn't have any new pictures of a transportation package to provide. If you would like an older one to put into the brochure, just let me know.

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: Sampson, Michele
Sent: Wednesday, January 20, 2016 11:07 AM
To: White, Bernard; Saverot, Pierre
Cc: Conley, Maureen
Subject: Pictures of Transportation Casks

Bernie and Pierre,
Maureen is working on an update to NUREG/BR-0292. Because there is not any current large-scale commercial spent fuel shipping in the US, there are not a lot of transport package pictures. Would you reach out to your vendors, NAC, Holtec and AREVA-TN to see if they have any pictures of their current transportation package designs that they would voluntarily provide for us to consider using in the brochure update. If they could identify which package it is and where the picture was taken (i.e., photograph of NAC-LWT taken at public meeting in Virginia; or empty HI-STAR storage and transportation package being transported to a utility for storage). I don't think we need super-precise details, but we need to be able to identify what the picture is and roughly how it is being used in the picture.

Please send Maureen whatever you get or let her know if the vendor doesn't have anything. You should also let the vendors know that we are asking all three – I don't want anyone to think they have an exclusive deal.

Thanks,
Michele Sampson
Division of Spent Fuel Management
301-415-7493

From:	White, Bernard
To:	Conley, Maureen
Subject:	RE: Query: do you know what the package is in the bottom of this page?
Date:	Monday, August 08, 2016 1:37:30 PM
Attachments:	image001.png image002.png

I love reading Agatha Christie. One of the few authors I have ever reread. If you haven't seen the TV shows with David Suchet, they are fantastic. He makes a great Poriot

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: Conley, Maureen
Sent: Monday, August 08, 2016 1:36 PM
To: White, Bernard <Bernard.White@nrc.gov>
Subject: RE: Query: do you know what the package is in the bottom of this page?

Details details (I'd actually forgotten that, it's been a l o n g time since I've read any Agatha Christie…)

From: White, Bernard
Sent: Monday, August 08, 2016 1:35 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Query: do you know what the package is in the bottom of this page?

Except for Hercule is Belgian….

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: Conley, Maureen
Sent: Monday, August 08, 2016 1:34 PM
To: White, Bernard <Bernard.White@nrc.gov>
Subject: RE: Query: do you know what the package is in the bottom of this page?

Awesome sleuthing!

We may have to rename him Pierre Poirot.

From: White, Bernard
Sent: Monday, August 08, 2016 1:31 PM

To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: FW: Query: do you know what the package is in the bottom of this page?

Maureen,

Pierre Saverot gets the credit. He has your answer below. It isn't a package we have ever approved in the US, or at least not in the past 25 years.

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: Saverot, Pierre
Sent: Monday, August 08, 2016 12:55 PM
To: White, Bernard <Bernard.White@nrc.gov>
Subject: RE: Query: do you know what the package is in the bottom of this page?

Dear Dr. Watson,

The clue is in the figure!

Tons is written as Tonnes.

This is an English cask (flask), the Excellox....are used for importing irradiated fuel from Japan via Barrow-in-Furness docks; UK

This particular flask was photographed near Sellafield power station in Cumbria, England, after its arrival with a consignment of irradiated nuclear fuel from Japan.

Always at your service! [redacted] An Excellox....wow...

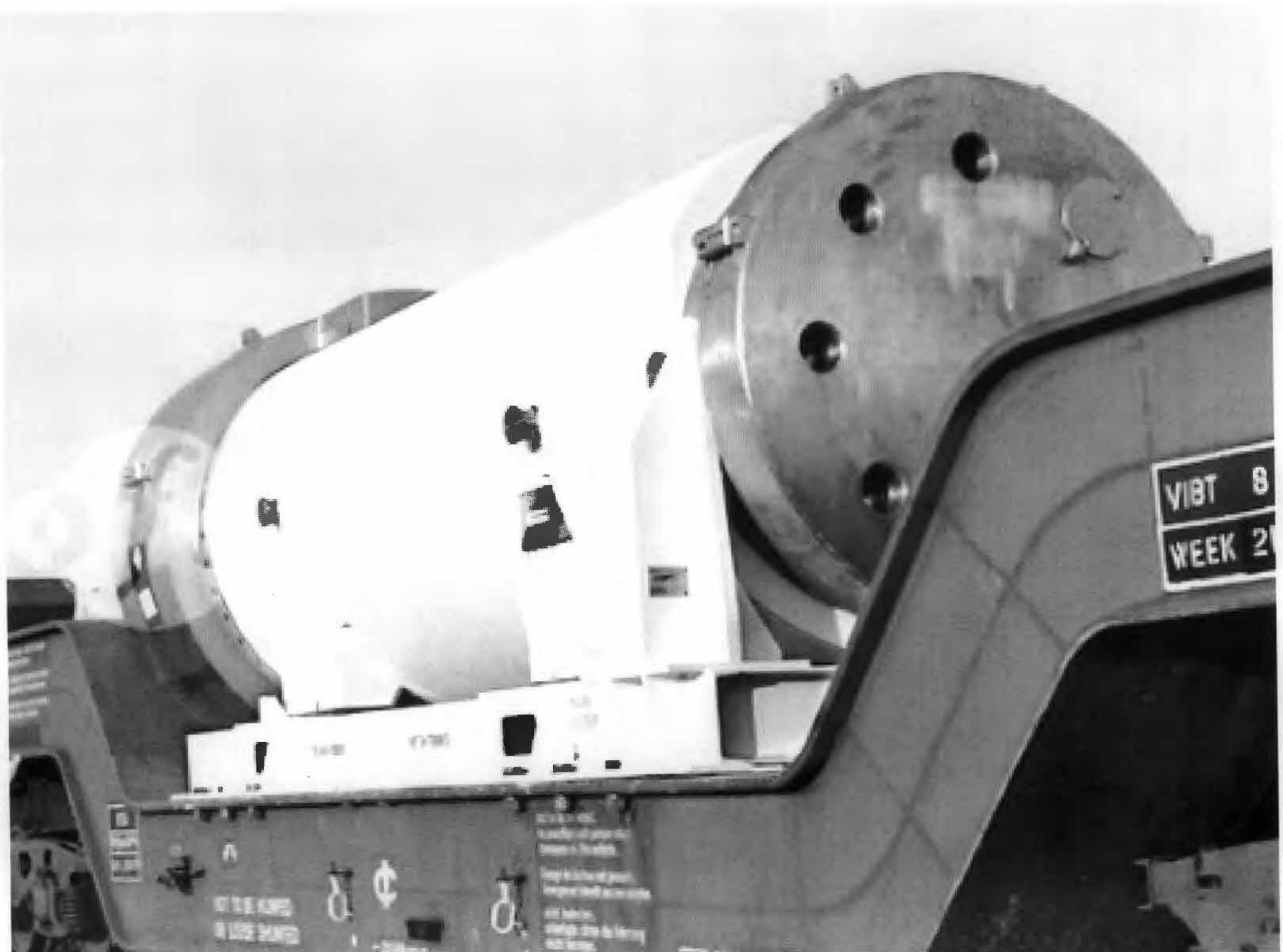
Pierre

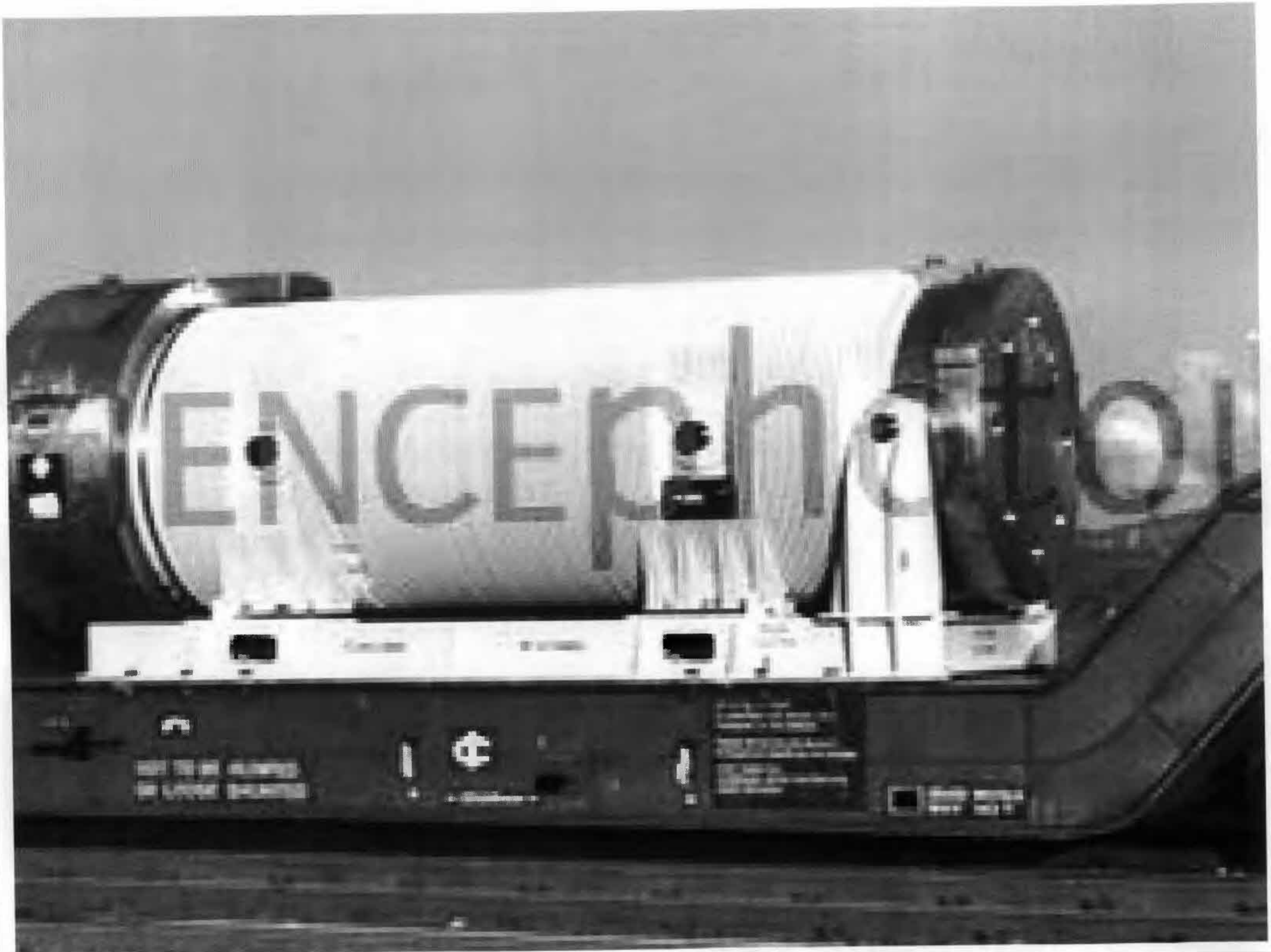
From: White, Bernard
Sent: Friday, August 05, 2016 2:59 PM
To: Saverot, Pierre <Pierre.Saverot@nrc.gov>
Subject: Query: do you know what the package is in the bottom of this page?

I don't recognize it and cannot read what is written on it. My initial thought is that it might be an AREVA package since it has 2.2 tonnes written on it.

Any thoughts?

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577


VIBT 8
WEEK 2



From:	Lombard, Mark
To:	Conley, Maureen
Cc:	Hsia, Anthony
Subject:	RE: Re: FW: Question from the media
Date:	Thursday, September 08, 2016 9:59:02 PM

Good reply Ms. Conley

-------- Original Message --------
From: "Conley, Maureen" <Maureen.Conley@nrc.gov>
Date: Thu, September 08, 2016 2:47 PM -0500
To: Daria Sokolova <dsokolova@pvtimes.com>
Subject: RE: Re: FW: Question from the media

Thanks Daria. We appreciate the opportunity to respond to your questions and the correction to the story. I don't think we can address Bob Halstead's comments because I can't tell what exactly he is referring to. He says we misrepresent our material but is not specific about what he thinks is wrong.

On the first two questions – As you alluded to in your story, the old brochure was published in 2003. Since that time the NRC has done quite a bit of work that further refines our understanding of how spent fuel casks would perform in real-world accidents, including in severe fires. As the brochure notes, the most recent risk assessment was completed in 2014. We will continue this work and update our publications as appropriate to reflect the most recent information.

The purpose of the brochure is to provide information to the members of the public who may have questions about spent fuel transportation safety. I'm not sure how an NRC brochure could impact Yucca Mountain.

I hope this helps. Please let me know if you need anything further.

Regards,

Maureen Conley
NRC Office of Public Affairs
301-415-8200

From: Daria Sokolova [mailto:dsokolova@pvtimes.com]
Sent: Thursday, September 08, 2016 3:21 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: [External_Sender] Re: FW: Question from the media

Hi Maureen,

I apologize for the situation. We will take the last line out of the article. Here are my questions for you:

1. Why did you decide to update this brochure?

2. Will this update affect the situation with Yucca Mountain, and if so, how?

3. Do you think the state of Nevada's concerns in this case are justified?

On Thu, Sep 8, 2016 at 12:10 PM, Conley, Maureen <Maureen.Conley@nrc.gov> wrote:

From: Conley, Maureen
Sent: Tuesday, September 06, 2016 9:41 AM
To: Rubenstone, James <James.Rubenstone@nrc.gov>; Daria Sokolova <dsokolova@pvtimes.com>
Cc: Pineda, Christine <Christine.Pineda@nrc.gov>
Subject: RE: Question from the media

Hi, Daria. I think you may be referring to the brochure we recently updated. If you let me know what you need, I can try answer any questions you have, or find people here who can.

Regards,

Maureen Conley
NRC Office of Public Affairs
301-415-8200

From: Rubenstone, James
Sent: Tuesday, September 06, 2016 9:25 AM
To: Daria Sokolova <dsokolova@pvtimes.com>
Cc: Pineda, Christine <Christine.Pineda@nrc.gov>
Subject: RE: Question from the media

Hi Daria,

Thanks for the inquiry. There are others at NRC who are better informed than me to answer questions about spent fuel transportation safety. I'm passing your email over to our Office of Public Affairs, who should be able to help you out.

Jim

From: Daria Sokolova [mailto:dsokolova@pvtimes.com]
Sent: Monday, September 05, 2016 3:49 PM
To: Rubenstone, James <James.Rubenstone@nrc.gov>
Cc: Pineda, Christine <Christine.Pineda@nrc.gov>
Subject: [External_Sender] Question from the media

Hi James,

This is Daria from the Pahrump Valley Times. I recently saw your updated document on the safety of spent fuel transportation and was wondering if I could ask you a couple of questions.

Thanks

--

Daria Sokolova
Pahrump Valley Times reporter

1570 E. Hwy. 372 Pahrump, NV 89048
office: 775-727-5102, ext. 39 cell: (b)(6)
on Twitter: DariaSokolova77

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Pahrump Valley Times reporter

1570 E. Hwy. 372 Pahrump, NV 89048
office: 775-727-5102, ext. 39 cell: (b)(6)
on Twitter: DariaSokolova77

From: Conley, Maureen
To: Pstrak, David
Cc: Silva, Patricia; Hsia, Anthony
Subject: RE: Revised NUREG/BR-0292
Date: Wednesday, August 31, 2016 3:31:00 PM

Hi, David. Thanks, and thank you for your help in getting this brochure updated.

We looked at the DOE comments and considered each one. We will keep a couple of the suggested changes in mind for the next revision. [redacted] Don't know if you need/want to feed any of this back but my explanation is below in red for each one.

Maureen

From: Pstrak, David
Sent: Wednesday, August 31, 2016 1:50 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Cc: Silva, Patricia <Patricia.Silva@nrc.gov>; Hsia, Anthony <Anthony.Hsia@nrc.gov>
Subject: Revised NUREG/BR-0292

Maureen – congratulations for getting this brochure completed and across the goal line.

I took the opportunity to open the link to NUREG/BR-0292 Rev 1 in the NRC email that was provided late yesterday. I also forwarded the .pdf to several stakeholders whom I routinely interact – at the US DOE, US DOT, State Regional Groups, and the Tribal Caucus.

While I did not request such input, I received the following comments from a DOE staff member. If there is the possibility of considering some of these changes to the new revision of this brochure, I am happy to help revamp some of the language, based on these comments.

In a related comment, this DOE staff member also asked me if they could include a link to NUREG/BR-0292 in their similar DOE publication on spent fuel transport, which is under development. If you agree, I will reply that they can provide a link to our NUREG, but only after we consider the comments (see below) that they have provided.

Thank you –

David
415-7053

Comments from DOE staff:
I do have just a few areas of suggestion for improvement of their site, especially since we may want to feature it:

Page 2: [redacted]

We do have those images in several other public products that discuss spent fuel storage.

There is no room on the page for anything to be added.

Page 3, (b)(5)

(b)(5)

This is a standard NRC graphic that has been used in many other publications for some time. We will consider this suggestion in our next revision.

Page 3: (b)(5)

(b)(5)

This is not a LLRW truck. As the caption states, it carries the NAC LWT (spent fuel) transport package. The photo on p. 1 shows the package inside the vehicle.

Page 3: (b)(5)

(b)(5)

This language appears on p. 8 in a section clearly headed "The Accident-Free Scenario." The section above ("The Accident Scenario") addresses accidents and provides a context for the term "most."

(b)(5)

We have a number of other products that go into detailed explanations about what is meant by background radiation. There is very little room on this page to add these additional words or provide a comparison, however we will consider this suggestion in our next revision.

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected States to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Cover Photos:
(Left) Transportable spent fuel storage casks on storage pad. *(Courtesy: Holtec International)*
(Middle) Spent fuel transport cask arriving at Rancho Seco. *(Courtesy: Areva)*
(Right) Spent fuel transport cask on truck.
(Bottom) Spent fuel transport cask on train.

Page 1 Photos:
(Left) Spent fuel transport package inside conveyance vehicle. *(Courtesy: NAC International)*
(Right) Transportable spent fuel storage systems readied for storage. *(Courtesy: NAC Areva)*
(Bottom) NRC Headquarters in Rockville MD.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

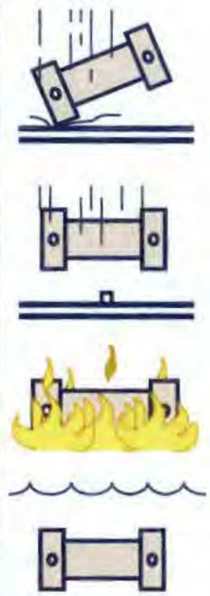
These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance through a public rulemaking process. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

3. fire, and

4. water immersion.

and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

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Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance through a public rulemaking process. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents. But none of the shipments resulted in a release of radioactive material or a fatality due to radiation exposure.

NAC LWT spent fuel transport package being moved by crane. (Courtesy: NAC International)

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. These studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

1. *http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf*
2. *http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/*
3. *http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf*
4. *http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf*

The risk assessment found:

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask

Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

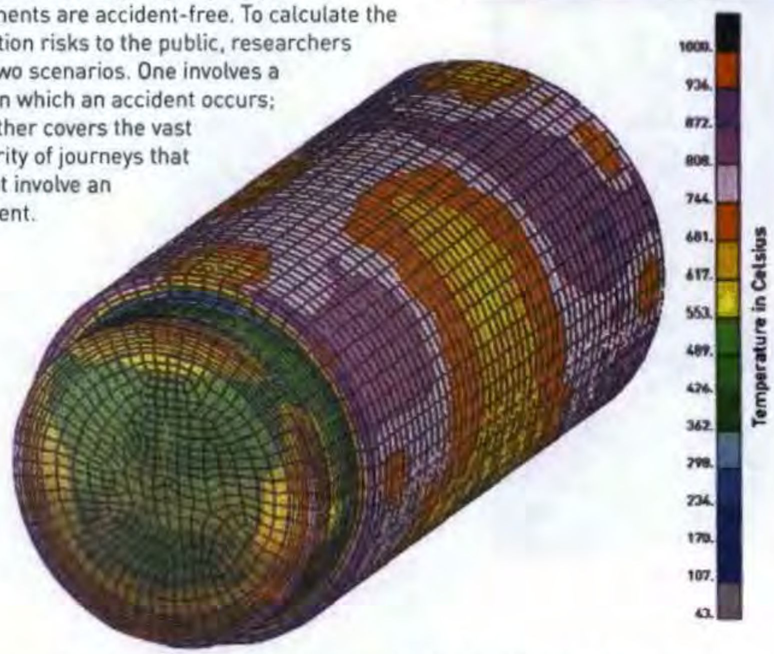
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions and
  - Doing inspections to ensure casks are built, maintained and used properly.
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors, and
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

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U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

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The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Cover Photos:

(Left) Transportable spent fuel storage casks on storage pad. *(Courtesy: Holtec International)*

(Middle) Spent fuel transport cask arriving at Rancho Seco. *(Courtesy: Areva)*

(Right) Schematic of spent fuel transport cask on transport vehicle. *(Courtesy: Holtec International)*

(Bottom) Spent fuel transport cask on train.

Page 1 Photos:

(Left) Spent fuel transport package inside conveyance vehicle. *(Courtesy: NAC International)*

(Right) Transportable spent fuel storage systems readied for storage. *(Courtesy: NAC Areva)*

(Bottom) Empty transportable spent fuel storage system at Prairie Island. *(Courtesy: Areva)*

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials will helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
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What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

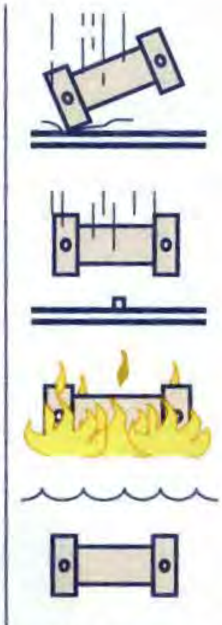
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

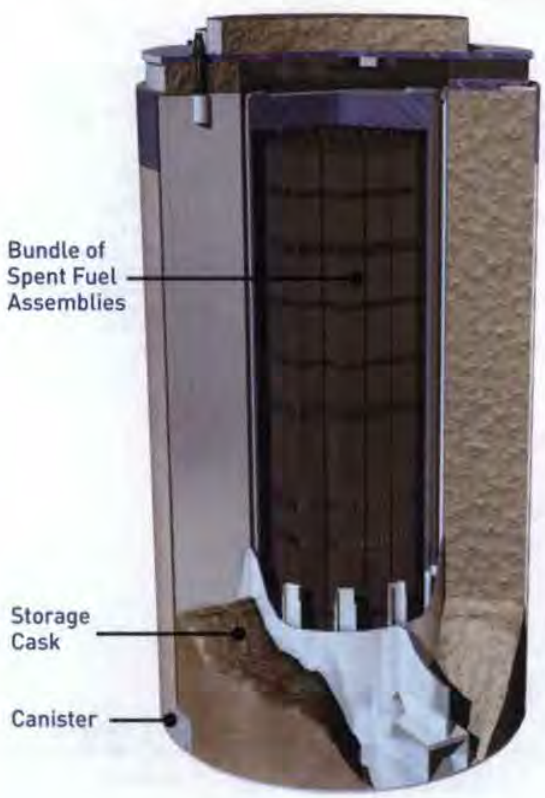
3. fire, and

4. water immersion.

Truck carrying NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance through a public rulemaking process. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

1. *http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf*
2. *http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/*
3. *http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf*
4. *http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf*

The risk assessment found:

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask

Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

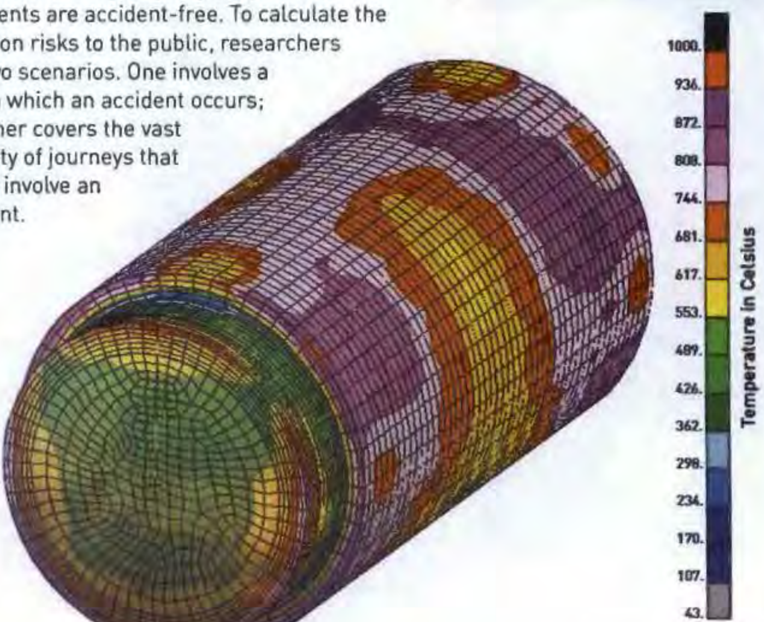
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1 billion.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

@NRCgov

From:	Raaum, Darrin
To:	Conley, Maureen
Subject:	RE: Safety and Spent Fuel Transport r5
Date:	Friday, July 22, 2016 10:06:46 AM

Monday at 8:30 am is fine.
How many copies do they want?
We may have to have the Print shop print them.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Friday, July 22, 2016 10:05 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport r5

Hey, Darrin. How about if I bring everything to you Monday at 8:30? NMSS has asked if we can provide a couple printed copies (they don't have to be the formal NUREG version) for a meeting they're having Tuesday afternoon. If we can't swing that we can give them the old brochure.

I'll send a scheduler...

Thanks,
Maureen

From: Raaum, Darrin
Sent: Friday, July 22, 2016 6:48 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: Safety and Spent Fuel Transport r5

Maureen,

I am in on Friday, however I am only working a half day and Stephanie West is coming down at 8:30 am to work on the Info Digest.
I am available all day on Monday. I get in at 6 am.

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC

4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Thursday, July 21, 2016 4:26 PM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: Safety and Spent Fuel Transport r5

Hey, Darrin. Are you still here, or in Friday? I have the final (famous last words) tweaks to the transportation brochure. Let me know if there's a good time and I'll swing by.

Thanks,
Maureen

From: Couret, Ivonne
To: Conley, Maureen
Subject: RE: Safety of Spent Fuel Transportation brochure
Date: Friday, May 27, 2016 1:27:08 PM

I will discuss with Graphics and see who it will be assigned to this job and what then we can set up meeting when you return. Ivonne

From: Conley, Maureen
Sent: Friday, May 27, 2016 10:46 AM
To: Couret, Ivonne <Ivonne.Couret@nrc.gov>
Subject: Safety of Spent Fuel Transportation brochure

Ivonne,

I created a folder on the g: drive that has files with the revised text (marked up with changes per QTE), photo captions, and 12 images that I think will work.

G:\Maureen\Safety of Spent Fuel Transportation brochure

Do you want to communicate with the graphics folks about this, or should I?

Thanks,

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Castelveter, David
To:	Conley, Maureen; Harrington, Holly
Subject:	RE: TNT
Date:	Thursday, September 08, 2016 5:46:40 PM

Thanks Maureen. Good job in getting the correction. Kudos.

David A. Castelveter
Office Director
U.S. Nuclear Regulatory Commission
Office of Public Affairs (Mail Stop O-16D3)
11555 Rockville Pike, MD 20852

301-415-8200 (O)
(b)(6) (C)
david.castelveter@nrc.gov
www.nrc.gov

From: Conley, Maureen
Sent: Thursday, September 08, 2016 3:53 PM
To: Harrington, Holly <Holly.Harrington@nrc.gov>; Castelveter, David <David.Castelveter@nrc.gov>
Subject: TNT

FUKUSHIMA FOLLOW-UP – Platts had questions about the status of supplemental seismic analyses of spent fuel pools. JLD helped us provide the number of plants affected, due dates and status of submittals, and directed the reporter to the October 2015 NRC letter to licensees asking for the information.

SPENT FUEL TRANSPORTATION SAFETY – We spoke to the Pahrump Valley (Nev.) Times reporter who wrote the story appearing today on our recently updated brochure that said NRC didn't return requests for comment. She said she overlooked emails from two NRC officials responding to her inquiries and will correct the story. We also responded to her questions on why we updated the brochure (it was outdated) and whether it would impact Yucca Mountain (huh?)

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From: Conley, Maureen
To: Lombard, Mark
Subject: RE: discuss plan to engage/respond to RegCon questions
Date: Monday, November 30, 2015 11:44:00 AM

[redacted] (b)(6)

On a separate note – we just got back from graphics a layout of the revised spent fuel transportation safety brochure. It would be good if we could sit down and go over it – especially to get your feedback on images. We have our regular monthly meeting on the calendar for Dec. 16 (at the same time as the Chairman's open house). Let me know if you want to push it up to next week and I can try to find a time that will work for everyone.

Maureen

From: Lombard, Mark
Sent: Monday, November 30, 2015 10:35 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: discuss plan to engage/respond to RegCon questions

[redacted] (b)(6)

-----Original Appointment-----
From: Conley, Maureen
Sent: Friday, November 27, 2015 11:47 AM
To: Lombard, Mark
Subject: Tentative: discuss plan to engage/respond to RegCon questions
When: Tuesday, December 01, 2015 4:00 PM-5:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: T4E14

Have to be tentative – [redacted] (b)(6) – not sure what time but hopefully we'll be back by then.

From:	White, Bernard
To:	Conley, Maureen
Subject:	RE: following up on images
Date:	Monday, March 07, 2016 3:52:55 PM

I will do the same

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: Conley, Maureen
Sent: Monday, March 07, 2016 3:53 PM
To: White, Bernard <Bernard.White@nrc.gov>
Subject: RE: following up on images

I thought I remembered some LWT pictures but couldn't put my hands on them. Let me scour my email and see if I can locate them…

From: White, Bernard
Sent: Monday, March 07, 2016 3:51 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: following up on images

Didn't they sent us some of the NAC-LWT when we did the blog article, do you have them?

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: Conley, Maureen
Sent: Monday, March 07, 2016 3:42 PM
To: White, Bernard <Bernard.White@nrc.gov>
Subject: RE: following up on images

I think the only images OPA has are the pics I took on our field trip. They've got some photos and diagrams on their website, if they could send those that'd be great. Make sure they know we have a dozen or more from TN (!)

From: White, Bernard
Sent: Monday, March 07, 2016 3:28 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: following up on images

I talked with NAC and they stated they didn't have any new pictures to add. I can try again if you like..

Bernie White
Senior Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
(301) 415-6577

From: Conley, Maureen
Sent: Monday, March 07, 2016 2:06 PM
To: White, Bernard <Bernard.White@nrc.gov>; Saverot, Pierre <Pierre.Saverot@nrc.gov>
Subject: following up on images

Hi, guys. Just wanted to touch base and see if you've had any luck getting NAC and Holtec to provide photos of their fabulous transportation cask systems for the brochure on the safety of spent fuel transport that we're updating.

If you haven't received any yet, perhaps the RIC will be the perfect opportunity to tighten the thumb screws? Or maybe a carrot would be better, you can send them to the OPA table where they can spin the wheel for a chance to win a candy bar!

Maureen Conley
NRC Office of Public Affairs
301-415-8202

(b)(5)

From: Raaum, Darrin
To: Conley, Maureen
Subject: RE: language for brochure
Date: Monday, July 25, 2016 8:53:26 AM
Attachments: Spent Fuel Transport bro 6-2016 r6.pdf

Maureen,

Attached is the latest!

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
Sent: Monday, July 25, 2016 8:42 AM
To: Raaum, Darrin <Darrin.Raaum@nrc.gov>
Subject: language for brochure

On my way down. I'll explain this when I get there:

NRC studies show that the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a radioactive release in 99.99973% of those 5 accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

Maureen Conley
NRC Office of Public Affairs
301-415-8202

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste, and licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected States to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Cover Photos:

(Left) Transportable spent fuel storage casks sit on a storage pad. (Courtesy: Holtec International)

(Middle) Spent fuel transport cask arrives at Rancho Seco. (Courtesy: Areva)

(Right) Schematic of spent fuel transport cask. (Courtesy: Holtec International)

(Bottom) Spent fuel transport cask arrives on site.

Page 1 Photos:

(Left) Empty transportable spent fuel storage system arrives at Prairie Island. (Courtesy: Areva)

(Right) Transportable spent fuel storage system is readied for storage. (Courtesy: Areva)

(Bottom) Transport package is placed inside conveyance vehicle. (Courtesy: NAC International)

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely around the world.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments. However, the NRC does not control the timing or destination of spent fuel shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates that information against its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

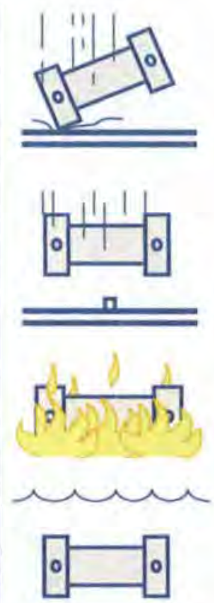
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

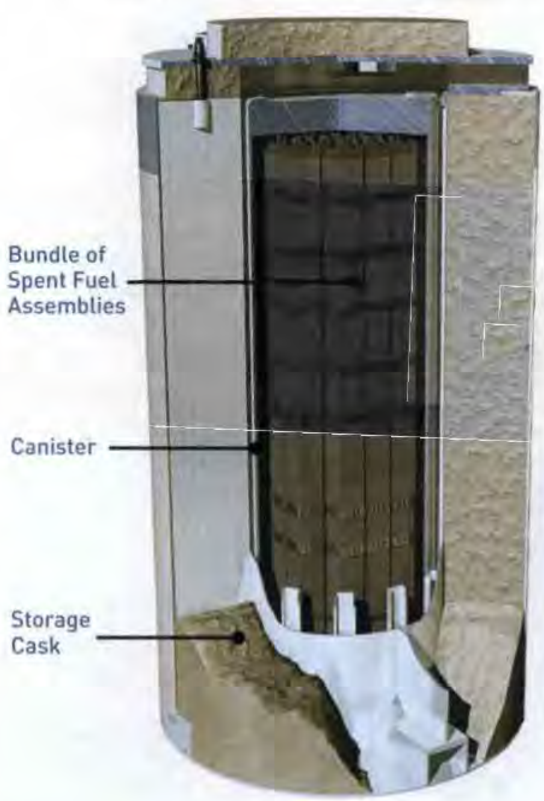
3. fire, and

4. water immersion.

Truck carries NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations when needed. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance. This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

NAC LWT spent fuel transport package is moved by crane. (Courtesy: NAC International)

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

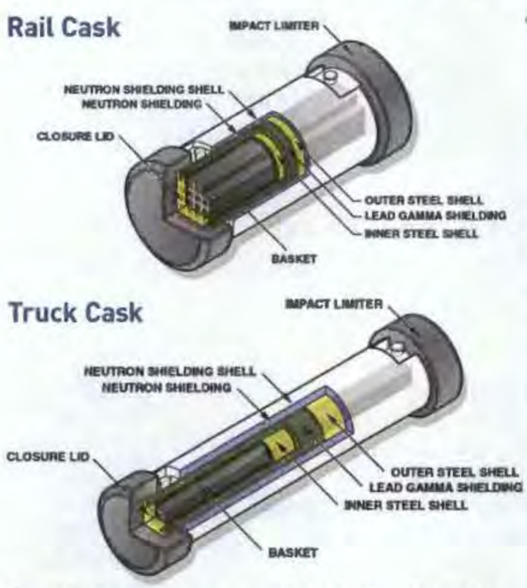
1. http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf
2. http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/
3. http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf
4. http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf

The risk assessment found:

Transportable spent fuel storage cask moves to storage pad.
(Courtesy: Holtec International)

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.



Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

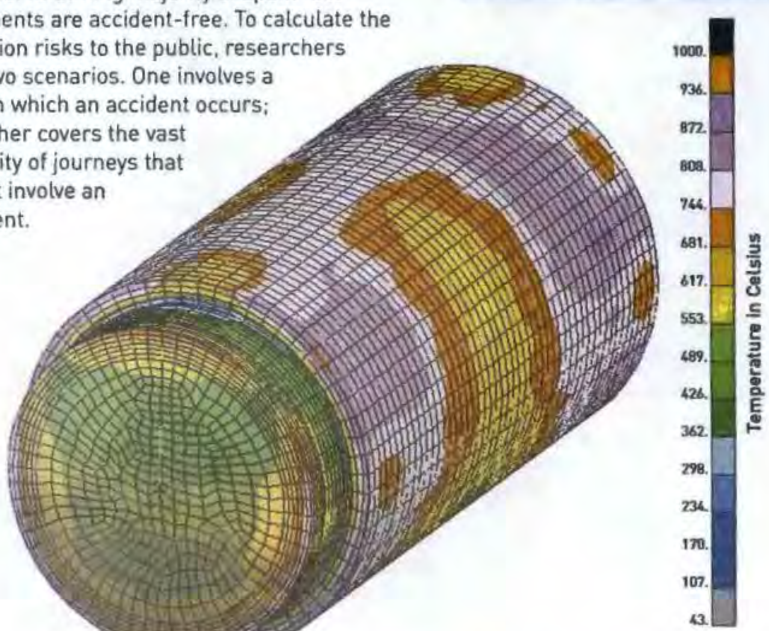
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a radioactive release in 99.99973% of those 5 accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand potential safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

@NRCgov

From: Hsia, Anthony
To: Lombard, Mark; Conley, Maureen; Marcano, Damaris; Sampson, Michele
Subject: RE: spent fuel communication products
Date: Tuesday, December 01, 2015 9:13:07 PM

I will be at CNWRA for the annual program review meeting and not be able to join you on 12/9.

Tony

From: Lombard, Mark
Sent: Tuesday, December 01, 2015 6:09 PM
To: Conley, Maureen; Hsia, Anthony; Marcano, Damaris; Sampson, Michele
Subject: RE: spent fuel communication products

Sounds good. My only potential conflict is if Scott wants me to attend another meeting for him. Will know more next week.

-----Original Appointment-----

From: Conley, Maureen

Sent: Tuesday, December 01, 2015 4:29 PM

To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris; Sampson, Michele

Subject: spent fuel communication products

When: Wednesday, December 09, 2015 3:00 PM-4:00 PM (UTC-05:00) Eastern Time (US & Canada).

Where: Mark's office

Hi, all. Mark and I talked about getting together to discuss the spent fuel transportation safety brochure next week, maybe we can combine that with a discussion about responses to RegCon questions?

Also, as we discussed, I'm sending this as a recurring meeting – we'll see how that works going forward. Thanks!

From:	Conley, Maureen
To:	Sampson, Michele
Subject:	RE: two questions for you`
Date:	Wednesday, January 20, 2016 11:06:00 AM

Welcome neighbor! What will you be doing for OEDO?

Thank you for this info. I tried to figure this all out on DOE's website but their public information is conflicting or at least vague….

And thanks for whatever images you can get before you move over here.

Maureen

From: Sampson, Michele
Sent: Wednesday, January 20, 2016 10:52 AM
To: Conley, Maureen <Maureen.Conley@nrc.gov>
Subject: RE: two questions for you`

Good thing you followed up as I seem to have completely dropped the ball on asking the vendors for pics. I'll do that today.

You remember correctly, the TMI-2 ISFSI is in operation. The other Idaho ISFSI (formerly known as Foster-Wheeler) has never been put into operation. Just for fun, I've attached a letter from DOE which has a definitive statement to that effect from DOE to get them out of the annual fee.

As for the fuel …. My understanding is that the Foster Wheeler site was intended to store fuel from the shutdown Peach Bottom and Shippingport reactors, along with some other TRIGA fuel. At least some of the fuel is already at DOE ID. I believe that all of the Shippingport fuel and Peach Bottom 1 fuel was already shipped there (it isn't still at either reactor site). I've never really looked into it, but my understanding is that DOE was working out a waste management plan with the state of ID and the Foster Wheeler ISFSI was some part of that agreement. However, DOE failed to meet some waste processing goals/requirements, and the state took them to court and somehow the ISFSI is in some permanent limbo. The ISFSI was not central to the state's issues, I think it is just a secondary casualty of the lawsuit/agreement.

FYI – I'll soon be your neighbor again. I'm moving over to OEDO Feb. 1st.

Thanks,
Michele Sampson
Division of Spent Fuel Management
301-415-7493

From: Conley, Maureen
Sent: Wednesday, January 20, 2016 10:13 AM
To: Sampson, Michele <Michele.Sampson@nrc.gov>

Subject: two questions for you`

Hi, Michele. Am I remembering correctly that DOE only built one of the two NRC-licensed Isfsis in Idaho? TMI-2 is operating, but not the Idaho spent fuel facility? (and if that's correct, where are they storing research reactor fuel?)

Also – I'm wondering whether you had any luck getting images out of the cask vendors for that brochure. No rush, just following up.

Thanks,

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Saverot, Pierre
To:	Conley, Maureen
Subject:	Re: following up on images
Date:	Monday, March 07, 2016 4:35:56 PM

Joy is no longer in charge of this...

You will not see me in any way since I am thousands of miles away from you, working remotely (ah!) to check on what is important: your emails.

(b)(5)

Kudos to TN and their follow-up shall be recognized...

From: Conley, Maureen
Sent: Monday, March 7, 2016 4:25 PM
To: Saverot, Pierre; White, Bernard
Subject: RE: following up on images

True true – If I see Joy Russell or Pierre at the RIC I'll mention it to her - (b)(5)

(b)(5)

Maureen

From: Saverot, Pierre
Sent: Monday, March 07, 2016 4:22 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>; White, Bernard <Bernard.White@nrc.gov>
Subject: Re: following up on images

I was successful the very first day in having TN sending you several high quality pictures of their casks....To the contrary, Holtec has only forwarded my request to their "information dept" and have not heard anything from them since.

My position is that you shall recognize in that NUREG those who readily respond, i.e., show TN casks !

And between you and me, this Nureg is for public consumption, right? A cask looks like any other cask for the uninitiated.....

Pierre

From: Conley, Maureen
Sent: Monday, March 7, 2016 2:05 PM
To: White, Bernard; Saverot, Pierre
Subject: following up on images

Hi, guys. Just wanted to touch base and see if you've had any luck getting NAC and Holtec to provide photos of their fabulous transportation cask systems for the brochure on the safety of spent fuel transport that we're updating.

If you haven't received any yet, perhaps the RIC will be the perfect opportunity to tighten the thumb screws? Or maybe a carrot would be better, you can send them to the OPA table where they can spin the wheel for a chance to win a candy bar!

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Lombard, Mark
To:	Conley, Maureen; Hsia, Anthony; Marcano, Damaris
Cc:	Pham, Bo
Subject:	Re: spent fuel communication products
Date:	Saturday, February 27, 2016 5:15:46 AM

The latter please.
------Original Message------
From: Maureen Conley
To: Mark Lombard
To: Anthony Hsia
To: Damaris Marcano
Cc: Bo Pham
Subject: spent fuel communication products
Sent: Feb 26, 2016 4:53 PM

Hi, folks. In looking ahead to our next scheduled meeting March 16 – I will be out on travel that whole week. The week prior is the RIC, which leaves either the week of Feb. 29 or the week of March 21 for the next time we can all get together. Do you have a preference? I'm leaning toward that latter. With any luck I will have a closer-to-final transport safety brochure and a couple more blog posts ready to go by then…

Let me know what you prefer and I'll update the scheduler. Thanks,

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	GRAPHICS Resource
To:	Conley, Maureen
Subject:	Safety and Spent Fuel Transport Word file
Date:	Wednesday, June 01, 2016 8:16:02 AM

Maureen,

I am working on updating the Safety and Spent Fuel Transportation brochure.
I noted that the Word file has many highlighted comments.
Could you send me the updated Word file with no comments so I do not introduce any errors.

Thank you,

Darrin Raaum | Graphic Designer Contractor for USNRC
T 301.415.1492
OP1-35 02

Project 216/RGM LLC
4350 East-West Highway, Suite 101
Bethesda, MD 20814

From: Conley, Maureen
To: Couret, Ivonne
Subject: Safety of Spent Fuel Transportation brochure
Date: Friday, May 27, 2016 10:45:00 AM

Ivonne,

I created a folder on the g: drive that has files with the revised text (marked up with changes per QTE), photo captions, and 12 images that I think will work.

G:\Maureen\Safety of Spent Fuel Transportation brochure

Do you want to communicate with the graphics folks about this, or should I?

Thanks,

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Harrington, Holly
To:	Harrington, Holly
Subject:	Tomorrow"s News Tonight
Date:	Thursday, September 08, 2016 5:02:59 PM

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~~may contain material proprietary to news agencies~~

POWER RESOURCES -- In continuing coverage, OPA Region IV spoke to a reporter from The Cortez (Colorado) Journal newspaper and from Nuclear Intelligence Weekly about the Confirmatory Action Letter issued last week, documenting actions the company has agreed to take following two incidents in which radioactive sludge leaked from containers used to transport it to a processing site in Utah.

FUKUSHIMA FOLLOW-UP – Platts had questions about the status of supplemental seismic analyses of spent fuel pools. JLD helped us provide the number of plants affected, due dates and status of submittals, and directed the reporter to the October 2015 NRC letter to licensees asking for the information.

SPENT FUEL TRANSPORTATION SAFETY – OPA HQ spoke to the Pahrump Valley (Nev.) Times reporter who wrote a story appearing today on our recently updated brochure that said NRC didn't return requests for comment. She said she overlooked emails from two NRC officials responding to her inquiries and will correct the story. We also responded to her questions on why we updated the brochure (it was outdated) and whether it would impact Yucca Mountain.

TMI – Exelon is hosting a community night at the plant tonight. About 400 people have indicated they'll be attending, as will the NRC Resident Inspectors. Media is also expected to attend.

EXELON – The company issued a press release on the performance of its nuclear fleet over the summer. It can be found here: http://www.exeloncorp.com/newsroom/exelon-nuclear-stations-deliver-when-summer-heats-up

INDIAN POINT – Entergy issued a press release about a security exercise at the plant tomorrow. Participants will be using MILES gear, which can be heard off-site. It can be found here: http://www.safesecurevital.com/indian-point-to-conduct-security-training-exercises-friday-drills-to-include-simulated-weaponry-artificial-gunfire/

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~~may contain material proprietary to news agencies~~

From:	Daria Sokolova
To:	Conley, Maureen
Subject:	[External_Sender] Re: Re: FW: Question from the media
Date:	Thursday, September 08, 2016 4:52:32 PM

Hi Maureen,

Thanks for your answers. I will make sure to reach out to you next time I have a question.

On Thu, Sep 8, 2016 at 12:47 PM, Conley, Maureen <Maureen.Conley@nrc.gov> wrote:

> Thanks Daria. We appreciate the opportunity to respond to your questions and the correction to the story. I don't think we can address Bob Halstead's comments because I can't tell what exactly he is referring to. He says we misrepresent our material but is not specific about what he thinks is wrong.
>
> On the first two questions – As you alluded to in your story, the old brochure was published in 2003. Since that time the NRC has done quite a bit of work that further refines our understanding of how spent fuel casks would perform in real-world accidents, including in severe fires. As the brochure notes, the most recent risk assessment was completed in 2014. We will continue this work and update our publications as appropriate to reflect the most recent information.
>
> The purpose of the brochure is to provide information to the members of the public who may have questions about spent fuel transportation safety. I'm not sure how an NRC brochure could impact Yucca Mountain.
>
> I hope this helps. Please let me know if you need anything further.
>
> Regards,
>
> Maureen Conley
>
> NRC Office of Public Affairs
>
> 301-415-8200
>
> **From:** Daria Sokolova [mailto:dsokolova@pvtimes.com]
> **Sent:** Thursday, September 08, 2016 3:21 PM
> **To:** Conley, Maureen <Maureen.Conley@nrc.gov>

Subject: [External_Sender] Re: FW: Question from the media

Hi Maureen,

I apologize for the situation. We will take the last line out of the article. Here are my questions for you:

1. Why did you decide to update this brochure?

2. Will this update affect the situation with Yucca Mountain, and if so, how?

3. Do you think the state of Nevada's concerns in this case are justified?

On Thu, Sep 8, 2016 at 12:10 PM, Conley, Maureen <Maureen.Conley@nrc.gov> wrote:

From: Conley, Maureen
Sent: Tuesday, September 06, 2016 9:41 AM
To: Rubenstone, James <James.Rubenstone@nrc.gov>; Daria Sokolova <dsokolova@pvtimes.com>
Cc: Pineda, Christine <Christine.Pineda@nrc.gov>
Subject: RE: Question from the media

Hi, Daria. I think you may be referring to the brochure we recently updated. If you let me know what you need, I can try answer any questions you have, or find people here who can.

Regards,

Maureen Conley

NRC Office of Public Affairs

301-415-8200

From: Rubenstone, James
Sent: Tuesday, September 06, 2016 9:25 AM
To: Daria Sokolova <dsokolova@pvtimes.com>
Cc: Pineda, Christine <Christine.Pineda@nrc.gov>
Subject: RE: Question from the media

Hi Daria,

Thanks for the inquiry. There are others at NRC who are better informed than me to answer questions about spent fuel transportation safety. I'm passing your email over to our Office of Public Affairs, who should be able to help you out.

Jim

From: Daria Sokolova [mailto:dsokolova@pvtimes.com]
Sent: Monday, September 05, 2016 3:49 PM
To: Rubenstone, James <James.Rubenstone@nrc.gov>
Cc: Pineda, Christine <Christine.Pineda@nrc.gov>
Subject: [External_Sender] Question from the media

Hi James,

This is Daria from the Pahrump Valley Times. I recently saw your updated document on the safety of spent fuel transportation and was wondering if I could ask you a couple of questions.

Thanks

--

Daria Sokolova

Pahrump Valley Times reporter

1570 E. Hwy. 372 Pahrump, NV 89048

office: [775-727-5102, ext. 39](tel:775-727-5102) cell [redacted]

on Twitter: DariaSokolova77

--

Daria Sokolova

Pahrump Valley Times reporter

1570 E. Hwy. 372 Pahrump, NV 89048

office: [775-727-5102, ext. 39](tel:775-727-5102) cell [redacted]

on Twitter: DariaSokolova77

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Daria Sokolova
Pahrump Valley Times reporter

1570 E. Hwy. 372 Pahrump, NV 89048
office: 775-727-5102, ext. 39 cell: (b)(6)
on Twitter: DariaSokolova77

From: Saverot, Pierre
To: Conley, Maureen
Subject: do you know what the package is in the bottom of this page?
Date: Monday, August 08, 2016 8:21:41 AM
Attachments: Cover page from SF brochure.pdf

Maureen,

I sent you a lot of cask pictures at your request a while back from TN/AREVA. Do you know which cask is at the bottom of the page?

Thanks

Pierre

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

From: Conley, Maureen
To: Lombard, Mark; Hsia, Anthony; Pham, Bo
Subject: follow up
Date: Monday, March 21, 2016 5:44:00 PM
Attachments: Dry Cask 101.docx

Hi, guys. Just to follow up on our meeting today –

I updated the list of blog posts (please see attachment). I added consolidated storage, noted the ones we're deferring to 2017 and added a few notes about timing.

If we want to do a dry storage brochure, it would be good to have it available at the first public meeting related to WCS. [redacted] (b)(5) We're scheduled to meet next on April 20. Please let me know your thoughts on this.

I will make the shielding blog and the transportation safety brochure priorities. Shielding would make sense to put in the dry storage brochure and you may want that transportation brochure at the meeting too…

Thanks,
Maureen

Dry Cask 101

3/21/2016

In the queue for posting:

Structural

Needed from DSFM:

Consolidated storage/WCS (plan to post when we receive WCS application)

Research

Awaiting OPA edits:

Isfsi dry runs

Confinement

Inspections

Shielding

Extended storage and transportation (plan to post when paper goes to Commission May 31)

30-foot drop test

Deferred to 2017

Renewals

Renewal inspections

Material degradation

Posted:

Dry Casks 101: Managing Heat
Caylee Johanson

Dry Cask 101: Storage and Transport – The Right Materials for the Job
John Wise

Dry Cask 101 – Criticality Safety
Drew Barto

Spent Fuel Casks 101 -- What We Regulate and Why
Mark Lombard

From: Conley, Maureen
To: Couret, Ivonne
Subject: images for spent fuel transport brochure
Date: Tuesday, December 22, 2015 8:43:00 AM

Hey, Ivonne. FYI, I met with the spent fuel folks last week to talk about the brochure. Unfortunately most of the images in it will need to be replaced (only one on the front cover appears to be an actual transport cask). The problem is most of the certified transport casks have not been built. The good news is, Michele Sampson offered to reach out to the cask vendors to ask for any images they might be able to share.

Check out this DOE link – one of the rolling photos on the landing page shows three trucks in a row, the middle one appears to have a transport cask on it.

http://energy.gov/ne/consent-based-siting

Let's see what DSFM can come up with – we're pretty confident the vendors will want us to use their photos, so we can revisit after the holidays…

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Araguas, Christian
To:	Conley, Maureen
Cc:	Pstrak, David
Subject:	FW: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx
Date:	Thursday, December 04, 2014 5:31:20 PM
Attachments:	Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi Maureen,

I am one of the BCs in NMSS/SFM. I understand that you would like to add language to the attached brochure on the Baltimore tunnel fire and the MacArther Maze fire. How married are you to this concept? We do have two published studies on these accidents but I propose not saying much if anything at all. We are currently working on a compendium of both railway and roadway transportation accidents that compare the results of these accidents with existing requirements of spent nuclear fuel containers (which include both Baltimore and MacArthur Maze). There are several studies and while it would be ideal to just point to this work in the brochure, it is not complete and likely won't be until sometime in 2015. I think we could highlight in a short paragraph the fire studies we are doing but I don't think it should go beyond that. Thoughts?

Christian

From: Pstrak, David
Sent: Thursday, December 04, 2014 1:21 PM
To: Araguas, Christian
Cc: Silva, Patricia
Subject: FW: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Christian – I just was assigned the task to review this draft SNF transportation brochure.

Note the comment/request from Maureen Conley below about adding words about the Baltimore Tunnel Fire and the MacArthur Maze fire (i.e., the fire studies) to this brochure (attached). I think it best for that info to be developed by your staff along with consideration/recommendation as to where/how it best be added. On this flip side, if you believe that this brochure is not a suitable mechanism for sharing the results of the fire studies, I suggest that you weigh in as such.

In a separate email, Lombard requested this review be completed by 12/10/14.

Let me know if you have any questions on my suggestion or the action.

David
287-9121

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 6:31 PM
To: Pstrak, David; Rubenstone, James
Cc: Conley, Maureen; Silva, Patricia
Subject: Fw: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Can you gentlemen please also take a look at the attached and provide comments maybe by the end of this week?

Thanks,

Mark

From: Conley, Maureen
Sent: Friday, November 28, 2014 04:41 PM
To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
Subject: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi, all. Here is my first rough cut at the revision, mainly edited to simplify language and address Yucca Mountain uncertainties. I added in language on the latest transportation risk assessment but think it would be useful to also add something about the Howard st. tunnel fire and the MacArthur Maze fire and any other accidents you guys have studied that I might not be aware of (these probably could be added in call-out boxes in the margins unless we think a lot of text is required to explain them/give context/etc.)

When you have a chance, please let me know your thoughts.

Thanks!
Maureen

Original grade level 12.2

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency established by ~~the U.S.~~ Congress. Its mission is to license and regulate the Nation's civilian use of radioactive materials in a way that protects public health and the environment. ~~in 1974 to ensure adequate protection of~~ public health. safety, and the environment in the use of nuclear materials. The NRC regulates commercial nuclear power reactors; ~~non-power~~ research, test, and training reactors; ~~and~~ nuclear fuel cycle facilities; and . The ~~NRC~~ also ~~regulates~~ medical, academic, and industrial uses of nuclear materials. The NRC also regulates, as ~~well~~ as packaging for the transport, storage, and disposal of nuclear materials and waste. And it. ~~In addition, the NRC regulates the design,~~ manufacture, use, and maintenance of containers for high-level radioactive shipments. licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates, ~~in coordination~~ with the NRC to; sets rules for ~~governing~~ the packaging of nuclear materials. ~~With NRC and the affected states,~~ DOT works with the NRC and affected states to regulates their transport ~~of nuclear materials~~. ~~The~~ DOT also regulates carriers ~~of nuclear materials~~, sets standards for ~~transportation~~ routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for , among other things, oversees the ~~development~~ of disposal ~~systems for~~ of spent ~~nuclear~~ fuel from the nation's nuclear power plants. This activity is entirely funded by fees collected from nuclear power plant companies and ~~ultimately from~~ rate payers.

The International Atomic Energy Agency (IAEA) is aserves as the world's principal ~~intergovernmental~~ forum for scientific and technical cooperation in the nuclear field. ~~An agency~~ Part of the United Nations, the IAEA sets global published regulations for transporting nuclear materials transport. These regulations serve as a model for the United States and other nations.

The NRC has three ~~principal~~ main functions:
1. to set standards and develop regulations;
2. to issue licenses for nuclear facilities and nuclear materials users; and
3. to inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The ~~U S. Nuclear Regulatory Commission (~~NRC~~)~~ regulates the nuclear ~~materials~~ fuel cycle from beginning to end. ~~This cycle~~It begins with the mining of uranium. ~~It~~ The cycle continues through the manufacture of fuel, its use in reactors, ~~any temporary~~ storage and ~~(ultimately) with~~ permanent geologic disposal.

The NRC works ~~is dedicated~~ to maintaining public health and safety, protecting the environment. and ensureing our national security. ~~in ways that increase public confidence in the agency~~ To maintain the public's confidence, t~~T~~he NRC aims ~~plans~~ to do its work openly and to ~~achieve these goals by making its activities more~~ be effective, efficient, and realistic. ~~and by~~ to It also strives to keep the ~~reducing unnecessary~~ regulatory burden reasonable on all those involved in the use, handling, transport, and disposal of nuclear materials.

The NRC believes that pProper handling of nuclear materials will help to ensure the safety of the public and plant workers. That is why ~~oward that end~~, the NRC works with other agencies in the U.S. and internationally to ensure these materials are handled and transported safely. ~~such as the U.S. Department of Transportation (DOT), the U.S. Department of Energy (DOE), and the International Atomic Energy Agency (IAEA)~~

This booklet ~~relates~~ explains~~to~~ the NRC's role in ensuring ~~the safe transportation of~~ spent nuclear fuel from commercial nuclear power plants is transported ~~. Specifically, the~~safely. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments.

Radiation

Scientists say about estimate that nearly 90 percent of all radiation exposure comes from natural sources: radon gas, the human body, outer space, rocks, and soil. This natural Background radiation is called "background" and naturally present, but its levels can vary greatly. People living in areas with a lot significant amount of granite, for example, receive more earth-based radiation from the earth. Those living or working at high altitudes receive more cosmic radiation. Most natural exposure is from radon, a gas that seeps from the earth's crust into the air we breathe. The remaining 10 percent of all radiation exposure comes from man-made sources, mainly primarily medical x-rays. Natural and artificial radiation are similar in kind and effect.

What Is Spent Fuel?

Nuclear reactors ~~produce~~ make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor ~~powers reactors~~ for a number of years until it needs to be replaced~~, until its potential to produce electrical power is exhausted~~. The used ~~uranium~~ fuel is then ~~referred to~~known as "spent fuel." It must be stored safely ~~Nuclear power plants store spent fuel in enclosed cooling pools and, in some cases, in dry storage casks~~ until it can be shipped ~~to await shipment~~ offsite. ~~to a temporary storage or permanent disposal facility~~.

The Nuclear Waste Policy Act (NWPA) ~~, enacted by Congress in 1992, calls for spent fuel to be moved to a temporary storage facility or to a permanent DOE repository.~~

~~The NWPA~~ sets a ~~national~~ policy for safe, permanent disposal of spent ~~nuclear~~ fuel and other radioactive wastes. Congress in 1987 picked Yucca Mountain in Nevada as the site for ~~in~~ an underground repository. ~~The action by Congress and the President in July 2002 approving Yucca Mountain will permit the~~ DOE ~~to~~ applied~~y~~ to the NRC in 2008 to for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the proposed facility meets NRC regulatory requirements. Other policy considerations are up to DOE and Congress ~~under the NWPA is to use its independent judgment as an expert technical agency to decide whether to grant DOE a license to construct a high-level waste repository at Yucca Mountain. Only after extensive review of a DOE application will the NRC be able to judge whether DOE has satisfied the demands of the regulations. The NWPA gives NRC up to four years to decide whether to grant the license.~~

It will be some time before ~~Because~~ a repository is ~~won't be~~ available. ~~for some time, some~~ All nuclear power plants move their ~~are~~ spent fuel first into pools for storage on site. As the amount of spent fuel grows, many reactors are also using dry storage casks. ~~implementing plans for temporary storage on site. Other plants plan to store spent fuel away from the reactor at a temporary site until a permanent repository is built.~~ The NRC reviews and approves designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there safely from sites around the country. Given the widespread locations of power reactors, ~~if a disposal site is finally approved, licensees will need to transport spent fuel to that site safely.~~ These shipments would likely be made on railroads and on public highways.

Because sSpent fuel is highly radioactive, ~~and must be transported in large, heavy containers that shield the public from exposure.~~ Tthis raises the following ~~frequently asked~~ questions ~~in connection with such shipments~~:

- How does the NRC protect the public from radioactive waste that is being transported?
- What is the likelihood of these shipments being involved in an accident?
- How well can the transportation containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technologies and information become available, the NRC continually evaluates its existing safety requirements. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 30 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

Spent fuel is highly radioactive and must be heavily shielded and tightly contained to be transported safely. ~~An essential component for any~~ sSafe shipment requires ~~is~~ a robust spent fuel container, or "cask."

The NRC ~~establishes~~ regulatesions ~~and standards for~~ the design and construction of these ~~robust~~ casks to ensure the public is ~~as the primary way to~~ protected ~~the public during transport~~. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, ~~regulations require that~~ these containers must pass a series of tests that mimic accident damageforces. The NRC ~~conducts rigorous~~ reviews ~~to certify~~ that spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be ~~shown by test or analysis~~ able to survive ~~a sequence of~~ four tests~~simulated accident conditions~~ involving impact, puncture, fire, and submersion in water. During and after the tests, the ~~containers~~ casks must contain nuclear material, limit doses to acceptable levels, and prevent a nuclear reaction.

To protect workers and the public, a cask ~~containers~~ hasve walls of steel and shielding materials five to 15 inches thick, made of steel and shielding materials, and a massive lid. Truck containers weigh about 25 tons when loaded with ~~1~~ one to ~~2~~two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In ~~the event of~~ an accident, these limiters would crush, absorbing impact forces and protecting the container and its cargo.

Spent fuel containers are tightly sealed and provide heavy shielding fo~~r most radiation~~. ~~However,~~ But it is not possible to ~~eliminate~~ shield all the radiation ~~with shielding~~. The Ccontainers must provide enough shielding to protect anyone ~~reduce external radiation to low levels that meet DOT and NRC radiation standards for the radiation dose to individuals~~ who might be near the cask during transport.

~~Container~~ Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, scale-model testing, or a combination of these ~~techniques to demonstrate that containers are safe~~. ~~Most~~techniques. Most often, they use a combination of computer analyses and physical testing.

They explain their design and provide supporting documents in an application. The NRC evaluates each ~~application for a container~~ design, examines the information in depth, and then performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance. Then ~~for a spent fuel container design. fabricators make~~ the containers can be manufactured and used. Manufacturers and shippers have special ~~must adhere to a~~ programs to ~~that~~ ensures the containers ~~continuously~~ meet design specifications throughout fabrication and transportation.

But just having a certificate does not mean a cask can be used. NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure that radiation levels and contamination levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the ~~the applicable NRC~~ safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments regulated by the NRC have been completed safely in the U.S. during the past 25 years. Although there have been four accidents~~, involving those shipments~~, none has~~ve~~ resulted in a release of radioactive material.

This ~~e~~Experience ~~with past shipments~~ confirms that the ~~fundamental~~ safety system is sound. But will this hold true when there are ~~The question becomes "What might happen if there are~~ *thousands* of future shipments?" The NRC continuously evaluates risks associated with spent fuel transport in a methodical and scientific way. To provide additional confidence, the NRC has sponsored several risk studies related to spent fuel transportation on highways and railroads.

In 1977, the NRC completed a study that is now seen as ~~has since become~~ the "baseline" for comparison with new information and studies completed since then. That study allowed the NRC to say its transportation regulations adequately protect the public.

In 1987, the NRC used improved research methods to ~~evaluate~~ see how shipping containers react in accidents and to estimate the risk of releasing radioactive materials. The study results provided added assurances that ~~about the ability of~~ shipping casks would ~~to~~ withstand an accident ~~and confirmed results of the 1977 study~~.

Another ~~study, released~~ in ~~March~~ 2000, ~~used improved technology to~~ analyzed how well ~~the ability of~~ containers would hold up in ~~to withstand~~ an accident. Using improved technology, t~~T~~his study found ~~concluded that~~ the risk would be even smaller than originally estimated in 1977 even if ~~from~~ the ~~increased~~ number of spent fuel shipments increased greatly ~~that could occur in the first half of this century would be even smaller than originally estimated in 1977~~.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. The study confirmed that NRC regulations for spent fuel transport are adequate to ensure safety of the public and the environment. It examined how three NRC-certified packages would behave during both normal shipments and accidents. It modeled a variety of transport routes using population data from the 2000 census, as updated in 2008. It used actual highway and rail accident statistics. It considered doses from normal shipments to people living along transportation routes, occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. And it used state-of-the-art computer models. The risk assessment found:

- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year
- There is less than a 1 in 1 billion chance that radioactive material would be released in an accident
- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm

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Commented [MEC3]: This language comes out of the blog post John Cook and I put together on the risk assessment. http://public-blog.nrc-gateway.gov/2013/09/19/transporting-spent-nuclear-fuel-how-do-we-know-its-safe/

On the basis of these studies, operational experience, and its own ~~technical~~ reviews, the NRC concluded that the shipment of spent fuel ~~is~~ will be safe, even is hundreds of shipments are made each year ~~at projected shipment levels~~. The NRC is continuing to ~~follow developments in~~track spent fuel shipping, including the performance of ~~additional~~ more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the ~~possibility~~ chance of injury, damage, or some kind of loss. ~~Given that understanding, t~~The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show ~~indicate that~~ this risk is low. As a part of its safety effort, the NRC aims to minimize~~ing~~ risk ~~is an important concept to the NRC~~. To evaluate the risks, ~~t~~The NRC~~'s risk assessment~~ asks the following three questions and then converts the answers into numbers ~~to arrive at a risk value~~:

• What can go wrong?
• How likely is it?
• If something goes wrong, what are the consequences?

~~Although t~~The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, , researchers ~~calculate radiation risks to the public using~~ use two scenarios. One ~~scenario~~ involves a ~~journey~~ trip~~during~~ on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects ~~on a container~~.
Step 1. Experts use historic records to determine what might happen.
• *They gather historic records.*
• *They also ~~gather~~ put together data on how many spent fuel shipments are likely each year.*
• *They look at the rate of accidents for rail and highway shipments.*
• *~~Researchers~~ They look at a large number of accidents that are ~~conceivable~~credible.*
• *They also look at crash impact forces, fires, or punctures. They pick forces that are more severe than those covered by NRC standards.*

Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to ~~assure safe~~ transportation ~~of spent fuel~~.

The Accident Scenario

NRC studies show that the chance of an accident is low, and that fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions of the design standards. However, if a very unlikely chain of events occurs, the accident might be severe enough to cause a radioactive release.

To estimate the ~~likelihood and consequences~~risk of unusually severe accidents, researchers use a multi-step approach ~~to calculate risk~~. They use ~~That approach uses~~ ~~accident~~ data and their experience with past trucking and rail accidents involving other hazardous materials. Part of this step is to determine ~~This also involves determining~~ what kinds of accidents could happen and looking at what their ~~potential~~ effects might be.

According to the DOE Final Environmental Impact Statement ~~(FEIS)~~ for the Yucca Mountain Project, about 11,000 rail or 53,000 truck shipments might be expected during the 24 years of operation of the repository~~, should it be approved~~. The chances that any accident would occur during a spent fuel shipment are about 1 in 10,000 for rail shipments and 1 in 1,000 for highway transport. Put another way, these estimates indicate that 1 to 50 accidents involving casks are conceivable in the process of moving ~~all current~~ spent fuel to a ~~permanent~~ repository.

Looking at these conceivable accidents, the chance that even one would be serious enough to lead to even a small release is about 1 in 1,000. The chance of a large release is estimated to be less than one in 1,000,000,000.

***Step 2.** Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.*
- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows them to estimate ~~provides estimates on~~ the size of any potential leak and how much nuclear material might escape.

***Step 3.** Researchers match accident scenarios from Step 1 with the ~~assessments~~ analyses from Step 2. This gives them ~~to~~ determine the chance of severe damage to the container or its contents.*

***Step 4.** Researchers use a special computer program to compute a risk estimate ~~with a special computer program~~. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.*

The Accident-Free Scenario

For most spent fuel shipments, ~~In an accident-free journey,~~ nothing will ~~goes~~ go wrong and no nuclear material will be ~~is~~ released ~~from the container~~. In this scenario, experts calculate the total ~~of~~ radiation dose ~~all radiological exposures, or doses,~~ that all people along the route could ~~be~~ receive~~d by all people along the transportation route, is calculated~~. Because spent fuel~~, even fully contained,~~ ~~still~~ emits low levels of radiation through the ~~container~~ cask walls, researchers estimate the total radiation dose to people who could be exposed. They use information on routes and local populations ~~information~~ to determine ~~estimate~~ the number of people who might be affected ~~who could be exposed~~ and the ~~total radiation dose that~~ dose they might receive.

The risk to the public from an accident-free journey results from the very ~~low-level~~ radiation field that surrounds the ~~spent fuel container~~transport cask. If the container is moving past a person, ~~perhaps~~ such as someone standing along the highway or railroad track, the exposure is brief and well below regulatory limits. Exposure will vary depending upon the speed of the ~~train or tractor-trailer rig~~vehicle and how far away ~~the distance~~ the person is standing ~~from the highway or track~~. The very low doses to each person along the route ~~is~~ are added to ~~obtain~~ get the total population dose. ~~As a basis for comparison, a~~A passenger flying ~~traveling~~ round-trip ~~by air~~ from New York to Los Angeles receives a dose from background radiation ~~dose~~ that is 25 times greater than the dose to persons closest to a typical spent fuel shipment.

(b)(5)

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by:
– Regulating their design and construction ~~of shipping containers~~.
– Reviewing designs and independently checking a container's ability to meet accident conditions
– Ensuring that ~~containers~~casks are built, maintained, and used properly

• The NRC also ~~follows an aggressive program to~~ investigates and assesses the risks involved in spent fuel shipments. The agency:
– Analyzes~~ing~~ spent fuel transportation records to fully understand safety issues ~~better~~
– Evaluates~~ing~~ new transportation issues, such as ~~increased~~ projections for the number of shipment ~~levels~~, changes in ~~denser~~ populations along some routes, and other factors
– Keeps up with ~~Using new~~ technology as it evolves to refine estimates of current and future levels of potential risk to the public

Although there will always be a slight chance that an accident will cause a release of nuclear material, the NRC has found that the likelihood of such an event and the ~~associated~~ risk to the public are extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

(b)(5)

Spent Fuel Transport Security

The NRC also regulates the ~~physical~~ protection of spent nuclear fuel in transit against sabotage or other malicious acts. The NRC's current rules for the physical protection ~~regulations for~~of spent fuel transportation include:
• Coordinating with ~~Pre-shipment coordination with~~ law enforcement agencies before the shipment
• Requiring advance ~~Pre-shipment~~ notice to ~~of~~ States and the NRC
• Using a communications center and other means to monitor shipments while in route~~In-transit shipment call-in to communications center~~
• ~~Shipment monitoring~~
• Armed escorts ~~(in populated areas)~~; and
• Immobilization devices.

(b)(5)

Since September 11, 2001, the NRC has taken additional steps to protect the public. ~~These steps involve a heightening of the security posture, including new measures taken to protect nuclear facilities and regulated activities, such as spent fuel transportation, and orders that NRC has issued to licensees.~~

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear Regulatory Commission
NUREG/BR-0292
March 2015

From:	Lombard, Mark
To:	Pstrak, David
Cc:	Conley, Maureen; Silva, Patricia; Hsia, Anthony
Subject:	FW: Safety of Spent Fuel Transportation brochure working draft rev 3.docx
Date:	Friday, April 03, 2015 4:26:04 PM
Attachments:	Safety of Spent Fuel Transportation brochure working draft rev 3.docx

David,

I have been sitting on this far too long. Can you please look at Maureen's replies and questions and let us know if we need any additional changes, in your opinion?

Thanks,

Mark

From: Conley, Maureen
Sent: Friday, January 30, 2015 3:17 PM
To: Lombard, Mark
Subject: Safety of Spent Fuel Transportation brochure working draft rev 3.docx

Hi, Mark. I am sending you back the latest revision to the brochure. I made many of the suggested changes. I did not make changes where I felt the information was redundant or did not support the clear messaging we are aiming for with this brochure. In those cases where possible I did try to address the substance of the change. Where there were comments, I did my best to address them.

Also, one point of style: the modern convention is to leave a single space between sentences, not the two that we all grew up with.

Please share with those whomever needs to see this again. I am happy to correct any factual errors but need to be careful about how we are wording some of these complicated technical topics.

Thanks for all your help and the support from your staff!
Maureen

Original grade level 12.2
Current 9.6

Safety of Spent Fuel Transportation

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

The NRC has three main functions:
1. To set standards and develop regulations;
2. To issue licenses for nuclear facilities and nuclear materials users; and
3. To inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient and realistic.

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the U.S., and internationally, with the IAEA. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

Commented [MEC1]: Once the text is finalized, OPA will provide planned images for NMSS review.

(b)(5)

Commented [MEC3]: This comes from the NRC website "About NRC." Because this section is an overview, it is more top-level than what appears below.

(b)(5)

Commented [MEC5]: Info digest is meant to be a comprehensive list, whereas this is very top-level. Again, this comes from the "About NRC" page on the website.

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. For such low levels of exposure, any biological effects are so small that, if they exist, they would not be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

What Is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:
• How does the NRC protect the public from radiation during transport?
• What is the likelihood one of these shipments will be involved in an accident?
• How well can the shipping containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a "cask."

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these containers must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials five to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, and physical testing of a scale model or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

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A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure.

Commented [MEC15]: Still an accurate number?

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?
The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the regulations in place to assure the safety of spent fuel transport.

In a 1977 study, the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987 and 2000, the NRC looked more closely how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. These studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study looked at how three NRC-certified packages would behave during both normal shipments and accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. The risk assessment found:

- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year
- There is less than a 1 in 1 billion chance that radioactive material would be released in an accident
- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm

In addition to these risk studies, the NRC has looked closely at real-world accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would have performed. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, Cal.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

- What can go wrong?
- How likely is it to occur?
- If something goes wrong, what are the consequences?

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.
Step 1. Experts determine what might happen.
- ***They gather historic records.***
- ***They also put together data on how many spent fuel shipments are likely each year.***
- ***They look at the rate of accidents for rail and highway shipments.***
- ***They look at a large number of accidents that are credible.***
- ***They also look at crash impact forces, fires or punctures. They pick forces that are more severe than those covered by NRC standards.***

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

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To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past trucking and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

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Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

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Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.
- ***They gather data on how much spent fuel each container will carry.***
- ***They analyze how the spent fuel might respond in a given type of accident.***
- ***They calculate the temperature of the container and the spent fuel itself during a long-term fire.***

This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This gives them the chance of severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

- The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

~~A passenger flying round trip from New York to Los Angeles receives a dose from background radiation that is 25 times greater than the dose to persons closest to a typical spent fuel shipment.~~ ~~To put this estimated dose in perspective, the 0.0037 person-Sv estimated from spent fuel transportation is a very small fraction of the estimated collective annual dose for a chest X-ray of almost 13,000 person-Sv~~

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The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by:
– Defining strict requirements for package design and performance
– Reviewing designs and independently checking a container's ability to meet accident conditions and
– Doing inspections to ensure casks are built, maintained and used properly.

• The NRC also looks at the risks involved in spent fuel shipments. The agency:
– Analyzes spent fuel transport records to fully understand any safety issues
– Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes and other factors, and
– Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

Although there will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public are extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

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The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:

- Coordinating with law enforcement agencies before the shipment
- Requiring advance notice to States and the NRC
- Using a communications center and other means to monitor shipments while in route
- Armed escorts, and
- Remote devices that allow vehicles to be turned off.

Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear Regulatory Commission
NUREG/BR-0292
March 2015

From:	Lombard, Mark
To:	Conley, Maureen
Subject:	FW: Thank you!
Date:	Friday, September 04, 2015 6:17:36 PM
Attachments:	Safety of Spent Fuel Transportation brochure working draft rev 3 Pstrak comments 082015.docx

David made some edits to the attached. He was unable to confirm accuracy of the statement below so I am trying to contact one of our contractors who worked on the risk study to confirm it. I don't have his contact information yet but should have it next week. I think it is otherwise good to go.

Mark

From: Pstrak, David
Sent: Friday, August 14, 2015 6:48 AM
To: Lombard, Mark <Mark.Lombard@nrc.gov>
Cc: Silva, Patricia <Patricia.Silva@nrc.gov>
Subject: RE: Thank you!

As requested.

I have highlighted the new comments and changes I made in yellow for ease of identification.

Overall, I accept Maureen's comments to the original comments that I (and Jim Rubenstone) made late last year and early this year. In general, it appears that Maureen is seeking to not get into too much/unnecessary detail.

I am still pursuing the accuracy and details of the following statement. I have reached out to NRC colleagues, but have yet to confirm this information. The only change to this statement from the original NUREG (published in 2003) is the change from 25 years to 35 years.
More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure.

Let me know if you have any questions on my new comments.

David

From: Lombard, Mark
Sent: Thursday, August 13, 2015 6:09 PM
To: Pstrak, David <David.Pstrak@nrc.gov>
Cc: Silva, Patricia <Patricia.Silva@nrc.gov>
Subject: Re: Thank you!

Thank you David. Please send it to me and I will take a look and then forward it to Maureen.

Mark

From: Pstrak, David
Sent: Thursday, August 13, 2015 03:45 PM
To: Lombard, Mark
Cc: Silva, Patricia
Subject: RE: Thank you!

Mark – On the spent fuel transportation brochure, I did receive it from you back in April. Due to other pressing and high priority work, my focus has not been on the brochure. However, I took it upon myself to move it up the list to review it while I was recovering from my recent surgery. I have done, that, and reviewed Maureen's comments, and added just a small handful of clarifying text.

I am ready to resend that to her. Do you want to see it before I send it? Or do you want me to handle this and move it forward and make myself available to Maureen to address any qs she develops/has?

Let me know –

David

From: Lombard, Mark
Sent: Tuesday, August 11, 2015 1:05 PM
To: Pstrak, David <David.Pstrak@nrc.gov>
Subject: RE: Thank you!

I am glad you are doing well Dave. It has been so long since we talked about the transportation brochure. Maureen Conley had given us some comments and I can't remember if I had sent them to you for resolution. The upgrade to Office 2013 resulted in a loss of my archived emails so I can't retrace my steps. Did I send the comments to you and did you send the resolutions back to me? Sorry to ask but can you help me refresh my memory please?

Thanks,

Mark

From: Pstrak, David
Sent: Tuesday, August 11, 2015 11:38 AM
To: NMSS_DSFM Distribution <NMSS_DSFMDistribution@nrc.gov>
Subject: Thank you!

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I appreciate your strong support!

David

Original grade level *12.2*
Current *9.6*

Safety of Spent Fuel Transportation

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

The NRC has three main functions:
1. To set standards and develop regulations,
2. To issue licenses for nuclear facilities and nuclear materials users; and
3. To inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient and realistic.

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the U.S., and internationally, with the IAEA. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

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Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. For such low levels of exposure, any biological effects are so small that, if they exist, they would not be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

What Is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:
• How does the NRC protect the public from radiation during transport?
• What is the likelihood one of these shipments will be involved in an accident?
• How well can the shipping containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 40 years.

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Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance through a public rulemaking process. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

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But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

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This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

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- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.
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spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

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The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway~~trucking~~ and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

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Commented [MDL29]: How about this?

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The Bottom Line

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- Using a communications center and other means to monitor shipments while in route
- Armed escorts, and
- Remote devices that allow vehicles to be turned off.

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Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear Regulatory Commission
NUREG/BR-0292
March 2015

From: Conley, Maureen
To: Araguas, Christian
Subject: RE: Fire Studies Input
Date: Friday, January 30, 2015 8:57:00 AM

Great, thanks so much!

From: Araguas, Christian
Sent: Friday, January 30, 2015 7:22 AM
To: Conley, Maureen
Cc: Chang, Jimmy
Subject: RE: Fire Studies Input

Hi Maureen,

See below. Everything but the last sentence is correct.

From: Conley, Maureen
Sent: Thursday, January 29, 2015 4:44 PM
To: Araguas, Christian
Cc: Chang, Jimmy
Subject: RE: Fire Studies Input

Hi, thanks so much for sending this information. I have incorporated it into the draft brochure but wanted to run the language by you to make sure it's still accurate. Can you please take a look and let me know?

Thanks!
Maureen

In addition to these risk studies, the NRC has looked closely at real-world accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would have performed. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, Cal.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

From: Araguas, Christian
Sent: Friday, January 16, 2015 11:29 AM
To: Conley, Maureen
Cc: Chang, Jimmy
Subject: Fire Studies Input

Maureen,

See input below that can be included at the end of the "Brief History" section.

In addition to the studies mentioned above, the NRC has conducted studies of very long duration fire scenarios that bound expected real-world accident conditions for a representative set of package designs that are likely to be used in future shipping programs. The NRC has documented the predicted performance of NRC certified spent fuel packages in these real life severe accidents. The NRC conducted a screening of real life transportation accidents, performed case studies for the most severe accidents, and examined it current regulations as a result of the consequences of the accidents. The results of these case studies have been documented in several NUREG reports (NUREG/CR 6894, 6987, 7035, 7101, 6793, 6886, 7101, 7034). For example, the NRC has performed case studies of the Baltimore tunnel fire of 2001, the Caldecott tunnel fire of 1982, the MacArthur Maze fire of 2007, and the New Hall Pass tunnel fire of 2007.

The NRC has also conducted additional studies to determine accident parameters that could produce a severe fire with the potential to engulf a SNF transportation package, and analyzed and updated statistics for accidents (e.g., frequency of road and rail accidents involving a long duration fire). The NRC also analyzed accidents and determined trends associated with these accidents.

The NRC is currently working to publish a compendium to summarize the severe fire accident study for both roadway and railway, with an expected goal to have these summary documents out for public comment during the 4th quarter of fiscal year 2015.

From: Conley, Maureen
To: Coffin, Stephanie
Cc: Lombard, Mark
Subject: RE: Public Outreach on Spent Fuel
Date: Thursday, February 27, 2014 1:21:00 PM

No worries, I'll call you in about a half-hour. Thanks,

Maureen

From: Coffin, Stephanie
Sent: Thursday, February 27, 2014 12:52 PM
To: Conley, Maureen
Cc: Lombard, Mark
Subject: RE: Public Outreach on Spent Fuel

Maureen,

Mark is working an urgent issue; I'm not sure he will be able to support the meeting below.

I think he would like to be involved; so if he can't make, I plan to reschedule.

Give me a ring before you head over here (301-287-9452), and I will let you know the status.

If you prefer, I can reschedule now.

Sorry for the uncertainty,

Stephanie

-----Original Appointment-----
From: Coffin, Stephanie
Sent: Sunday, February 23, 2014 1:43 PM
To: Coffin, Stephanie; Lombard, Mark; Conley, Maureen
Subject: Public Outreach on Spent Fuel
When: Thursday, February 27, 2014 2:00 PM-2:30 PM (UTC-05:00) Eastern Time (US & Canada).
Where: Mark's Office (3WFN 14B16)

Maureen,

I went over all the facts sheets and brochures you sent me, and I think we have good material to support a Category III public meeting…or a webinar…or a live chat….or a blog….

Mark and I wanted to discuss all the venues open to us and see where it might make sense to start and what you might recommend.

Thanks,

Stephanie

From: Conley, Maureen
To: Lombard, Mark; Pstrak, David
Cc: Hsia, Anthony
Subject: RE: Re: [EXTERNAL] request for assistance please
Date: Monday, October 05, 2015 10:18:00 AM

Awesome, thanks Mark!

From: Lombard, Mark
Sent: Friday, October 02, 2015 6:09 PM
To: Conley, Maureen <Maureen.Conley@nrc.gov>; Pstrak, David <David.Pstrak@nrc.gov>
Cc: Hsia, Anthony <Anthony.Hsia@nrc.gov>
Subject: FW: Re: [EXTERNAL] request for assistance please

I have an answer on the question David had on the statement below.

From: Ammerman, Douglas J [mailto:djammer@sandia.gov]
Sent: Friday, October 02, 2015 4:57 PM
To: Lombard, Mark <Mark.Lombard@nrc.gov>
Subject: [External_Sender] Re: [EXTERNAL] request for assistance please

Mark,
I would say that the statement is correct. In the past ten years there was an accident involving an empty Naval Reactors M-140 cask. I believe that the four accidents referred to in the statement only include loaded casks, because I think there had been more than four cask accidents ten years ago.
Doug

On Oct 2, 2015, at 1:48 PM, Lombard, Mark <Mark.Lombard@nrc.gov> wrote:

Doug,

If this is not appropriate to ask, please let me know. We are updating our Transportation brochure and are wondering is the following statement is accurate: "More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure."

The only change to this statement from the original NUREG (published in 2003) is from 25 years to 35 years. If it is not appropriate for me to ask for your review, that is OK.

Thank you,

Mark

From:	Lombard, Mark
To:	Pstrak, David
Cc:	Conley, Maureen; Silva, Patricia; Rubenstone, James
Subject:	RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx
Date:	Monday, December 15, 2014 8:51:08 AM

Thank you David. I will go over your comments with Maureen.

Mark

From: Pstrak, David
Sent: Friday, December 05, 2014 11:00 AM
To: Lombard, Mark
Cc: Conley, Maureen; Silva, Patricia; Rubenstone, James
Subject: RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Mark – attached please find my initial comments and suggestions on the SNF transportation brochure.

Please let me know if you have questions on my edits and input.

I will look for the info on the couple of items I offered to confirm or Maureen requested confirmation of.

David

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 6:48 PM
To: Pstrak, David; Rubenstone, James
Cc: Conley, Maureen; Silva, Patricia
Subject: Re: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

On second thought, how about by next Wednesday COB?

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 06:31 PM
To: Pstrak, David; Rubenstone, James
Cc: Conley, Maureen; Silva, Patricia
Subject: Fw: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Can you gentlemen please also take a look at the attached and provide comments maybe by the end of this week?

Thanks,

Mark

From: Conley, Maureen
Sent: Friday, November 28, 2014 04:41 PM

To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
Subject: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi, all. Here is my first rough cut at the revision, mainly edited to simplify language and address Yucca Mountain uncertainties. I added in language on the latest transportation risk assessment but think it would be useful to also add something about the Howard st. tunnel fire and the MacArthur Maze fire and any other accidents you guys have studied that I might not be aware of (these probably could be added in call-out boxes in the margins unless we think a lot of text is required to explain them/give context/etc.)

When you have a chance, please let me know your thoughts.

Thanks!
Maureen

Original grade level 12.2

Title?

Once the text is agreed upon and finalized, the photos that will be included as part of the brochure will need to be reviewed.

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The U.S. Nuclear Regulatory Commission (NRC) is an independent agency established by Congress. Its mission is to license and regulate the ~~Nation's~~ nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. ~~And~~ Additionally, it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT works with the NRC and affected states to regulate their transport. DOT also regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors~~plants~~.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. As ~~p~~Part of the United Nations, the IAEA sets global regulations for many areas of the nuclear industry, including nuclear materials~~packaging and~~ transportation. These IAEA's packaging and transportation regulations serve as a model for the United States and other nations.

The NRC has three main functions:
1. to set standards and develop regulations;
2. to issue licenses for nuclear facilities and nuclear materials users; and
3. to inspect facilities to ensure that NRC regulations are being met.

(b)(5)

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. It begins with the mining of uranium and . The ~~cycle~~ continues through the manufacture of fuel, its use in reactors, transportation, storage, and permanent geologic disposal.

The NRC works to maintain public health and safety, protect the environment and ensure our national security. To maintain the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic to It also strives to keep the regulatory burden reasonable on all those involved in the use, handling, transport, and disposal of nuclear materials.

Proper handling of nuclear materials will help to ensure the safety of the public and plant workers. That is why the NRC works with ~~other agencies~~the DOT and DOE in the U.S. and the IAEA internationally to ensure these materials are ~~handled~~ packaged and transported safely.

This booklet explains the NRC's role in ensuring spent nuclear fuel from commercial nuclear power plants is packaged and transported safely. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments.

Radiation

Scientists say about 90 percent of all radiation exposure comes from natural sources: radon gas, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly. People living in areas with a lot of granite, for example, receive more radiation from the earth. Those living or working at high altitudes receive more cosmic radiation. Most natural exposure is from radon, a gas that seeps from the earth's crust into the air we breathe. The remaining 10 percent of all radiation exposure comes from man-made sources, mainly medical x-rays. Natural and artificial radiation are similar in kind and effect.

What is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act (NWPA) sets a policy for safe, permanent disposal of spent fuel and other radioactive wastes. Congress in 1987 ~~picked~~ selected Yucca Mountain in Nevada as the site for an underground repository. DOE applied to the NRC in 2008 ~~to~~ for a permit to construct the repository ~~there~~ at Yucca Mountain. But DOE withdrew its application in 2010. The NRC's role is to assess whether the proposed facility meets NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will likely be some time before a geologic repository is available. All nuclear power reactors plants move their spent fuel first into pools for storage on site. As the ~~amount~~ volume of spent fuel in the pool increases ~~grows~~, many reactors are also using dry casks for storage ~~casks~~. The NRC reviews, ~~and~~ approves, and issues certificates for the design of these dry cask ~~designs for these~~ systems.

Since the proposed repository at Yucca Mountain is not currently operating, the DOE is considering storage of spent fuel, perhaps at a consolidated facility in the U.S. Once a central location for storage or disposal is approved, spent fuel will need to be transported there ~~safely~~ from sites around the country. These shipments would likely be made on railroads using specially designed casks and railcars as well as ~~and~~ on public highways.

Because spent fuel is highly radioactive, this raises the following questions:
• How does the NRC protect the public from the hazards associated with spent fuel and other radioactive waste during transportation ~~that is being transported~~?
• What is the likelihood of a ~~these~~ shipments of these types of material being involved in an accident?
• What steps does the NRC take to ensure that ~~How well can the~~ transportation containers can withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to continue to ensure safe transport. As new technologies and real-world information become available, the NRC continually evaluates its existing regulations and safety requirements. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 30 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a robust spent fuel container ~~or~~ called a "cask."

The NRC ~~regulates~~ reviews and approves the design and construction of these casks to ensure the public is protected from the associated hazards. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these containers must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be ~~able~~ designed to survive a sequence of four tests, including a 30-foot drop test onto an unyielding surface, a puncture test, a fully engulfing fire at 1,475 degrees Fahrenheit for 30 minutes, and immersion under ~~involving impact, puncture, fire and submersion in~~ water. During and after the tests, the casks must contain the nuclear material contents, limit radiation doses to acceptable levels, and prevent a nuclear criticality reaction.

To protect workers and the public, a cask has walls of steel and shielding materials five to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. Impact limiters contain crushable foam and/or wood that act to absorb the impact energy in a test or real-life accident. In an accident, these impact limiters would crush and absorb the ~~absorbing~~ impact forces ~~and~~, thereby protecting the container and its ~~cargo~~ content.

Spent fuel containers are engineered to be tightly sealed, very robust, and include ~~and provide~~ heavy shielding material to lower the associated radiation levels. But it is not possible to shield all the radiation. The containers must ~~provide~~ include enough shielding to protect anyone who might be near the cask during transport.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale-model ~~testing~~, or a combination of these techniques. Most often, they use a combination of computer analyses and physical testing. They meet with technical review staff from the NRC and explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and ~~then~~ performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural, and materials, thermal, and criticality engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC has completed its review and is satisfied that a design meets the requirements, it issues a Certificate of Compliance, which specifies, for example, the materials of construction, the authorized contents, and the size dimensions of the container. Then the containers can be manufactured and put into service~~used~~. Manufacturers and shippers use quality assurance ~~have special~~ programs to ensure the containers meet design specifications throughout fabrication and transportation. As a means to ensure the provisions of the Cerificate of Compliance are being met, NRC staff conduct inspections at both the manufacture and shipper facilities.

While having a certificate for a package design ensures the safety of the package during transportation, certain requirements of the NRC and DOT must also be met prior to offering a package for shipment ~~But just having a certificate does not mean a cask can be used.~~ Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and ~~tests~~assessments to ensure radiation levels are within the specified safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments regulated by the NRC have been completed safely in the U.S. during the past 25 years. Although there have been four accidents, none ~~has~~ have resulted in a release of radioactive material or a fatality due to exposure to radiation.

This experience confirms that the safety system is sound. In other words, the regulatory requirements of the NRC for package certification coupled with the transportation requirements of both the NRC and the DOT ensure the safety of the package during transportation. But will this hold true when there are increased shipping campaigns to a proposed repository or a centralized storage facility ~~thousands of~~ in the future ~~shipments~~? The NRC continuously evaluates risks associated with spent fuel transport in a methodical and scientific way. To provide additional confidence, the NRC has sponsored several risk studies over the years related to spent fuel transport on highways and railroads.

In 1977, the NRC completed a study that is now seen as the "baseline" for comparison with new information and studies completed since then. That study concluded that the transportation regulations adequately protect the public, and provided confidence to the public of the important safety role that NRC has~~allowed the NRC to say its transportation regulations adequately protect the public~~.

In 1987, the NRC used improved research methods to see how shipping containers react in accidents and to estimate the risk of releasing radioactive materials. The study results provided added assurance that certified shipping casks would withstand an accident.

Another study conducted in 2000 analyzed how well containers would ~~hold up in~~withstand an accident. Using improved technology, this study found the risk would be even smaller than originally estimated in 1977, even if the number of spent fuel shipments increased greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. The study confirmed that NRC regulations for spent fuel transport are adequate to ensure safety of the public and the environment. It examined how three NRC-certified packages would behave during both normal shipments and accidents. The study~~It~~ modeled a variety of transport routes using population data from the 2000 census, as updated in 2008, and ~~It~~ used actual highway and rail accident statistics. Using state-of-the-art computer models, the study~~It~~ considered doses from normal shipments to people living along transportation routes, occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. ~~And it used state-of-the-art computer models.~~ The risk assessment found:

- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year
- There is less than a 1 in 1 billion chance that radioactive material would be released in an accident

- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm

Commented [MEC12]: This language comes out of the blog post John Cook and I put together on the risk assessment. http //public-blog nrc-gateway gov/2013/09/19/transporting-spent-nuclear-fuel-how-do-we-know-its-safe/

On the basis of these studies, operational experience, and its own reviews, the NRC concluded that the shipment of spent fuel will be safe, even its hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic transportation safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

• What can go wrong during transportation?
• How likely is it to occur?
• If something goes wrong, what are the consequences for the package and the public?

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.
Step 1. Experts determine what might happen.
• They gather historic records.
• They also put together data on how many spent fuel shipments are likely each year.
• They look at the rate of accidents for rail and highway shipments.
• They look at a large number of accidents that are credible.
• They also look at crash impact forces, fires or punctures. They pick forces that are more severe than those covered by NRC standards.

The Accident Scenario

NRC studies show that the chancelikelihood of an accident is low, and that fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions of the design standards– However, if a very unlikely chain of events occurs, the accident might be severe enough to cause a radioactive release.

To estimate the risk of unusually severe accidents, researchers use a multi-step approach. They use data and their experience with past trucking and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

According to the DOE Final Environmental Impact Statement for the Yucca Mountain Project, about 11,000 rail or 53,000 truck shipments might be expected during the 24 years of operation of the proposed repository. The chances that any accident would occur during a spent fuel shipment are about 1 in 10,000 for rail shipments and 1 in 1,000 for highway transport. Put another way, these estimates indicate that approximately 1 to 50 accidents involving casks are conceivable in the process of moving spent fuel to a repository.

Looking at these conceivable accidents, the chance that even one would be serious enough to lead to even a small release is about 1 in 1,000. The chance of a large release is estimated to be less than one in 1,000,000,000.

***Step 2.** Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.*
• They gather data on how much spent fuel each container will carry.
• They analyze how the spent fuel might respond in a given type of accident.
• They calculate the temperature of the container and the spent fuel itself during a long-term fire.
This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

***Step 3.** Researchers match accident scenarios from Step 1 with the analyses from Step 2. This gives them the chance of severe damage to the container or its contents.*

***Step 4.** Researchers use a special computer program to compute a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.*

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. In this scenario, experts calculate the total radiation dose that all people along the route could receive. Because spent fuel emits low levels of radiation through the cask walls, researchers estimate the total radiation dose to people who could be exposed. They use information on routes and local populations to determine the number of people who might be affected and the dose they might receive.

The risk to the public from an accident-free journey results from the very low radiation field that surrounds the transport cask. If the container is moving past a person, such as someone standing along the highway or railroad track, the exposure is brief and well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. The very low doses to each person along the route are added to get the total population dose. A passenger flying round-trip from New York to Los Angeles receives a dose from background radiation that is 25 times greater than the dose to persons closest to a typical spent fuel shipment.

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by:
– ~~Regulating~~Reviewing and certifying their design and conducting inspections during construction.

– Reviewing designs and independently checking a container's ability to meet accident conditions
– Ensuring casks are built, maintained, and used properly.

• The NRC also investigates and assesses the risks involved in spent fuel shipments. The agency:
– Analyzes spent fuel transport records to fully understand safety issues
– Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors.
– Keeps up with technology as it evolves to refine estimates of current and future risk to the public

Although there will always be a slight chance that an accident will cause a release of nuclear material, the NRC has found that the likelihood of such an event and the risk to the public are extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

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The NRC also regulates the protection of spent nuclear fuel in transit against sabotage, theft, or diversion ~~or other malicious acts~~. The NRC's current ~~rules~~ regulations for the physical protection of spent fuel transport include:
• Coordinating with law enforcement agencies before the shipment
• Requiring advance notice to States and the NRC
• Using a communications center and other means to monitor shipments while in route
•
• Armed escorts ~~and~~
• Immobilization devices.

(b)(5)

(b)(5)

Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:
Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear
Regulatory

Commission
NUREG/BR-0292
March 2015

From:	Pstrak, David
To:	Lombard, Mark
Cc:	Conley, Maureen; Silva, Patricia; Rubenstone, James
Subject:	RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx
Date:	Thursday, December 04, 2014 12:50:09 PM

Wednesday works for me as well.

David

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 6:48 PM
To: Pstrak, David; Rubenstone, James
Cc: Conley, Maureen; Silva, Patricia
Subject: Re: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

On second thought, how about by next Wednesday COB?

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 06:31 PM
To: Pstrak, David; Rubenstone, James
Cc: Conley, Maureen; Silva, Patricia
Subject: Fw: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Can you gentlemen please also take a look at the attached and provide comments maybe by the end of this week?

Thanks,

Mark

From: Conley, Maureen
Sent: Friday, November 28, 2014 04:41 PM
To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
Subject: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi, all. Here is my first rough cut at the revision, mainly edited to simplify language and address Yucca Mountain uncertainties. I added in language on the latest transportation risk assessment but think it would be useful to also add something about the Howard st. tunnel fire and the MacArthur Maze fire and any other accidents you guys have studied that I might not be aware of (these probably could be added in call-out boxes in the margins unless we think a lot of text is required to explain them/give context/etc.)

When you have a chance, please let me know your thoughts.

Thanks!
Maureen

From: Conley, Maureen
To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
Subject: RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx
Date: Thursday, December 04, 2014 8:44:00 AM

It's a function in Microsoft Word. You may have to go into Options to change a setting. Here's how to do it:

In Word, click on the File tab at top left. Second from the bottom in the menu is Options. Click on that. Then select Proofing (third down). Under the third subhead (When correcting spelling and grammar in Word) find the last box and check it (show readability statistics). When this box is checked, if you click on the Review tab, then click the first button to run a spelling and grammar check, you will get some stats in a box at the end. The one we care about is the very last one, the Flesch-Kinkaid Grade Level.

You can have all sorts of fun with it…check entire documents, or single sentences/paragraphs.

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 6:30 PM
To: Conley, Maureen; Hsia, Anthony; Marcano, Damaris
Subject: Re: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

How do you figure that out?

From: Conley, Maureen
Sent: Friday, November 28, 2014 04:42 PM
To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
Subject: RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

P.S. I managed to knock the reading grade level down from 12.2 to 10.2…which is about where we like it to be.

From: Conley, Maureen
Sent: Friday, November 28, 2014 4:42 PM
To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
Subject: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi, all. Here is my first rough cut at the revision, mainly edited to simplify language and address Yucca Mountain uncertainties. I added in language on the latest transportation risk assessment but think it would be useful to also add something about the Howard st. tunnel fire and the MacArthur Maze fire and any other accidents you guys have studied that I might not be aware of (these probably could be added in call-out boxes in the margins unless we think a lot of text is required to explain them/give context/etc.)

When you have a chance, please let me know your thoughts.

Thanks!
Maureen

From:	Rubenstone, James
To:	Lombard, Mark; Pstrak, David
Cc:	Conley, Maureen; Silva, Patricia
Subject:	RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx
Date:	Thursday, December 04, 2014 8:17:13 AM

That works for me.

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 6:48 PM
To: Pstrak, David; Rubenstone, James
Cc: Conley, Maureen; Silva, Patricia
Subject: Re: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

On second thought, how about by next Wednesday COB?

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 06:31 PM
To: Pstrak, David; Rubenstone, James
Cc: Conley, Maureen; Silva, Patricia
Subject: Fw: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Can you gentlemen please also take a look at the attached and provide comments maybe by the end of this week?

Thanks,

Mark

From: Conley, Maureen
Sent: Friday, November 28, 2014 04:41 PM
To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
Subject: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi, all. Here is my first rough cut at the revision, mainly edited to simplify language and address Yucca Mountain uncertainties. I added in language on the latest transportation risk assessment but think it would be useful to also add something about the Howard st. tunnel fire and the MacArthur Maze fire and any other accidents you guys have studied that I might not be aware of (these probably could be added in call-out boxes in the margins unless we think a lot of text is required to explain them/give context/etc.)

When you have a chance, please let me know your thoughts.

Thanks!
Maureen

From:	Araguas, Christian
To:	Conley, Maureen
Subject:	RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx
Date:	Friday, January 16, 2015 7:14:29 AM

Maureen,

Sorry for the delayed response. We will try and get you something late next week.

Christian

From: Conley, Maureen
Sent: Tuesday, January 13, 2015 5:25 PM
To: Araguas, Christian
Cc: Pstrak, David
Subject: RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi, Christian. Just wanted to follow up – do you think a high level summary of these studies and how we use them is manageable? I'm working to resolve comments I've gotten back and would love to have your language to include in the next draft I send out for review.

Thanks,
Maureen

From: Conley, Maureen
Sent: Friday, December 19, 2014 11:06 AM
To: Araguas, Christian
Cc: Pstrak, David
Subject: RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi, Christian. I think Mark had asked for feedback by Dec. 10 but we don't have a hard and fast deadline.

A very high level summary of the Baltimore tunnel fire would be great, with a mention of the two other studies that are underway and how we identify and study accidents like them to better understand transportation risks. Maybe with a statement about how we consider whether our regulations would have been adequate in the situation, whether they've ever been found inadequate, and what we would do if they were.

I'll be here today and Monday, then not again until Jan. 2. If you are around over the next couple weeks and think you could get something together by that first full week in January, that would be great. If not, perhaps the following week?

Thanks very much,
Maureen

From: Araguas, Christian
Sent: Friday, December 19, 2014 11:00 AM
To: Conley, Maureen
Cc: Pstrak, David
Subject: RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi Maureen,

The fire studies likely won't be complete until Fall of next year. We are finalizing the MacArthur Maze and New Hall Pass studies as well as some seal testing efforts through NIST. These will likely go out for public comment and then all studies will be rolled up into both a road compendium and rail compendium. My guess is that this will not meet your timing needs. So with that I guess we can just summarize the Baltimore tunnel fire discussion. When is this needed by?

From: Conley, Maureen
Sent: Friday, December 05, 2014 12:21 PM
To: Araguas, Christian
Cc: Pstrak, David
Subject: RE: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hey, Christian. I just left you a voice mail.

The idea was to give a brief overview of how we look at major transport accidents in detail to see if there's anything new that we should incorporate into our regs. The two I mentioned are the ones I know about, but rather than detailing the findings from those two accidents, I think it would be useful to summarize how we go about identifying these kinds of accidents and learning what we can about them.

I'm curious about the timeframe for the compendium you mentioned. The brochure will not go out until sometime in 2015, so we might be able to link the information somehow.

Happy to chat further, please give a call when you get a chance. I'm leaving today around 1:15 but should be around next week. Thanks!

Maureen
Maureen Conley
NRC Office of Public Affairs
301-415-8202

From: Araguas, Christian
Sent: Thursday, December 04, 2014 5:31 PM
To: Conley, Maureen
Cc: Pstrak, David
Subject: FW: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Hi Maureen,

I am one of the BCs in NMSS/SFM. I understand that you would like to add language to the attached brochure on the Baltimore tunnel fire and the MacArther Maze fire. How married are you to this concept? We do have two published studies on these accidents but I propose not saying much if anything at all. We are currently working on a compendium of both railway and roadway transportation accidents that compare the results of these accidents with existing requirements of spent nuclear fuel containers (which include both

Baltimore and MacArthur Maze). There are several studies and while it would be ideal to just point to this work in the brochure, it is not complete and likely won't be until sometime in 2015. I think we could highlight in a short paragraph the fire studies we are doing but I don't think it should go beyond that. Thoughts?

Christian

From: Pstrak, David
Sent: Thursday, December 04, 2014 1:21 PM
To: Araguas, Christian
Cc: Silva, Patricia
Subject: FW: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Christian – I just was assigned the task to review this draft SNF transportation brochure.

Note the comment/request from Maureen Conley below about adding words about the Baltimore Tunnel Fire and the MacArthur Maze fire (i.e., the fire studies) to this brochure (attached). I think it best for that info to be developed by your staff along with consideration/recommendation as to where/how it best be added. On this flip side, if you believe that this brochure is not a suitable mechanism for sharing the results of the fire studies, I suggest that you weigh in as such.

In a separate email, Lombard requested this review be completed by 12/10/14.

Let me know if you have any questions on my suggestion or the action.

David
287-9121

From: Lombard, Mark
Sent: Wednesday, December 03, 2014 6:31 PM
To: Pstrak, David; Rubenstone, James
Cc: Conley, Maureen; Silva, Patricia
Subject: Fw: Safety of Spent Fuel Transportation brochure working draft rev. 1.docx

Can you gentlemen please also take a look at the attached and provide comments maybe by the end of this week?

Thanks,

Mark

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Sent: Friday, November 28, 2014 04:41 PM
To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
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When you have a chance, please let me know your thoughts.

Thanks!
Maureen

From: Conley, Maureen
To: Lombard, Mark
Subject: RE: Transportation reports
Date: Tuesday, September 11, 2012 10:36:00 AM

4 pm Monday works for me.

"Classics" is a generous description! The short answer to your question is yes.

Part of what I want to figure out is whether one or both are worth updating at all. The March 1987 report discusses studies "over the last decade" (1977-1987) that provide evidence spent fuel can be transported safely. If we are handing this thing out, it would make sense to have more recent information included. But maybe a better option is to retire this one, or just hang onto it as a historical document. It really focuses on summarizing the February 1987 LLNL accident study. It has a lot of good information for anyone who wants to get down in the technical weeds [redacted] (b)(5)

The other report from 2003 is much better geared to a non-technical audience. But it is a snapshot in time – it talks about the decision by Congress and the President in 2002 to approve Yucca Mountain and the four years NRC would have to make a licensing decision once DOE filed an application. It also refers to the then-current body of evidence regarding transportation safety. This one seems ripe for updating.

There is also the question of whether NRC should develop a similar brochure on the safety of spent fuel storage. We have a backgrounder that provides basic information on spent fuel storage, but it doesn't have the focus on safety that the transportation brochure has.

So, plenty for us to talk about Monday. Shall I come your way?

From: Lombard, Mark
Sent: Tuesday, September 11, 2012 9:30 AM
To: Conley, Maureen
Subject: RE: Transportation reports

How about 4pm on Monday? These reports are both classics. Are you thinking of refreshing them for public use?

Mark

From: Conley, Maureen
Sent: Monday, September 10, 2012 10:48 AM
To: Lombard, Mark
Subject: Transportation reports

Hey, Mark. Just checking on your availability this week to chat about my two transportation brochures. I am attaching the pdfs in case you want to take a look. I've got some time either early or late this afternoon, or anytime tomorrow (except between 1 and 2) or Friday.

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Conley, Maureen
To:	Cook, John
Cc:	Benner, Eric; Woodfield, Jon
Subject:	RE: checking on risk assessment
Date:	Thursday, January 09, 2014 2:58:00 PM

Hi, John. Thanks for that update. I think you may be thinking of a different brochure, "Transporting Spent Fuel" put together by RES in 1987, focusing on the LLNL study. Here is a link to the one I would like to revise :

http://pbadupws.nrc.gov/docs/ML0311/ML031140098.pdf

This is an OPA product that has been completely overtaken by events. OPA believes it would be useful to have a brochure available to the public that discusses spent fuel transportation safety, as the current one does, without specific references to a Yucca Mountain repository. But I do understand your concerns. I think both summaries in the risk assessment are good. If we were to update our brochure, it would be considerably shorter than the public summary (and would be packaged specifically as a brochure rather than as a Nureg appendix). Many of the graphics look like they would work well for our purposes..

It sounds as though it would be useful for you and I and perhaps others in SFST to have a longer conversation about what our revision would involve and whether it makes sense.

We are in no hurry to do this revision, but need to let Admin know how much to budget for our work on Nuregs over the next six months. I'll go ahead and put in a placeholder, pending further dialogue.

Thanks,
Maureen

From: Cook, John
Sent: Thursday, January 09, 2014 12:27 PM
To: Conley, Maureen
Cc: Benner, Eric; Woodfield, Jon
Subject: RE: checking on risk assessment

Hi Maureen-

Happy New year.

Yes, the process for publication is quite long here. We provided the Final report to Publications for review in November, and they said it would be the end of January before they could start on it. When we get it back from them, we'll need to make any changes they want. Then we need to prepare a Federal Register Notice announcing availability of the Final, and then release it. I'm sure there are many more sub-steps, approvals and processes in there too.

I would note that the outdated brochure to which you refer was also a long, drawn-out affair, subject to many reviews and revisions. It was quite labor intensive both for staff and our contractor, and ended up costing almost a third of the project it summarized. Frankly, I'm not sure the effort was cost-effective.

In recognition of that experience, NUREG-2125 actually contains 2 Summaries. The Draft contains a 2-page Executive Summary at the beginning of the report, and a 12-page Public Summary that was located in the last Appendix. ACRS recommended that we give the Public Summary more prominence, which led to our decision to move it to the front of the report so that it immediately follows the Executive Summary in the Final report (Publications made a special exception for us to use this out-of-the-box format). The Public Summary is intended to be a self-contained brochure, although we do not identify it as such.

We took care to try to keep both Summaries readable for the public. For example, did you notice that the Executive Summary, which conveys the results of a 600-page technical analysis, contains almost no numbers?

The Public Summary is intended to provide members of the public who are interested in the topic, but have no technical background, with a fundamental introduction to the report. The challenge here is that while most of the public has a feel for transportation, what we are really talking about is radiation dose, which is not obvious, and the risk of that dose, which even less obvious. Furthermore, dose and risk have their own lexicon, which is not easily translated using common language. Also, the more simply you try to describe a complex topic, the less accurate and/or complete the description becomes [redacted] (b)(5)

Our approach in the Public Summary was to strike a balance between clarity and completeness by using straightforward illustrations and graphics to (hopefully) convey enough technical information for the results to make sense. Some of the public comments we received on the Draft report were complimentary of the Public Summary So, I would like to think we will at least partially succeed in addressing accessibility and transparency in the Final report too, but we really won't know until after we publish it.

Now as to another separate brochure, it is my view that Public Summary described above obviates that need. Also note that, unlike the Draft, the Final report will be printed in full-color. The contract supporting SFTRA expires in March 2014, and we have no funds currently budgeted to make any revisions to the text, figures, graphs, tables etc., beyond that point. However, I don't believe we would object if you wanted to develop a separate brochure, provided that you take the text, figures, graphs, tables, etc. as-is from the Final report. [Note this does not constitute any commitment of SFST resources to support such an effort.]

Those are my thoughts. Hope they help.

-John

From: Conley, Maureen
Sent: Wednesday, January 08, 2014 4:55 PM
To: Cook, John
Subject: checking on risk assessment

Hi, John. Just wanted to check with you on the status of the transportation risk assessment. I see the draft but not the final. Are we still waiting for publication?

I'm interested partly because I am reviewing a very outdated spent fuel transportation brochure that OPA published in 2003 (that includes way too much about NWPA and Yucca Mountain, even alluding to PFS). We are weighing whether to spike it altogether or update it. My inclination is to update and refocus it on this new risk assessment. I believe the current brochure was issued when the Package Performance Study was being planned. While we have no definite prospects for transporting spent fuel in the near future, with all the reactors shutting down, there is a growing population that will be clamoring to get the

(b)(5)

I know your executive summary is intended for general public consumption. We could put that language in our glossy full-color brochure (assuming my supervisor approves). Curious to know what you think….

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Conley, Maureen
To:	Cool, Donald
Subject:	RE: how does this language sound?
Date:	Friday, January 30, 2015 4:00:00 PM

K thanks!

From: Cool, Donald
Sent: Friday, January 30, 2015 3:58 PM
To: Conley, Maureen
Subject: RE: how does this language sound?

Looks Good

From: Conley, Maureen
Sent: Friday, January 30, 2015 3:13 PM
To: Cool, Donald
Subject: RE: how does this language sound?

Definitely not! But I'm going to tweak your tweaks. Let me know if it still works.

From: Cool, Donald
Sent: Friday, January 30, 2015 10:09 AM
To: Conley, Maureen
Subject: RE: how does this language sound?

See below suggestions. Too geeky?

From: Conley, Maureen
Sent: Friday, January 30, 2015 10:00 AM
To: Cool, Donald
Subject: how does this language sound?

For my updated brochure on spent fuel transportation safety:

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests, that are used in health care. Radiation that can be traced to ~~nuclear power or~~ radioactive materials transport makes up a tiny fraction of an average person's overall exposure. ~~For~~ Such low levels of exposure~~,~~ are very unlikely to have any biological effect, but if they did they would be too ~~s are so~~ small ~~that, if they exist, they would not~~ to be detectable ~~they may not even be detectable~~. The human body responds to radiation in ~~Radiation behaves~~ the same way whether it comes from natural or manmade sources.

Thanks!
Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Conley, Maureen
To:	Jackson, Gerard
Cc:	Gott, William
Subject:	RE: question - spent fuel transport security
Date:	Thursday, February 05, 2015 6:05:00 PM

Thanks for your comments, Gerry. Since this is a brochure for the public, I'd like to keep the language as-is RE: your first comment. Our current brochure has images of the Nureg covers for all the relevant Nuregs, so we'll probably add in 0561—and that way people will have the title.

RE: your second comment, to keep this in as simple language as possible, how about, Devices that allow drivers and escorts to shut the vehicle off?

Maureen

From: Jackson, Gerard
Sent: Thursday, February 05, 2015 11:19 AM
To: Conley, Maureen
Cc: Gott, William
Subject: RE: question - spent fuel transport security

Maureen,
Happy to go over anything else.
I just made two changes. I made the rule statement the title of the NUREG for consistence and the same with the comment on the immobilization devise requirement.

Best regards,
Gerry

From: Conley, Maureen
Sent: Thursday, February 05, 2015 9:31 AM
To: Jackson, Gerard
Cc: Gott, William
Subject: RE: question - spent fuel transport security

Thanks, Gerry. If you could just make sure the language we have is accurate, I would greatly appreciate it:

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the ~~physical protection of spent fuel transport include:~~ physical protection of spent nuclear fuel (SNF) during transportation by road, rail and water.

• Coordinating with law enforcement agencies before the shipment
• Requiring advance notice to States and the NRC
• Using a communications center and other means to monitor shipments while in route
• Armed escorts, and
• ~~Remote devices that allow vehicles to be turned off.~~ Driver and escorts assigned to the vehicle are provided a means to immobilize the transport vehicle.

Since September 11, 2001, the NRC has taken additional steps to protect the public.

Regards,

Maureen

From: Jackson, Gerard
Sent: Wednesday, February 04, 2015 2:36 PM
To: Conley, Maureen
Cc: Gott, William
Subject: RE: question - spent fuel transport security

Yes,
Sorry for the delay.
Do you also need the safety aspects of transporting spent fuel.
For your reference for spent fuel you can reference NUREG-0561 Rev.2 (Spent Fuel Only)
But if you wish me to review I can do that.

Best
Gerry

From: Conley, Maureen
Sent: Friday, January 30, 2015 9:55 AM
To: Jackson, Gerard
Subject: question - spent fuel transport security

Hi, we spoke about a year ago when a reporter was looking at our approval of a transport route through Buffalo for those shipments from Canada to Savannah River. I have been updating our brochure on spent fuel transportation and there's a very short section that deals with security. Would you be the right person to review that? Or if not, who can I send it to? This is the extent of it:

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:
• Coordinating with law enforcement agencies before the shipment
• Requiring advance notice to States and the NRC
• Using a communications center and other means to monitor shipments while in route
• Armed escorts, and
• Remote devices that allow vehicles to be turned off.

Since September 11, 2001, the NRC has taken additional steps to protect the public.

Just want to be sure we are accurate and including the most important information. Thanks for any help you can provide!

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Harrington, Holly
To:	Conley, Maureen
Cc:	Couret, Ivonne
Subject:	RE: that NUREG brochure
Date:	Thursday, January 09, 2014 10:11:20 AM

If you'd like to redo it that's fine with me. I'm cc'ing Ivonne so she'll circle back to graphics and update my original response that we weren't doing any NUREGs this year.(oops)

From: Conley, Maureen
Sent: Wednesday, January 08, 2014 5:08 PM
To: Harrington, Holly
Subject: that NUREG brochure

Holly,

I have reviewed the Safety of Spent Fuel Transportation brochure. It has a lot of good graphics but (b)(5) [redacted] (b)(5) Most of the content exists in other products, but there is some good language about how we assess the risks of transporting spent fuel that I haven't seen elsewhere. I checked with Dave and he's not aware of it existing in any other OPA product.

My recommendation is to refocus the brochure on the new spent fuel transportation risk assessment (the one we did the blog post on several months ago). I believe the current brochure was issued when the Package Performance Study was being planned (major, expensive tests on actual casks that would've taken fuel to Yucca Mountain). (b)(5) (b)(5) [redacted] (b)(5) So I think it is a good idea for us to have a user-friendly product that addresses the actual risks.

I don't believe the final risk assessment is out yet, but it will include an executive summary intended for general public consumption. We could combine that language with some of the other good basic transportation risk assessment stuff in our glossy full-color brochure.

Happy to talk more about this tomorrow if you want.

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Conley, Maureen
To:	Lombard, Mark
Cc:	Marcano, Damaris; Hsia, Anthony
Subject:	RE: updating spent fuel transportation brochure
Date:	Friday, November 28, 2014 11:22:00 AM
Attachments:	Safety of Spent Fuel Transportation brochure working draft.docx

Sure do. Here is an unedited version.

I'm taking a first cut to simplify some of the language. I will send that as well in redline/strikeout when I'm done going through it. The current version comes in at a 12.2 reading grade level. We aim for 10.0, though in some of these more technical products that can be challenging.

A couple things I think we need to focus on:

Revising language about Yucca Mountain (to be more current [redacted]
Adding the 2013 transportation risk assessment
Adding info on the MacArthur Maze and Baltimore tunnel fire studies
Addressing high burnup spent fuel.

I'll try to wrap up my first run-through by this afternoon.

Maureen

From: Lombard, Mark
Sent: Friday, November 28, 2014 11:13 AM
To: Conley, Maureen
Cc: Marcano, Damaris; Hsia, Anthony
Subject: RE: updating spent fuel transportation brochure

Thanks Maureen. Do you have a Word or other electronic version that we can use to do redline/strikeout please?

From: Conley, Maureen
Sent: Friday, November 28, 2014 9:43 AM
To: Lombard, Mark; Hsia, Anthony
Cc: Marcano, Damaris
Subject: updating spent fuel transportation brochure

All,

I am finally getting around to updating this March 2003 brochure. I can handle most of the text myself but wanted to coordinate with you to make sure it's factually accurate and includes the latest information and images. No hard deadline on this, but it would be useful to have to hand out at public meetings as they arise.

Here's a link to the electronic version on our website:
http://pbadupws.nrc.gov/docs/ML0311/ML031140098.pdf

We have hard copies here as well, let me know if you want any and I'll run them over.

Thanks!

Maureen Conley
NRC Office of Public Affairs
301-415-8202

Original grade level 12.2

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency established by the U.S. Congress in 1974 to ensure adequate protection of public health, safety, and the environment in the use of nuclear materials. The NRC regulates commercial nuclear power reactors; non-power research, test, and training reactors; and fuel cycle facilities. The NRC also regulates medical, academic, and industrial uses of nuclear materials, as well as packaging for the transport, storage, and disposal of nuclear materials and waste. In addition, the NRC regulates the design, manufacture, use, and maintenance of containers for high-level radioactive shipments.

The U.S. Department of Transportation (DOT), in coordination with the NRC, sets rules governing the packaging of nuclear materials. With NRC and the affected states, DOT regulates the transport of nuclear materials. The DOT also regulates carriers of nuclear materials, sets standards for transportation routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE), among other things, oversees the development of disposal systems for spent nuclear fuel from the nation's nuclear power plants. This activity is entirely funded by fees collected from nuclear power plant companies and ultimately from rate payers.

The International Atomic Energy Agency (IAEA) serves as the world's principal intergovernmental forum for scientific and technical cooperation in the nuclear field. An agency of the United Nations, the IAEA published regulations for transporting nuclear materials. These regulations serve as a model for the United States and other nations.

The NRC has three principal functions:
1. to set standards and develop regulations;
2. to issue licenses for nuclear facilities and nuclear materials users; and
3. to inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The U.S. Nuclear Regulatory Commission (NRC) regulates the nuclear materials cycle from beginning to end. This cycle begins with the mining of uranium. It continues through the manufacture of fuel, its use in reactors, any temporary storage, and (ultimately) with permanent geologic disposal.

The NRC is dedicated to maintaining public health and safety, protecting the environment, and ensuring our national security in ways that increase public confidence in the agency. The NRC plans to achieve these goals by making its activities more effective, efficient, and realistic, and by reducing unnecessary regulatory burden on all those involved in the use, handling, transport, and disposal of nuclear materials.

The NRC believes that proper handling of nuclear materials will help to ensure the safety of the public and plant workers. Toward that end, the NRC works with other agencies, such as the U.S. Department of Transportation (DOT), the U.S. Department of Energy (DOE), and the International Atomic Energy Agency (IAEA).

This booklet relates to the NRC's role in the safe transportation of spent nuclear fuel from commercial nuclear power plants. Specifically, the NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments.

Radiation

Scientists estimate that nearly 90 percent of all radiation exposure comes from natural sources: radon gas, the human body, outer space, rocks, and soil. Background radiation is naturally present, but its levels can vary greatly. People living in areas with a significant amount of granite, for example, receive more earth-based radiation. Those living or working at high altitudes receive more cosmic radiation. Most natural exposure is from radon, a gas that seeps from the earth's crust into the air we breathe. The remaining 10 percent of all radiation exposure comes from man-made sources, primarily medical x-rays. Natural and artificial radiation are similar in kind and effect.

What is Spent Fuel?

Nuclear reactors produce electricity and, as a waste product, spent fuel. Uranium fuel powers reactors for a number of years, until its potential to produce electrical power is exhausted. The used uranium fuel is then referred to as "spent fuel." Nuclear power plants store spent fuel in enclosed cooling pools and, in some cases, in dry storage casks to await shipment to a temporary storage or permanent disposal facility. The Nuclear Waste Policy Act (NWPA), enacted by Congress in 1992, calls for spent fuel to be moved to a temporary storage facility or to a permanent DOE repository.

The NWPA sets a national policy for safe, permanent disposal of spent nuclear fuel and other radioactive wastes in an underground repository. The action by Congress and the President in July 2002 approving Yucca Mountain will permit the DOE to apply to NRC to construct the repository.

The NRC's role under the NWPA is to use its independent judgment as an expert technical agency to decide whether to grant DOE a license to construct a high-level waste repository at Yucca Mountain. Only after extensive review of a DOE application will the NRC be able to judge whether DOE has satisfied the demands of the regulations. The NWPA gives NRC up to four years to decide whether to grant the license.

Because a repository won't be available for some time, some nuclear power plants are implementing plans for temporary storage on site. Other plants plan to store spent fuel away from the reactor at a temporary site until a permanent repository is built.

Given the widespread locations of power reactors, if a disposal site is finally approved, licensees will need to transport spent fuel to that site safely. These shipments would likely be made on railroads and on public highways.

Spent fuel is highly radioactive and must be transported in large, heavy containers that shield the public from exposure. This raises the following frequently asked questions in connection with such shipments:
• How does the NRC protect the public from radioactive waste that is being transported?
• What is the likelihood of these shipments being involved in an accident?
• How well can the transportation containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technologies and information become available, the NRC continually evaluates its existing safety requirements.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

Spent fuel is highly radioactive and must be heavily shielded and tightly contained to be transported safely. An essential component for any safe shipment is a robust spent fuel container, or "cask."

The NRC establishes regulations and standards for the design and construction of robust casks as the primary way to protect the public during transport. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. U.S. and international regulations require that these containers must pass a series of tests that mimic accident damage. The NRC conducts rigorous reviews to certify that spent fuel containers meet the design standards and test conditions in the regulations.

These containers must be shown, by test or analysis, to survive a sequence of four simulated accident conditions involving impact, puncture, fire, and submersion. During and after the tests, the containers must contain nuclear material, limit doses to acceptable levels, and prevent nuclear reaction.

To protect workers and the public, containers have walls five to 15 inches thick, made of steel and shielding materials, and a massive lid. Truck containers weigh about 25 tons when loaded with 1 to 2 tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In the event of an accident, these limiters would crush, absorbing impact forces and protecting the container and its cargo.

Spent fuel containers are tightly sealed and provide shielding for most radiation. However, it is not possible to eliminate all radiation with shielding. Containers provide enough shielding to reduce external radiation to low levels that meet DOT and NRC radiation standards for the radiation dose to individuals who might be near the cask during transport.

Container designers may use computer analyses, comparisons with other designs, component testing, scale-model testing, or a combination of these techniques to demonstrate that containers are safe. Most often, they use a combination of computer analyses and physical testing. NRC evaluates each application for a container design, examines the information in depth, and then performs its own calculations. NRC reviewers include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC issues a Certificate of Compliance for a spent fuel container design, fabricators make the containers. Manufacturers and shippers must adhere to a program that ensures the containers continuously meet design specifications.

NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure that radiation levels and contamination levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet the applicable NRC safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments regulated by the NRC have been completed safely in the U.S. during the past 25 years. Although there have been four accidents involving those shipments, none have resulted in a release of radioactive material.

Experience with past shipments confirms that the fundamental safety system is sound. The question becomes, "What might happen if there are *thousands* of future shipments?" The NRC continuously evaluates risks associated with spent fuel transport in a methodical and scientific way. To provide additional confidence, the NRC has sponsored several risk studies related to spent fuel transportation on highways and railroads.

In 1977, the NRC completed a study that has since become the "baseline" for comparison with new information and studies completed since then.

In 1987, the NRC used improved research methods to evaluate how shipping containers react in accidents and to estimate the risk of releasing radioactive materials. The study results added assurances about the ability of shipping casks to withstand an accident and confirmed results of the 1977 study.

Another study, released in March 2000, used improved technology to analyze the ability of containers to withstand an accident. This study concluded that the risk from the increased number of spent fuel shipments that could occur in the first half of this century would be even smaller than originally estimated in 1977.

On the basis of these studies, operational experience, and its own technical reviews, the NRC concluded that the shipment of spent fuel is safe at projected shipment levels. The NRC is continuing to follow developments in spent fuel shipping, including the performance of additional analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the possibility of injury, damage, or some kind of loss. Given that understanding, the spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies indicate that this risk is low. As a part of its safety effort, minimizing risk is an important concept to the NRC. The NRC's risk assessment asks the following three questions and then converts the answers into numbers to arrive at a risk value:

- What can go wrong?
- How likely is it?
- If something goes wrong, what are the consequences?

Although the overwhelming majority of spent fuel shipments are accident-free, researchers calculate radiation risks to the public using two scenarios. One scenario involves a journey during which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects on a container.
Step 1. Experts use historic records to determine what might happen.
• They also gather data on how many spent fuel shipments are likely each year.
• They look at the rate of accidents for rail and highway shipments.
• Researchers look at a large number of accidents that are conceivable.
• They also look at crash impact forces, fires, or punctures that are more severe than those covered by NRC standards.

Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

The Accident Scenario

NRC studies show that fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions of the design standards. However, if a very unlikely chain of events occurs, the accident might be severe enough to cause a radioactive release.

To estimate the likelihood and consequences of unusually severe accidents, researchers use a multi-step approach to calculate risk. That approach uses accident data and their experience with past trucking and rail accidents involving other hazardous materials. This also involves determining what kinds of accidents could happen and looking at their potential effects.

According to the DOE Final Environmental Impact Statement (FEIS) for the Yucca Mountain Project, about 11,000 rail or 53,000 truck shipments might be expected during the 24 years of operation of the repository, should it be approved. The chances that any accident would occur during a spent fuel shipment are about 1 in 10,000 for rail shipments and 1 in 1,000 for highway transport. Put another way, these estimates indicate that 1 to 50 accidents involving casks are conceivable in the process of moving all current spent fuel to a permanent repository.

Looking at these conceivable accidents, the chance that even one would be serious enough to lead to even a small release is about 1 in 1,000. The chance of a large release is estimated to be less than one in 1,000,000.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.
• They gather data on how much spent fuel each container will carry.
• They analyze how the fuel might respond in a given type of accident.
• They calculate the temperature of the container and the spent fuel itself during a long-term fire.
This information provides estimates on the size of any potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the assessments from Step 2 to determine the chance of severe damage to the container or its contents.

Step 4. Researchers compute a risk estimate with a special computer program. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident-Free Scenario

In an accident-free journey, nothing goes wrong and no nuclear material is released from the container. In this scenario, the total of all radiological exposures, or doses, that could be received by all people along the transportation route, is calculated. Because spent fuel, even fully contained, still emits low levels of radiation through the container walls, researchers use route and population information to estimate the number of people who could be exposed and the total radiation dose that they might receive.

The risk to the public from an accident-free journey results from the low-level radiation field that surrounds the spent fuel container. If the container is moving past a person, perhaps someone standing along the highway or railroad track, the exposure is brief and well below regulatory limits. Exposure will vary depending upon the speed of the train or tractor-trailer rig and the distance the person is standing from the highway or track. The very low dose to each person along the route is added to obtain the total population dose.

As a basis for comparison, a passenger traveling round-trip by air from New York to Los Angeles receives a background radiation dose that is 25 times greater than the dose to persons closest to a typical spent fuel shipment.

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by:
– Regulating the design and construction of shipping containers.
– Reviewing designs and independently checking a container's ability to meet accident conditions.
– Ensuring that containers are built, maintained, and used properly.

• The NRC also follows an aggressive program to investigate and assess the risks involved in spent fuel shipments:
– Analyzing spent fuel transportation records to understand safety issues better.
– Evaluating new transportation issues, such as increased shipment levels, denser populations along some routes, and other factors.
– Using new technology to estimate current and future levels of potential risk to the public.

Although there will always be a slight chance that an accident will cause a release of nuclear material, the NRC has found that the likelihood of such an event and the associated risk to the public are extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates the physical protection of spent nuclear fuel in transit against sabotage or other malicious acts. The NRC's current physical protection regulations for spent fuel transportation include:
• Pre-shipment coordination with law enforcement agencies
• Pre-shipment notice of States and NRC
• In-transit shipment call-in to communications center
• Shipment monitoring
• Armed escorts (in populated areas)
• Immobilization devices

Since September 11, 2001, the NRC has taken additional steps to protect the public. These steps involve a heightening of the security posture, including new measures taken to protect nuclear facilities and regulated activities, such as spent fuel transportation, and orders that NRC has issued to licensees.

For Additional Information Contact:

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NRC

U.S. Nuclear Regulatory Commission

NUREG/BR-0292
March 2015

From:	Lombard, Mark
To:	Conley, Maureen
Cc:	Pstrak, David; Rubenstone, James; Hsia, Anthony; Marcano, Damaris
Subject:	Safety of Spent Fuel Transportation brochure working draft rev 1 Pstrak_JR (2).docx
Date:	Wednesday, December 31, 2014 1:57:55 PM
Attachments:	Safety of Spent Fuel Transportation brochure working draft rev 1 Pstrak_JR (2).docx

Maureen,

Sorry I sat on this so long. Attached are our comments on the draft brochure. David is checking on one item. We can discuss next week if you are available.

Mark

Original grade level 12.2

Title?

Once the text is agreed upon and finalized, the photos that will be included as part of the brochure will need to be reviewed.

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The U.S. Nuclear Regulatory Commission (NRC) is an independent agency established by Congress. Its mission is to license and regulate the ~~Nation's~~ nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And Additionally, It licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT works with the NRC and affected states to regulate their transport. DOT also regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactorsplants.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. As pPart of the United Nations, the IAEA sets global regulations for many areas of the nuclear industry, including nuclear materialspackaging and transportation. These IAEA's packaging and transportation regulations serve as a model for the United States and other nations.

The NRC has three main functions:
1. to set standards and develop regulations,
2. to issue licenses for nuclear facilities and nuclear materials users; and
3. to inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. It begins with the mining of uranium, and The cycle continues through the manufacture of fuel, its use in reactors, transportation, storage, and permanent geologic disposal.

The NRC works to maintain public health and safety, protect the environment and ensure our national security. To maintain the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic to It also strives to keep the regulatory burden reasonable on all those involved in the use, handling, transport, and disposal of nuclear materials.

Proper handling of nuclear materials will help to ensure the safety of the public and plant workers. That is why the NRC works with ~~other agencies~~the DOT and DOE in the U.S. and the IAEA internationally to ensure these materials are ~~handled~~ packaged and transported safely.

This booklet explains the NRC's role in ensuring spent nuclear fuel from commercial nuclear power plants is packaged and transported safely. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments.

Radiation

~~Scientists say about~~ About 90 percent of all radiation exposure comes from natural sources: radon gas, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly. People living in areas with a lot of granite, for example, receive more radiation from the earth. Those living or working at high altitudes receive more cosmic radiation. Most natural exposure is from radon, a gas that seeps from the earth's crust into the air we breathe. The remaining 10 percent of all radiation exposure comes from man-made sources, mainly medical x-rays. Natural and artificial radiation are similar in kind and effect.

What Is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act (NWPA) sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 ~~picked~~ selected Yucca Mountain in Nevada as the site to be studied for an underground repository. DOE applied to the NRC in 2008 ~~to~~ for a permit to construct the repository ~~there~~ at Yucca Mountain. But DOE withdrew its application in 2010. The NRC's role is to assess whether the proposed facility meets NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will likely be some time before a geologic repository is available. All nuclear power reactors ~~plants~~ move their spent fuel first into pools for storage on site. As the ~~amount~~ volume of spent fuel in the pool increases ~~grows~~, many reactors are also using dry casks for storage ~~casks~~. The NRC reviews, ~~and~~ approves, and issues certificates for the design of these dry cask ~~designs for these systems~~.

Since the proposed repository at Yucca ~~Mountain~~for spent fuel is ~~not currently operating~~, the DOE is considering storage of spent fuel, perhaps at a consolidated facility in the U.S. Once a ~~central~~ location for storage or disposal is approved, spent fuel will need to be transported there ~~safely~~ from sites around the country. These shipments would likely be made on railroads ~~using specially designed casks and railcars as well as~~ ~~and~~ on public highways, using specially-designed casks on railcars or heavy-haul trucks.

Because spent fuel is highly radioactive, this raises the following questions:

- How does the NRC protect the public from the hazards associated with spent fuel and other radioactive waste during transportation ~~that is being transported~~?
- What is the likelihood of a ~~these~~ shipments of these types of material being involved in an accident?
- What steps does the NRC take to ensure that ~~How well can~~ the transportation containers can withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to continue to ensure safe transport. As new technologies and real-world information become available, the NRC continually evaluates its existing regulations and safety requirements. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 30 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

The highly radioactive ~~Spent~~ spent fuel ~~is highly radioactive and~~ must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container~~,~~ ~~or~~ called a "cask."

The NRC ~~regulates~~ reviews and approves the design and construction of these casks to ensure the public is protected from the associated hazards. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these containers must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be ~~able~~ designed to survive a sequence of four tests, including a 30-foot drop test onto an unyielding surface, a puncture test, a fully engulfing fire at 1475 degrees Fahrenheit for 30 minutes, and immersion under ~~involving impact, puncture, fire and submersion~~ in water. During and after the tests, the casks must contain the nuclear material contents, limit radiation doses to acceptable levels, and prevent a nuclear criticality reaction.

To protect workers and the public, a cask has walls of steel and shielding materials five to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. Impact limiters contain crushable foam and/or wood that act to absorb the impact energy in a test or real-life accident. In an accident, these impact limiters would crush and absorb the ~~absorbing~~ impact forces ~~and~~, thereby protecting the container and its ~~cargo~~ content.

Spent fuel containers are engineered to be tightly sealed, very robust, and include ~~and provide~~ heavy shielding material to lower the associated radiation levels. ~~But~~ While it is not possible to shield all the radiation, ~~The~~ the containers must ~~provide~~ include enough shielding to protect anyone who might be near the cask during transport.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale-model ~~testing~~, or a combination of these techniques. Most often, they use a combination of computer analyses and physical testing. They meet with technical review staff from the NRC and explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and then performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural, ~~and~~ materials, thermal, and criticality engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC has completed its review and is satisfied that a design meets the requirements, it issues a Certificate of Compliance, which specifies, for example, the materials of construction, the authorized contents, and the size dimensions of the container. Then the containers can be manufactured and put into service~~used~~. Manufacturers and shippers use quality assurance have special programs to ensure the containers meet design specifications throughout fabrication and transportation. As a means to ensure the provisions of the Certificate of Compliance are being met, NRC staff conduct inspections at both the manufacture and shipper facilities.

While having a certificate for a package design ensures the safety of the package during transportation, certain requirements of the NRC and DOT must also be met prior to offering a package for shipment.~~But just having a certificate does not mean a cask can be used.~~ Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and ~~tests~~assessments to ensure radiation levels are within the specified safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments regulated by the NRC have been completed safely in the U.S. during the past 25 years. Although there have been four accidents, none ~~has~~ have resulted in a release of radioactive material or a fatality due to exposure to radiation.

This experience confirms that the safety system is sound. In other words, the regulatory requirements of the NRC for package certification coupled with the transportation requirements of both the NRC and the DOT ensure the safety of the package during transportation. But will this hold true ~~when there are~~for increased shipping ~~campaigns~~that moves spent fuel to a future ~~proposed~~ repository or a ~~centralized~~consolidated storage facility ~~thousands of in the future shipments~~? The NRC continuously evaluates risks associated with spent fuel transport in a methodical and scientific way. To provide additional confidence, the NRC has sponsored several risk studies over the years related to spent fuel transport on highways and railroads.

In 1977, the NRC completed a study that is now seen as the "baseline" for comparison with new information and studies completed since then. That study concluded that the transportation regulations adequately protect the public, and provided confidence to the public of the important safety role that NRC has~~allowed the NRC to say its transportation regulations adequately protect the public.~~

In 1987, the NRC used improved research methods to see how shipping containers react in accidents and to estimate the risk of releasing radioactive materials. The study results provided added assurance that certified shipping casks would withstand an accident.

Another study conducted in 2000 analyzed how well containers would ~~hold up in~~withstand an accident. Using improved technology, this study found the risk would be even smaller than originally estimated in 1977, even if the number of spent fuel shipments increased greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. The study confirmed that NRC regulations for spent fuel transport are adequate to ensure safety of the public and the environment. It examined how three NRC-certified packages would behave during both normal shipments and accidents. The study~~It~~ modeled a variety of transport routes using population data from the 2000 census, as updated in 2008, and ~~It~~ used actual highway and rail accident statistics. Using state-of-the-art computer models, the study~~It~~ considered doses from normal shipments to people living along transportation routes, occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. ~~And it used state-of-the-art computer models.~~ The risk assessment found:

- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year
- There is less than a 1 in 1 billion chance that radioactive material would be released in an accident
- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm

Commented [MEC18]: This language comes out of the blog post John Cook and I put together on the risk assessment http://public-blog.nrc-gateway.gov/2013/09/19/transporting-spent-nuclear-fuel-how-do-we-know-its-safe/

On the basis of these studies, operational experience, and its own reviews, the NRC concluded that the shipment of spent fuel will be safe, even ifs hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic transportation safety standards

While shipping spent fuel does involve risk, NRC studies show this risk is low As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers

• What can go wrong during transportation?
• How likely is it to occur?
• If something goes wrong, what are the consequences for the package and the public?

The overwhelming majority of spent fuel shipments are accident-free To calculate the radiation risks to the public, researchers use two scenarios One involves a trip on which an accident occurs, the other covers the vast majority of journeys that do not involve an accident

Researchers use a four-step process to study actual and potential accidents and their effects.
Step 1. Experts determine what might happen.
• They gather historic records.
• They also put together data on how many spent fuel shipments are likely each year.
• They look at the rate of accidents for rail and highway shipments.
• They look at a large number of accidents that are credible.
• They also look at crash impact forces, fires or punctures. They pick forces that are more severe than those covered by NRC standards.

The Accident Scenario

NRC studies show that the ~~chance~~likelihood of an accident is low, and that fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions
the design standards However, if a very unlikely chain of events occurs, the accident might be severe enough to cause a radioactive release

To estimate the risk of unusually severe accidents, researchers use a multi-step approach. They use data and their experience with past trucking and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

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According to the DOE Final Environmental Impact Statement for the Yucca Mountain Project, about 11,000 rail or 53,000 truck shipments might be expected during the 24 years of operation of the repository. The chances that any accident would occur during a spent fuel shipment are about 1 in 10,000 for rail shipments and 1 in 1,000 for highway transport. Put another way, these estimates indicate that approximately 1 to 50 accidents involving casks are conceivable in the process of moving spent fuel to a repository.

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Looking at these conceivable accidents, the chance that even one would be serious enough to lead to even a small release is about 1 in 1,000. The chance of a large release is estimated to be less than one in 1,000,000,000.

***Step 2.** Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.*

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

***Step 3.** Researchers match accident scenarios from Step 1 with the analyses from Step 2. This gives them the chance of severe damage to the container or its contents.*

***Step 4.** Researchers use a special computer program to compute a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.*

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. In this scenario, experts calculate the total radiation dose that all people along the route could receive. Because spent fuel emits low levels of radiation through the cask walls, researchers estimate the total radiation dose to people who could be exposed. They use information on routes and local populations to determine the number of people who might be affected and the dose they might receive.

> The risk to the public from an accident-free journey results from the very low radiation field that surrounds the transport cask. If the container is moving past a person, such as someone standing along the highway or railroad track, the exposure is brief and well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. The very low doses to each person along the route are added to get the total population dose.

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The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by

– ~~Regulating~~Reviewing and certifying their design and conducting inspections during construction
– Reviewing designs and independently checking a container's ability to meet accident conditions
– Ensuring casks are built, maintained, and used properly

• The NRC also investigates and assesses the risks involved in spent fuel shipments. The agency
– Analyzes spent fuel transport records to fully understand safety issues
– Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
– Keeps up with technology as it evolves to refine estimates of current and future risk to the public

Although there will always be a slight chance that an accident will cause a release of nuclear material, the NRC has found that the likelihood of such an event and the risk to the public are extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates the protection of spent nuclear fuel in transit against sabotage, theft, or diversion or other malicious acts. The NRC's current ~~rules~~ regulations for the physical protection of spent fuel transport include:
• Coordinating with law enforcement agencies before the shipment
• Requiring advance notice to States and the NRC
• Using a communications center and other means to monitor shipments while in route
•
• Armed escorts ~~and~~
• Immobilization devices

Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:

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NRC

U.S. Nuclear
Regulatory
Commission
NUREG/BR-0292
March 2015

Original grade level 12.2

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency established by ~~the~~ U.S. Congress. Its mission is to license and regulate the Nation's civilian use of radioactive materials in a way that protects public health and the environment. ~~in~~ 1974 ~~to ensure adequate protection of public health, safety, and the environment in the use of nuclear materials.~~ The NRC regulates commercial nuclear power reactors; non-~~power~~ research, test, and training reactors; ~~and~~ nuclear fuel cycle facilities; and . The NRC ~~also~~ regulates medical, academic, and industrial uses of nuclear materials. The NRC also regulates, ~~as well as~~ packaging for the transport, storage, and disposal of nuclear materials and waste. And it. ~~In addition~~, the NRC ~~regulates~~ the design, manufacture, use, and maintenance of containers for high-level radioactive shipments. licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates, ~~in coordination~~ with the NRC to, sets rules for governing the packaging of nuclear materials. ~~With NRC and the affected states, DOT~~ works with the NRC and affected states to regulates their transport ~~of nuclear materials~~. The DOT also regulates carriers of nuclear materials, sets standards for transportation routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for , among other things, oversees the development of disposal systems for of spent nuclear fuel from the nation's nuclear power plants. This activity is entirely funded by fees collected from nuclear power plant companies and ultimately from rate payers.

The International Atomic Energy Agency (IAEA) is aserves as the world's principal intergovernmental forum for scientific and technical cooperation in the nuclear field. ~~An agency~~ Part of the United Nations, the IAEA sets global ~~published~~ regulations for transporting nuclear materials transport. These regulations serve as a model for the United States and other nations.

The NRC has three principal main functions:
1. to set standards and develop regulations;
2. to issue licenses for nuclear facilities and nuclear materials users; and
3. to inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The ~~U.S. Nuclear Regulatory Commission~~ (NRC) regulates the nuclear ~~materials~~ fuel cycle from beginning to end. ~~This cycle~~It begins with the mining of uranium. ~~It~~ The cycle continues through the manufacture of fuel, its use in reactors, any ~~temporary~~ storage, and (~~ultimately~~) with permanent geologic disposal.

The NRC works is ~~dedicated~~ to maintaining public health and safety, protecting the environment, and ensureing our national security ~~in ways that increase public confidence in the agency~~. To maintain the public's confidence, tThe NRC aims ~~plans~~ to do its work openly and to ~~achieve these goals by making its activities more~~ be effective, efficient, and realistic. ~~and by~~ to It also strives to keep the ~~reducing unnecessary~~ regulatory burden reasonable on all those involved in the use, handling, transport, and disposal of nuclear materials.

~~The NRC believes that~~ pProper handling of nuclear materials will help to ensure the safety of the public and plant workers. That is why ~~oward that end~~ the NRC works with other agencies in the U.S. and internationally to ensure these materials are handled and transported safely. ~~such as the U.S. Department of Transportation (DOT), the U.S. Department of Energy (DOE), and the International Atomic Energy Agency (IAEA).~~

This booklet ~~relates~~ explains~~to~~ the NRC's role in ensuring ~~the safe~~ ~~transportation of~~ spent nuclear fuel from commercial nuclear power plants is transported -~~Specifically~~. thesafely The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments.

Radiation

Scientists say about estimate that nearly 90 percent of all radiation exposure comes from natural sources: radon gas, the human body, outer space, rocks, and soil. This natural Background radiation is called "background" and naturally present, but its levels can vary greatly. People living in areas with a lot significant amount of granite, for example, receive more earth-based radiation from the earth. Those living or working at high altitudes receive more cosmic radiation. Most natural exposure is from radon, a gas that seeps from the earth's crust into the air we breathe. The remaining 10 percent of all radiation exposure comes from man-made sources, mainly primarily medical x-rays. Natural and artificial radiation are similar in kind and effect.

What is Spent Fuel?

Nuclear reactors ~~produce~~ make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor ~~powers reactors~~ for a number of years until it needs to be replaced. ~~until its potential to produce electrical power is exhausted~~. The used ~~uranium~~ fuel is then ~~referred to~~known as "spent fuel." It must be stored safely ~~Nuclear power plants store spent fuel in enclosed cooling pools and, in some cases, in dry storage casks~~ until it can be shipped ~~to await shipment~~ offsite. ~~to a temporary storage or permanent disposal facility~~.

The Nuclear Waste Policy Act (NWPA), ~~enacted by Congress in 1992, calls for spent fuel to be moved to a temporary storage facility or to a permanent DOE repository~~

The ~~NWPA~~ sets a ~~national~~ policy for safe, permanent disposal of spent ~~nuclear~~ fuel and other radioactive wastes. Congress in 1987 picked Yucca Mountain in Nevada as the site for ~~in~~ an underground repository. The action by Congress and the President in July 2002 approving ~~Yucca Mountain will permit the~~ DOE to appliedy to the NRC in 2008 ~~to~~ for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the proposed facility meets NRC regulatory requirements. Other policy considerations are up to DOE and Congress ~~under the NWPA is to use its independent judgment as an expert technical agency to decide whether to grant DOE a license to construct a high-level waste repository at Yucca Mountain. Only after extensive review of a DOE application will the NRC be able to judge whether DOE has satisfied the demands of the regulations. The NWPA gives NRC up to four years to decide whether to grant the license~~

It will be some time before ~~Because~~ a repository is ~~won't be~~ available. ~~for some time, some~~ All nuclear power plants move their ~~are~~ spent fuel first into pools for storage on site. As the amount of spent fuel grows, many reactors are also using dry storage casks ~~implementing plans for temporary storage on site. Other plants plan to store spent fuel away from the reactor at a temporary site until a permanent repository is built.~~ The NRC reviews and approves designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there safely from sites around the country. Given the widespread locations of power ~~reactors, if a disposal site is finally approved, licensees will need to transport spent fuel to that site safely~~. These shipments would likely be made on railroads and on public highways.

Because ~~s~~Spent fuel is highly radioactive, ~~and must be transported in large, heavy containers that shield the public from exposure~~. ~~T~~this raises the following ~~frequently asked~~ questions ~~in connection with such shipments~~:

- How does the NRC protect the public from radioactive waste that is being transported?
- What is the likelihood of these shipments being involved in an accident?
- How well can the transportation containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technologies and information become available, the NRC continually evaluates its existing safety requirements. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 30 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

Spent fuel is highly radioactive and must be heavily shielded and tightly contained to be transported safely. ~~An essential component for any~~ ~~s~~Safe shipment requires ~~is~~ a robust spent fuel container, or "cask."

The NRC ~~establishes~~ regulates~~ions and standards for~~ the design and construction of these ~~robust~~ casks to ensure the public is ~~as the primary way to~~ protected ~~the public during transport~~. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, ~~regulations require~~ that these containers must pass a series of tests that mimic accident ~~damage~~forces. The NRC ~~conducts~~ rigorous reviews to certify that spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be ~~shown by test or analysis~~ able to survive ~~a sequence of~~ four tests~~simulated accident conditions~~ involving impact, puncture, fire, and submersion in water. During and after the tests, the ~~containers~~ casks must contain nuclear material, limit doses to acceptable levels, and prevent a nuclear reaction.

To protect workers and the public, a cask ~~containers~~ ha~~s~~ve walls of steel and shielding materials five to 15 inches thick, ~~made of steel and shielding materials~~, and a massive lid. Truck containers weigh about 25 tons when loaded with ~~1~~ one to ~~2~~two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In the event of an accident, these limiters would crush, absorbing impact forces and protecting the container and its cargo.

Spent fuel containers are tightly sealed and provide heavy shielding ~~for most radiation~~. ~~However~~, But it is not possible to ~~eliminate~~ shield all the radiation ~~with shielding~~. The ~~C~~containers must provide enough shielding to protect anyone ~~reduce external radiation to low levels that meet DOT and NRC radiation standards for the radiation dose to individuals who~~ might be near the cask during transport.

~~Container~~ Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, scale-model testing, or a combination of these ~~techniques to demonstrate that containers are safe~~. ~~Most~~techniques. Most often, they use a combination of computer analyses and physical testing.

They explain their design and provide supporting documents in an application. The NRC evaluates each ~~application for a container~~ design, examines the information in depth, and then performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance. Then, ~~for a spent fuel container design, fabricators make~~ the containers can be manufactured and used. Manufacturers and shippers have special ~~must adhere to a~~ programs to ~~that~~ ensures the containers ~~continuously~~ meet design specifications throughout fabrication and transportation.

But just having a certificate does not mean a cask can be used. NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure that radiation levels and contamination levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the ~~the applicable~~ NRC safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments regulated by the NRC have been completed safely in the U.S. during the past 25 years. Although there have been four accidents, ~~involving those shipments~~, none hasve resulted in a release of radioactive material.

This eExperience ~~with past shipments~~ confirms that the ~~fundamental~~ safety system is sound. But will this hold true when there are ~~The question becomes: "What might happen if there are~~ *thousands* of future shipments?" The NRC continuously evaluates risks associated with spent fuel transport in a methodical and scientific way. To provide additional confidence, the NRC has sponsored several risk studies related to spent fuel transportation on highways and railroads.

In 1977, the NRC completed a study that is now seen as ~~has since become~~ the "baseline" for comparison with new information and studies completed since then. That study allowed the NRC to say its transportation regulations adequately protect the public.

In 1987, the NRC used improved research methods to ~~evaluate~~ see how shipping containers react in accidents and to estimate the risk of releasing radioactive materials. The study results provided added assurances that ~~about the ability of~~ shipping casks would ~~to~~ withstand an accident and confirmed results of the 1977 study.

Another ~~study, released in March 2000, used improved technology to~~ analyzed how well the ~~ability of~~ containers would hold up in ~~to withstand~~ an accident. Using improved technology, tThis study found ~~concluded that~~ the risk would be even smaller than originally estimated in 1977 even if ~~from~~ the ~~increased~~ number of spent fuel shipments increased greatly ~~that could occur in the first half of this century would be even smaller than originally estimated in 1977~~.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. The study confirmed that NRC regulations for spent fuel transport are adequate to ensure safety of the public and the environment. It examined how three NRC-certified packages would behave during both normal shipments and accidents. It modeled a variety of transport routes using population data from the 2000 census, as updated in 2008. It used actual highway and rail accident statistics. It considered doses from normal shipments to people living along transportation routes, occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. And it used state-of-the-art computer models. The risk assessment found:

- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.
- There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.
- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

On the basis of these studies, operational experience, and its own ~~technical~~ reviews, the NRC concluded that the shipment of spent fuel is will be safe, even is hundreds of shipments are made each year at ~~projected shipment levels~~. The NRC is continuing to ~~follow developments~~ intrack spent fuel shipping, including the performance of additional more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the ~~possibility~~ chance of injury, damage, or some kind of loss. ~~Given that understanding, t~~The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show ~~indicate that~~ this risk is low. As a part of its safety effort, the NRC aims to minimizeing risk is an important concept to the NRC. To evaluate the risks, tThe NRC's risk ~~assessment~~ asks the following three questions and then converts the answers into numbers to arrive at a risk value:

• What can go wrong?
• How likely is it?
• If something goes wrong, what are the consequences?

Although tThe overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers calculate radiation risks to the public using use two scenarios. One scenario involves a journey tripduring on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects on a container.
Step 1. Experts use historic records to determine what might happen.
• They gather historic records.
• They also gather put together data on how many spent fuel shipments are likely each year.
• They look at the rate of accidents for rail and highway shipments.
• Researchers They look at a large number of accidents that are conceivablecredible.
• They also look at crash impact forces, fires, or punctures. They pick forces that are more severe than those covered by NRC standards.

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Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC ~~to~~ assure safe transportation of spent fuel.

The Accident Scenario

NRC studies show that the chance of an accident is low, and that fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions of the design standards However, if a very unlikely chain of events occurs, the accident might be severe enough to cause a radioactive release.

To estimate the ~~likelihood and consequences~~risk of unusually severe accidents, researchers use a multi-step approach ~~to calculate risk~~. They use ~~That approach uses accident~~ data and their experience with past trucking and rail accidents involving other hazardous materials. Part of this step is to determine ~~This also involves determining~~ what kinds of accidents could happen and looking at what their ~~potential~~ effects might be.

According to the DOE Final Environmental Impact Statement ~~(FEIS)~~ for the Yucca Mountain Project, about 11,000 rail or 53,000 truck shipments might be expected during the 24 years of operation of the repository, should it ~~be approved~~. The chances that any accident would occur during a spent fuel shipment are about 1 in 10,000 for rail shipments and 1 in 1,000 for highway transport. Put another way, these estimates indicate that 1 to 50 accidents involving casks are conceivable in the process of moving ~~all current~~ spent fuel to a ~~permanent~~ repository.

Looking at these conceivable accidents, the chance that even one would be serious enough to lead to even a small release is about 1 in 1,000. The chance of a large release is estimated to be less than one in 1,000,000,000.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- ***They gather data on how much spent fuel each container will carry.***
- ***They analyze how the fuel might respond in a given type of accident.***
- ***They calculate the temperature of the container and the spent fuel itself during a long-term fire.***

This information allows them to estimate provides estimates on the size of any potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the ~~assessments~~ analyses from Step 2. This gives them to determine the chance of severe damage to the container or its contents.

Step 4. Researchers use a special computer program to compute a risk estimate ~~with a special computer program~~. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident-Free Scenario

For most spent fuel shipments, ~~In an accident-free journey,~~ nothing will goes wrong and no nuclear material will be is released ~~from the container~~. In this scenario, experts calculate the total ~~of~~ radiation dose ~~all radiological exposures - or doses~~ that all people along the route could ~~be~~ received ~~by all people along the transportation route~~ ~~is calculated~~. Because spent fuel ~~even fully contained~~, ~~still~~ emits low levels of radiation through the ~~container~~ cask walls, researchers estimate the total radiation dose to people who could be exposed. They use information on routes and local populations ~~information~~ to determine ~~estimate~~ the number of people who might be affected ~~who could be exposed~~ and the ~~total radiation dose that~~ dose they might receive

The risk to the public from an accident-free journey results from the very low~~-level~~ radiation field that surrounds the spent fuel ~~container~~transport cask. If the container is moving past a person, ~~perhaps~~ such as someone standing along the highway or railroad track, the exposure is brief and well below regulatory limits. Exposure will vary depending upon the speed of the ~~train or tractor-trailer rig~~vehicle and how far away ~~the distance~~ the person is standing ~~from the highway or track~~. The very low doses to each person along the route ~~is~~ are added to ~~obtain~~ get the total population dose. ~~As a basis for comparison~~ aA passenger flying ~~traveling~~ round-trip ~~by air~~ from New York to Los Angeles receives a dose from background radiation ~~dose~~ that is 25 times greater than the dose to persons closest to a typical spent fuel shipment.

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by
– Regulating their design and construction ~~of shipping containers~~
– Reviewing designs and independently checking a container's ability to meet accident conditions.
– Ensuring that ~~containers~~casks are built, maintained, and used properly

• The NRC also ~~follows an aggressive program to~~ investigates and assesses the risks involved in spent fuel shipments. The agency
– Analyzes~~ing~~ spent fuel transportation records to fully understand safety issues ~~better~~
– Evaluates~~ing~~ new transportation issues, such as ~~increased~~ projections for the number of shipment ~~levels~~, changes in ~~denser~~ populations along some routes, and other factors.
– Keeps up with ~~Using~~ new technology as it evolves to refine estimates of current and future levels of potential risk to the public.

Although there will always be a slight chance that an accident will cause a release of nuclear material, the NRC has found that the likelihood of such an event and the ~~associated~~ risk to the public are extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates the ~~physical~~ protection of spent nuclear fuel in transit against sabotage or other malicious acts. The NRC's current rules for the physical protection ~~regulations for~~of spent fuel transportation include:
• Coordinating with ~~Pre-shipment coordination with~~ law enforcement agencies before the shipment
• Requiring advance ~~Pre-shipment~~ notice to ~~of~~ States and the NRC
• Using a communications center and other means to monitor shipments while in route~~In-transit shipment call-in to communications center~~
• ~~Shipment monitoring~~
• Armed escorts (~~in populated areas~~), and
• Immobilization devices.

Commented [MEC7]: Not sure what this means

Since September 11, 2001, the NRC has taken additional steps to protect the public. ~~These steps involve a heightening of the security posture, including new measures taken to protect nuclear facilities and regulated activities, such as spent fuel transportation, and orders that NRC has issued to licensees.~~

For Additional Information Contact:

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NRC

U.S. Nuclear Regulatory Commission
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Current *9.6*

Safety of Spent Fuel Transportation

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The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

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The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

The NRC has three main functions:
1. To set standards and develop regulations;
2. To issue licenses for nuclear facilities and nuclear materials users; and
3. To inspect facilities to ensure that NRC regulations are being met.

Commented [MEC5]: Info digest is meant to be a comprehensive list, whereas this is very top-level. Again, this comes from the "About NRC" page on the website

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient and realistic.

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the U.S., and internationally, with the IAEA. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. For such low levels of exposure, any biological effects are so small that, if they exist, they would not be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

What is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- How does the NRC protect the public from radiation during transport?
- What is the likelihood one of these shipments will be involved in an accident?
- How well can the shipping containers withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a "cask."

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these containers must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials five to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, and physical testing of a scale model or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.

But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure.

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This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?
The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the regulations in place to assure the safety of spent fuel transport.

In a 1977 study, the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987 and 2000, the NRC looked more closely how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. These studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study looked at how three NRC-certified packages would behave during both normal shipments and accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. The risk assessment found:

- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year
- There is less than a 1 in 1 billion chance that radioactive material would be released in an accident
- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm

In addition to these risk studies, the NRC has looked closely at real-world accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would have performed. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, Cal.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers

- What can go wrong?
- How likely is it to occur?
- If something goes wrong, what are the consequences?

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.
Step 1. Experts determine what might happen.
- ***They gather historic records.***
- ***They also put together data on how many spent fuel shipments are likely each year.***
- ***They look at the rate of accidents for rail and highway shipments.***
- ***They look at a large number of accidents that are credible.***
- ***They also look at crash impact forces, fires or punctures. They pick forces that are more severe than those covered by NRC standards.***

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

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To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past trucking and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

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Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

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Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.
- ***They gather data on how much spent fuel each container will carry.***
- ***They analyze how the spent fuel might respond in a given type of accident.***
- ***They calculate the temperature of the container and the spent fuel itself during a long-term fire.***

This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This gives them the chance of severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

- The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than [illegible] the amount of radiation people receive from background sources each year.

  ~~A passenger flying round trip from New York to Los Angeles receives a dose from background radiation that is 25 times greater than the dose to persons closest to a typical spent fuel shipment.~~ To put this estimated dose in perspective, the 0.[illegible] person-Sv estimated from spent fuel transportation is a very small fraction of the estimated collective annual dose for a chest X-ray of almost [illegible] person-Sv.

Commented [MEC23]: This comes straight out of the blog post

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The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by:
– Defining strict requirements for package design and performance
– Reviewing designs and independently checking a container's ability to meet accident conditions and
– Doing inspections to ensure casks are built, maintained and used properly.

• The NRC also looks at the risks involved in spent fuel shipments. The agency:
– Analyzes spent fuel transport records to fully understand any safety issues
– Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes and other factors, and
– Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

Although there will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public are extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

Commented [MEC28]: With NSIR for review

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:

- Coordinating with law enforcement agencies before the shipment
- Requiring advance notice to States and the NRC
- Using a communications center and other means to monitor shipments while in route
- Armed escorts, and
- Remote devices that allow vehicles to be turned off.

Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear
Regulatory
Commission
NUREG/BR-0292
March 2015

From: Conley, Maureen
To: Cool, Donald
Subject: another request
Date: Tuesday, January 27, 2015 3:59:00 PM

Hi, was hoping you could take a look at some language that is in a brochure we're updating on the safe transport of nuclear fuel.

This is basically unchanged from the original, maybe just a few tweaks to language here and there. Is this OK to say?

About 90 percent of all radiation exposure comes from natural sources: radon gas, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly. People living in areas with a lot of granite, for example, receive more radiation from the earth. Those living or working at high altitudes receive more cosmic radiation. Most natural exposure is from radon, a gas that seeps from the earth's crust into the air we breathe. The remaining 10 percent of all radiation exposure comes from man-made sources, mainly medical x-rays. Natural and artificial radiation are similar in kind and effect. [Dwp1]

Maureen Conley
NRC Office of Public Affairs
301-415-8202

(b)(5)

From: Conley, Maureen
To: Coffin, Stephanie
Subject: baackgrounders etc.
Date: Tuesday, January 28, 2014 5:16:00 PM

Hey, Stephanie. Here are links to our relevant backgrounders:

http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/storage-spent-fuel-fs.html

http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/dry-cask-storage.html

http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bg-high-burnup-spent-fuel.html

http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/transport-spenfuel-radiomats-bg.html

http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/radwaste.html
(This one was last updated in 2007 so it may not be our best option)

Also the Safety of Spent Fuel Transportation Nureg:
http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0292/

I'll start looking at the brochure and thinking about how to package the updated version…

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From: Conley, Maureen
To: Cook, John
Subject: checking on risk assessment
Date: Wednesday, January 08, 2014 4:55:00 PM

Hi, John. Just wanted to check with you on the status of the transportation risk assessment. I see the draft but not the final. Are we still waiting for publication?

I'm interested partly because I am reviewing a very outdated spent fuel transportation brochure that OPA published in 2003 (b)(5) (b)(5) We are weighing whether to spike it altogether or update it. My inclination is to update and refocus it on this new risk assessment. I believe the current brochure was issued when the Package Performance Study was being planned.

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I know your executive summary is intended for general public consumption. We could put that language in our glossy full-color brochure (assuming my supervisor approves). Curious to know what you think….

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From:	Conley, Maureen
To:	Lombard, Mark; Hsia, Anthony
Cc:	Marcano, Damaris
Subject:	follow-up on today"s meeting
Date:	Wednesday, July 15, 2015 5:55:00 PM
Attachments:	BG_highburnupspentfuel 2015 update.docx

Hi, guys. Just a few notes from our meeting today:

Mark, you were going to follow up on the transportation brochure. I am attaching the draft updated backgrounder, as discussed. Please take a look and let me know if you have any comments. We can move ahead with the update in the short-term, or wait to do it once the Oak Ridge data is all in.

I did locate the thermal blog post and will give it one last read tomorrow before sending to you for review. I also have the materials post on my plate to review tomorrow and will make Mark's edits to the criticality safety post.

Over the next couple weeks I will draft a blog post on Part 72, our reviews, etc. as an intro to the discipline-specific blog posts. I will also take a look at the current dry cask storage backgrounder to see what we can/should update.

I think that covers everything, but let me know if I missed something. Just sent an updated scheduler proposing a new date for our Aug. meeting – hopefully not the week Tony will be out.

Thanks!

Maureen Conley
NRC Office of Public Affairs
301-415-8202

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

BACKGROUNDER

Office of Public Affairs
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High Burnup Spent Fuel

Nuclear fuel is removed from a reactor every few years when it can no longer economically keep ~~sustain~~ a chain reaction going. This "spent" fuel remains radioactive and must be managed. ~~Initially,~~At first, it goes into a pool onsite for cooling and storage. Some utilities are moving their spent fuel after ~~it has cooled for~~ several years in the pool into NRC-certified dry storage casks. These casks are specially designed to contain the radioactivity and allow hot spent fuel to cool further.

What is burnup?

To understand "burnup," it is helpful to know more about the uranium that fuels a reactor. Before being made into fuel, uranium is processed to increase the concentration of atoms that can be split in the reactor. The energy released when these atoms split is what produces the heat that is turned into electricity. In general, the higher the concentration of those atoms, the longer the fuel can sustain a chain reaction. And the longer the fuel remains in the reactor, the higher the burnup.

In other words, ~~"B~~burnup~~"~~ is a way to measure ~~the~~ how much uranium is burned in the reactor. It is the amount of energy produced by the uranium. ~~It~~ Burnup is expressed in gigawatt-days per metric ton of uranium (GWd/MTU). Average burnup, around 35 GWd/MTU two decades ago, is over 45 GWd/MTU today. Utilities now are able to get more power out of their fuel before replacing it. This means they can operate longer between refueling outages. It also means they use less fuel.

Why does burnup matter?

The burnup level affects the fuel's temperature, radioactivity and physical makeup. It is important to the NRC's review of spent fuel cask designs because each system has limits on temperature and radioactivity. How hot and radioactive spent fuel is depends on burnup, as well as the fuel's initial makeup and conditions in the core. All these factors must be taken into account in designing dry storage and transport systems for spent fuel.

It was also once thought that cladding on higher burnup fuel could become more brittle as it cools. But research now shows that is not a concern. Nuclear fuel is encased in metal cladding. In the reactor, this cladding reacts with cooling water. The reaction forms oxide on the outside (similar to rust) and releases hydrogen. These processes begin slowly, then start to accelerate as the fuel reaches burnup of 45 GWd/MTU. Anything above this level is considered high burnup. But in reality there is no sharp line between low and high burnup. It is a continuum. That means the difference between fuel burned to 45 GWd/MTU and 46 or 47 GWd/MTU can be very small.

~~Burnup depends on how long the fuel is in the core and the power level it reaches. The burnup level affects the fuel's temperature, radioactivity and physical makeup.~~

~~In a reactor, uranium fuel fissions—splits apart and releases energy—and the metal cladding that encases the fuel reacts with cooling water. This reaction forms oxide on the outside (similar to rust) and releases hydrogen. These processes begin slowly then start to accelerate as the fuel reaches burnup of 45 GWd/MTU. Anything above this level is considered high burnup.~~

~~Over time, burnup, has increased, allowing utilities to get more power out of their fuel before replacing it. Average burnup, around 35 GWd/MTU two decades ago, is over 45 GWd/MTU today. How hot and radioactive spent fuel is depends on burnup, the fuel's initial makeup and conditions in the core. All these factors must be taken into account in designing dry storage and transport systems for spent fuel.~~

Is it safe to store and transport high burnup fuel?

To be certified by the NRC, dry cask designs must meet ~~transportation~~ NRC requirements. For transportation, these are found in 10 CFR Part 71 [link] ~~or~~ and for storage ~~requirements~~ in 10 CFR Part 72 [link]. The NRC approves designs only after a full safety review.

Based on these reviews, the NRC has certified ~~numerous~~ cask designs for ~~spent fuel~~ storage and transportation of high burnup spent fuel. Because low burnup spent fuel has been around longer and there is more of it, there are more casks for low than for high burnup spent fuel. There is also a great deal more data on low burnup fuel. Still, there is enough data on high burnup fuel that the NRC has certified high burnup spent fuel storage casks for an initial term of 20 or 40 years. Some systems have also been approved for transporting high burnup spent fuel. Operating experience since dry storage began in 1986 and short-term tests show both low and high burnup spent fuel can be stored and transported safely.

~~More casks are available for low than for high burnup spent fuel. Because it has been used longer, there is a great deal more data on low burnup fuel. There is enough data on high burnup fuel that the NRC has been able to certify some high burnup spent fuel storage casks for an initial term of 20 or 40 years. Some systems have also been approved for transporting high burnup spent fuel.~~

~~Why does burnup matter?~~

~~Burnup is important to the NRC's review of spent fuel cask designs because each system has limits on temperature and radioactivity. When the cask is being dried, pressure increases inside and the fuel heats up. This may cause the cladding to become more brittle when it cools. These changes depend on burnup and the type of cladding, and need to be accounted for in high burnup spent fuel systems. A great deal of work has been done to understand the conditions that make different types of fuel cladding more brittle.~~

~~Testing continues on high burnup spent fuel and the set of available data is growing. Cask designers use the results to redesign their casks for higher burnups and additional fuel types. As more data becomes available, the NRC expects to be able to certify more casks. Cask designers also need this data to demonstrate the long-term safety of their systems so they can continue storing spent fuel beyond the initial license term.~~

How does the NRC make sure it remains safe?

The NRC assures safety by requiring many layers of protection. Casks provide several layers and the fuel cladding itself is an important layer. The regulations are designed to ensure the casks will hold up and the cladding will not break during storage or in a transport accident. However, the NRC's regulations ensure the system will remain safe even if the cladding did break. The NRC carefully reviews each cask application to see if it meets the requirements. As part of this review, the NRC does its own analysis to confirm information in the application.

The NRC also does inspections before and during loading of dry casks to ensure the correct fuel will goes into the right storage systems. Fuel with burnup higher than the NRC certificate allows cannot be loaded. It must remain in pool storage until a cask approved for higher burnup becomes available. The NRC also inspects loaded casks every few years.

What confirmatory research is being done?

The primary focus of research today is to get more data to support the continued certification of storage systems beyond the initial 20- to 40-year license term. Additional research is ongoing to confirm that high burnup fuel will remain intact during transport after extended storage. This research is designed to ensure that the existing data on high burnup spent fuel is accurate and can be reproduced.

Cask designers are also involved in research. They will use the results redesign casks for higher burnups and additional fuel types. As more data becomes available, the NRC expects to be able to certify more casks. Testing has provided a lot of information on how different types of cladding on spent fuel will behave, and this work continues.

Planning ~~has begun~~is underway for an important new study, run jointly by the nuclear industry and the Department of Energy, with regulatory oversight by the NRC. In this study, high burnup spent fuel will be loaded into a cask fitted with instruments to provide temperature readings and allow gas sampling. Those readings, combined with tests on the fuel assemblies and inspection of the cask's interior after years of dry storage, will provide more data ~~a~~ that should confirm ~~much better~~ the current understanding of what happens to high burnup spent fuel in a storage cask as it cools over time.

~~Work is underway to create better models to determine how much cladding actually may become brittle and the impact of vibration during transport. The NRC is also monitoring work going on internationally.~~

All this work will help cask designers, users and regulators better understand how to ensure high burnup spent fuel will remain safe in ~~long-term~~ dry storage over the long-term and during transportation to a centralized storage or disposal facility.

~~December 2013~~May 2015

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From:	Conley, Maureen
To:	Cool, Donald
Subject:	how does this language sound?
Date:	Friday, January 30, 2015 9:59:00 AM

For my updated brochure on spent fuel transportation safety:

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest comes from medical sources such as x-rays and diagnostic tests. Radiation that can be traced to nuclear power or radioactive materials transport makes up a tiny fraction of a person's overall exposure. For such low levels of exposure, any biological effects are so small they may not even be detectable. Radiation behaves the same whether it comes from natural or manmade sources.

Thanks!

Maureen Conley
NRC Office of Public Affairs
301-415-8202

From: Conley, Maureen
To: Lombard, Mark; Hsia, Anthony; Marcano, Damaris
Subject: spent fue communication products
Date: Friday, June 05, 2015 1:17:00 PM

Hi, guys. I'm just going through my notes about the various things we have cooking. Perhaps we can talk about these items when we meet June 17:

Updating the spent fuel transportation brochure
Updating the high burnup spent fuel backgrounder
Finalizing the high burnup spent fuel blog post
Status of spent fuel storage blog post series (I have two from Damaris that I'm reviewing and one in the hopper)

Feel free to add anything to the list that I might have forgotten!

Maureen Conley
NRC Office of Public Affairs
301-415-8202

Original grade level 12.2

Title?

Once the text is agreed upon and finalized, the photos that will be included as part of the brochure will need to be reviewed.

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency established by Congress. Its mission is to license and regulate the ~~Nation's~~ nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. ~~And~~ Additionally, it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT works with the NRC and affected states to regulate their transport. DOT also regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for -disposal of spent fuel from the nation's nuclear power reactors~~plants~~.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. As p~~P~~art of the United Nations, the IAEA sets global regulations for many areas of the nuclear industry, including nuclear materialspackaging and transportation. The~~se~~ IAEA's packaging and transportation regulations serve as a model for the United States and other nations.

The NRC has three main functions:
1. to set standards and develop regulations;
2. to issue licenses for nuclear facilities and nuclear materials users; and
3. to inspect facilities to ensure that NRC regulations are being met.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. It begins with the mining of uranium, and ~~. The cycle~~ continues through the manufacture of fuel, its use in reactors, transportation, storage, and permanent geologic disposal.

The NRC works to maintain public health and safety, protect the environment and ensure our national security. To maintain the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.to It also strives to keep the regulatory burden reasonable on all those involved in the use, handling, transport, and disposal of nuclear materials.

Proper handling of nuclear materials will help to ensure the safety of the public and plant workers. That is why the NRC works with ~~other agencies~~the DOT and DOE in the U.S. and the IAEA internationally to ensure these materials are ~~handled~~ packaged and transported safely.

This booklet explains the NRC's role in ensuring spent nuclear fuel from commercial nuclear power plants is packaged and transported safely. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments.

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Radiation

~~Scientists say about~~ About 90 percent of all radiation exposure comes from natural sources: radon gas, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly. People living in areas with a lot of granite, for example, receive more radiation from the earth. Those living or working at high altitudes receive more cosmic radiation. Most natural exposure is from radon, a gas that seeps from the earth's crust into the air we breathe. The remaining 10 percent of all radiation exposure comes from man-made sources, mainly medical x-rays. Natural and artificial radiation are similar in kind and effect.

What is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite..

The Nuclear Waste Policy Act (NWPA) sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 ~~picked~~ selected Yucca Mountain in Nevada as the site to be studied for an underground repository. DOE applied to the NRC in 2008 ~~to~~ for a permit to construct the repository ~~there~~ at Yucca Mountain. But DOE withdrew its application in 2010. The NRC's role is to assess whether the proposed facility meets NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will likely be some time before a geologic repository is available. All nuclear power reactors ~~plants~~ move their spent fuel first into pools for storage on site. As the ~~amount~~ volume of spent fuel in the pool increases ~~grows~~, many reactors are also using dry casks for storage ~~casks~~. The NRC reviews~~, and~~ approves, and issues certificates for the design of these dry cask ~~designs for these~~ systems.

Since ~~the proposed~~ no repository ~~at Yucca Mountain~~for spent fuel is ~~not~~ currently operating, the DOE is considering storage of spent fuel, perhaps at a consolidated facility in the U.S. Once a ~~central~~ location for storage or disposal is approved, spent fuel will need to be transported there ~~safely~~ from sites around the country. These shipments would likely be made on railroads ~~using specially designed casks and railcars~~ as well as ~~and~~ on public highways, using specially-designed casks on railcars or heavy-haul trucks.

Because spent fuel is highly radioactive, this raises the following questions:

- How does the NRC protect the public from the hazards associated with spent fuel and other radioactive waste during transportation ~~that is being transported~~?
- What is the likelihood of a ~~these~~ shipments of these types of material being involved in an accident?
- What steps does the NRC take to ensure that ~~How well can the~~ transportation containers can withstand an accident and prevent the release of nuclear materials?

The NRC addresses these and other questions as ~~a~~ part of its ongoing efforts to continue to ensure safe transport. As new technologies and real-world information become available, the NRC continually evaluates its existing regulations and safety requirements. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 30 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

The highly radioactive ~~Spent~~ spent fuel ~~is highly radioactive and~~ must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container~~, or~~ called a "cask."

The NRC r~~egulates~~ reviews and approves the design and construction of these casks to ensure the public is protected from the associated hazards. Containers used to move spent fuel by rail or highway are

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designed to withstand severe accidents. In the U.S. and internationally, these containers must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be ~~able~~ designed to survive a sequence of four tests, including a 30-foot drop test onto an unyielding surface, a puncture test, a fully engulfing fire at 1,475 degrees Fahrenheit for 30 minutes, and immersion under ~~involving impact, puncture, fire and submersion in~~ water. During and after the tests, the casks must contain the nuclear material contents, limit radiation doses to acceptable levels, and prevent a nuclear criticality reaction.

To protect workers and the public, a cask has walls of steel and shielding materials five to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. Impact limiters contain crushable foam and/or wood that act to absorb the impact energy in a test or real-life accident. In an accident, the~~se~~ impact limiters would crush and absorb the ~~, absorbing~~ impact forces ~~and~~, thereby protecting the container and its ~~cargo~~ content.

Spent fuel containers are engineered to be tightly sealed, very robust, and include ~~and provide heavy~~ shielding material to lower the associated radiation levels. ~~But~~ While it is not possible to shield all the radiation,. ~~The~~ the containers must ~~provide~~ include enough shielding to protect anyone who might be near the cask during transport.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale-model ~~testing~~, or a combination of these techniques. Most often, they use a combination of computer analyses and physical testing. They meet with technical review staff from the NRC and explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and ~~then~~ performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural, ~~and~~ material~~s~~, thermal, and criticality engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC has completed its review and is satisfied that a design meets the requirements, it issues a Certificate of Compliance, which specifies, for example, the materials of construction, the authorized contents, and the size dimensions of the container. Then the containers can be manufactured and put into service~~used~~. Manufacturers and shippers use quality assurance ~~have special~~ programs to ensure the containers meet design specifications throughout fabrication and transportation. As a means to ensure the provisions of the Certificate of Compliance are being met, NRC staff conduct inspections at both the manufacture and shipper facilities.

While having a certificate for a package design ensures the safety of the package during transportation, certain requirements of the NRC and DOT must also be met prior to offering a package for shipment.~~But just having a certificate does not mean a cask can be used.~~ Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and ~~tests~~assessments to ensure radiation levels are within the specified safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

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More than 1,300 spent fuel shipments regulated by the NRC have been completed safely in the U.S. during the past 25 years. Although there have been four accidents, none ~~has~~ have resulted in a release of radioactive material or a fatality due to exposure to radiation.

This experience confirms that the safety system is sound. In other words, the regulatory requirements of the NRC for package certification coupled with the transportation requirements of both the NRC and the DOT ensure the safety of the package during transportation. But will this hold true ~~when there are~~for increased shipping ~~campaigns~~that moves spent fuel to a future ~~proposed~~ repository or a ~~centralized~~consolidated storage facility ~~*thousands* of~~ ~~in the~~ ~~future~~ ~~shipments~~? The NRC continuously evaluates risks associated with spent fuel transport in a methodical and scientific way. To provide additional confidence, the NRC has sponsored several risk studies over the years related to spent fuel transport on highways and railroads.

In 1977, the NRC completed a study that is now seen as the "baseline" for comparison with new information and studies completed since then. That study concluded that the transportation regulations adequately protect the public, and provided confidence to the public of the important safety role that NRC has~~allowed the NRC to say its transportation regulations adequately protect the public~~.

In 1987, the NRC used improved research methods to see how shipping containers react in accidents and to estimate the risk of releasing radioactive materials. The study results provided added assurance that certified shipping casks would withstand an accident.

Another study conducted in 2000 analyzed how well containers would ~~hold up in~~withstand an accident. Using improved technology, this study found the risk would be even smaller than originally estimated in 1977, even if the number of spent fuel shipments increased greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. The study confirmed that NRC regulations for spent fuel transport are adequate to ensure safety of the public and the environment. It examined how three NRC-certified packages would behave during both normal shipments and accidents. The study~~It~~ modeled a variety of transport routes using population data from the 2000 census, as updated in 2008, and~~. It~~ used actual highway and rail accident statistics. Using state-of-the-art computer models, the study~~It~~ considered doses from normal shipments to people living along transportation routes, occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. ~~And it used state-of-the-art computer models.~~ The risk assessment found:

- Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year
- There is less than a 1 in 1 billion chance that radioactive material would be released in an accident
- If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm

On the basis of these studies, operational experience, and its own reviews, the NRC concluded that the shipment of spent fuel will be safe, even i~~f~~s hundreds of shipments are made each year. The NRC is

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Comment [MEC]: This language comes out of the blog post John Cook and I put together on the risk assessment: http://public-blog.nrc-gateway.gov/2013/09/19/transporting-spent-nuclear-fuel-how-do-we-know-its-safe/

continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic transportation safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

• What can go wrong during transportation?
• How likely is it to occur?
• If something goes wrong, what are the consequences for the package and the public?

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.
Step 1. Experts determine what might happen.
• They gather historic records.
• They also put together data on how many spent fuel shipments are likely each year.
• They look at the rate of accidents for rail and highway shipments.
• They look at a large number of accidents that are credible.
• They also look at crash impact forces, fires or punctures. They pick forces that are more severe than those covered by NRC standards.

The Accident Scenario

NRC studies show that the ~~chance~~likelihood of an accident is low, and that fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions of the design standards. However, if a very unlikely chain of events occurs, the accident might be severe enough to cause a radioactive release.

To estimate the risk of unusually severe accidents, researchers use a multi-step approach. They use data and their experience with past trucking and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

According to the DOE Final Environmental Impact Statement for the Yucca Mountain Project, about 11,000 rail or 53,000 truck shipments might be expected during the 24 years of operation of the repository. The chances that any accident would occur during a spent fuel shipment are about 1 in 10,000 for rail shipments and 1 in 1,000 for highway transport. Put another way, these estimates indicate that approximately 1 to 50 accidents involving casks are conceivable in the process of moving spent fuel to a repository.

Looking at these conceivable accidents, the chance that even one would be serious enough to lead to even a small release is about 1 in 1,000. The chance of a large release is estimated to be less than one in 1,000,000,000.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

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• They gather data on how much spent fuel each container will carry.
• They analyze how the spent fuel might respond in a given type of accident.
• They calculate the temperature of the container and the spent fuel itself during a long-term fire.
This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This gives them the chance of severe damage to the container or its contents.

Step 4. Researchers use a special computer program to compute a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

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The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. In this scenario, experts calculate the total radiation dose that all people along the route could receive. Because spent fuel emits low levels of radiation through the cask walls, researchers estimate the total radiation dose to people who could be exposed. They use information on routes and local populations to determine the number of people who might be affected and the dose they might receive.

The risk to the public from an accident-free journey results from the very low radiation field that surrounds the transport cask. If the container is moving past a person, such as someone standing along the highway or railroad track, the exposure is brief and well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. The very low doses to each person along the route are added to get the total population dose. A passenger flying round-trip from New York to Los Angeles receives a dose from background radiation that is 25 times greater than the dose to persons closest to a typical spent fuel shipment.

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

• The NRC ensures that shipping containers are robust by:
– ~~Regulating~~Reviewing and certifying their design and conducting inspections during construction.
– Reviewing designs and independently checking a container's ability to meet accident conditions.
– Ensuring casks are built, maintained, and used properly.

• The NRC also investigates and assesses the risks involved in spent fuel shipments. The agency:
– Analyzes spent fuel transport records to fully understand safety issues.
– Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors.
– Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

Although there will always be a slight chance that an accident will cause a release of nuclear material, the NRC has found that the likelihood of such an event and the risk to the public are extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates the protection of spent nuclear fuel in transit against sabotage, theft, or diversion ~~or other malicious acts~~. The NRC's current ~~rules~~ regulations for the physical protection of spent fuel transport include:

• Coordinating with law enforcement agencies before the shipment
• Requiring advance notice to States and the NRC
• Using a communications center and other means to monitor shipments while in route
•
• Armed escorts~~, and~~
• Immobilization devices

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Since September 11, 2001, the NRC has taken additional steps to protect the public.

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

NRC

U.S. Nuclear Regulatory Commission

NUREG/BR-0292
March 2015

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Safety of Spent Fuel Transportation

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage, and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment, and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient, and realistic.

Proper handling of nuclear materials helps to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the United States, and with the IAEA internationally. Together, these agencies help make sure nuclear materials are packaged and transported safely around the world.

This publication explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use, and maintenance of containers for these radioactive shipments. However, the NRC does not control the timing or destination of spent fuel shipments.

The NRC has three main functions:

1. *To set standards and develop regulations*
2. *To issue licenses for nuclear facilities and nuclear materials users*
3. *To inspect facilities to ensure that NRC regulations are being met*

What is Spent Fuel?

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks, and soil. This natural radiation is called background and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as spent fuel. It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

The NRC would also review any proposal for central interim storage of spent fuel. Eventually, spent fuel will need to be transported to a central storage or disposal facility from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates that information against its regulations. It is important to know that spent fuel has been shipped safely within the United States and abroad for more than 40 years.

The Key to Ensuring Safety: the Spent Fuel Shipping Container

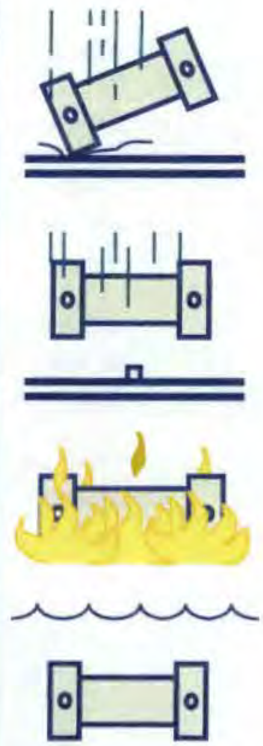
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a cask.

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5 to 15 inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding to protect anyone who might be near the cask during transport.



The NRC requires spent fuel shipping casks to survive four tests in sequence:

1. free-drop impact,

2. puncture impact,

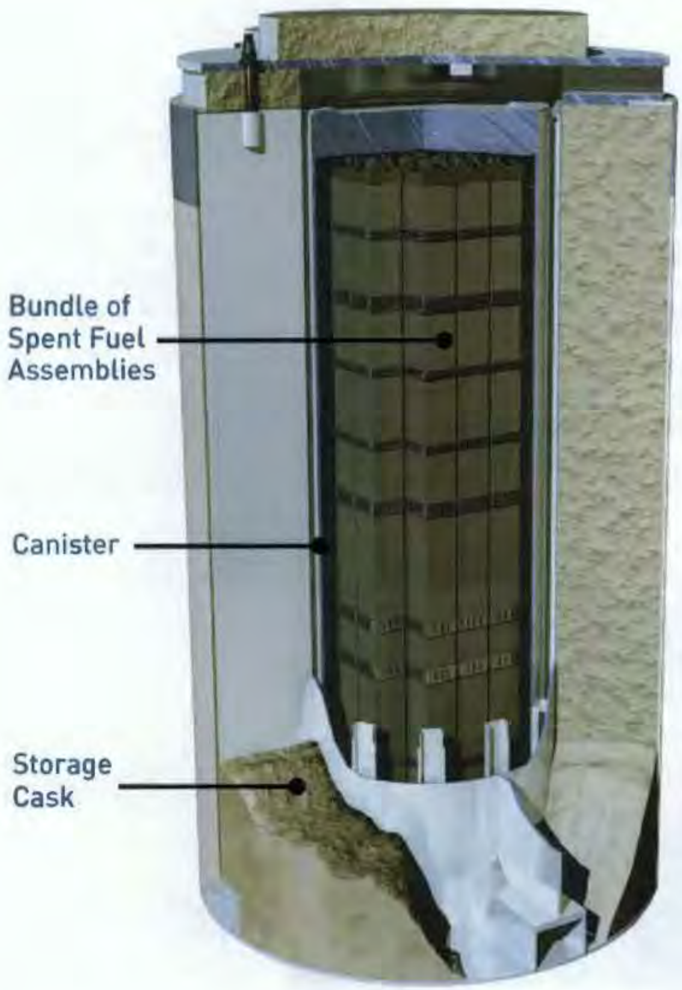
3. fire, and

4. water immersion.

Truck carries NAC LWT transport package.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing, physical testing of a scale model, or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design, and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations when needed. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a certificate of compliance ~~through a public rulemaking process.~~ This certificate describes the approved design (including what materials must be used), the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

A Brief History of Spent Fuel Shipments and Studies

More than 1,300 spent fuel shipments have been completed safely in the United States over the past 35 years. Four were involved in accidents, but none resulted in a release of radioactive material or a fatality due to radiation exposure.

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

NAC LWT spent fuel transport package is moved by crane. *(Courtesy: NAC International)*

In a 1977 study[1], the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987[2] and 2000[3], the NRC looked more closely at how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. Both of these studies ~~both~~ found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study[4] looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop.

1. *http://pbadupws.nrc.gov/docs/ML1219/ML12192A283.pdf*
2. *http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr4829/*
3. *http://pbadupws.nrc.gov/docs/ML0036/ML003698324.pdf*
4. *http://pbadupws.nrc.gov/docs/ML1403/ML14031A323.pdf*

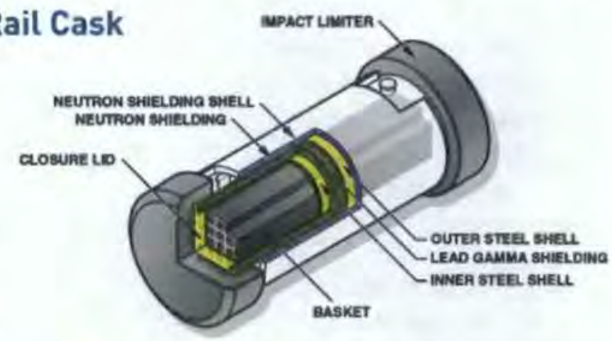
The risk assessment found:

Transportable spent fuel storage cask moves to storage pad.
(Courtesy: Holtec International)

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would perform. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, CA.; and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

Rail Cask



Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Understanding the Risks

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the United States has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

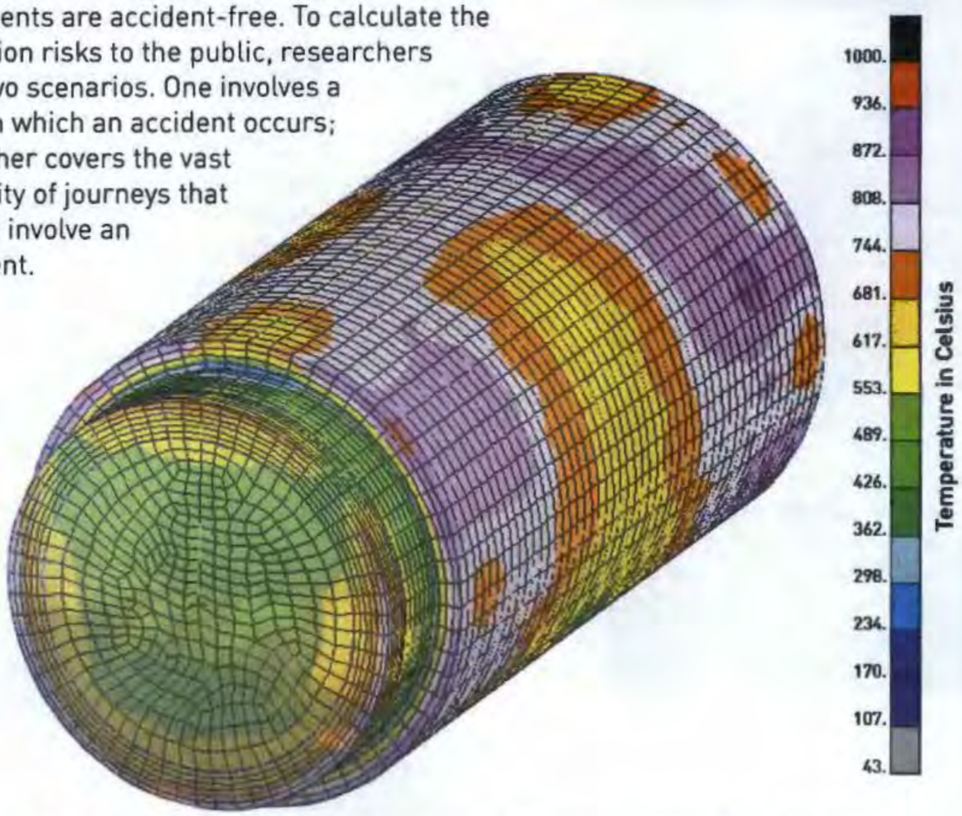
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires, or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

* We would not expect a radioactive release in 99.99973% of those accidents

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows engineers to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimatee.

The Accident Scenario

NRC studies show that the likelihood of an accident is very low. Fewer than ~~1~~ 5 in ~~100~~ 10,000 accidents involving a spent fuel container ~~will~~ may be more severe than the conditions defined in the design standards.* However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a ~~radioactive~~ release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a ~~small~~ release is about 1 in ~~1,000. The chance of a large release is less than one in~~ 1 billion. If an accident were to release radioactive material, the dose to the most affected individual would not cause immediate harm.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

NRC studies show [redacted] the likelihood of a radioactive release is very low. Fewer than 5 in 10,000 accidents involving a spent fuel container may be more severe than the conditions defined in the design standards. We would not expect a radioactive release in 99.99973% of those 5 accidents. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a release is 1 in 1 billion. If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.

The Bottom Line

The NRC believes that shipments of spent fuel in the United States are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions
  - Doing inspections to ensure casks are built, maintained and used properly
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand ~~any~~ potential safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes, and other factors
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The agency strengthened these rules after Sept. 11, 2001. The current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Using armed escorts, and**
- **Using devices that allow drivers and escorts to shut the vehicle off**

For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
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Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
June 2016

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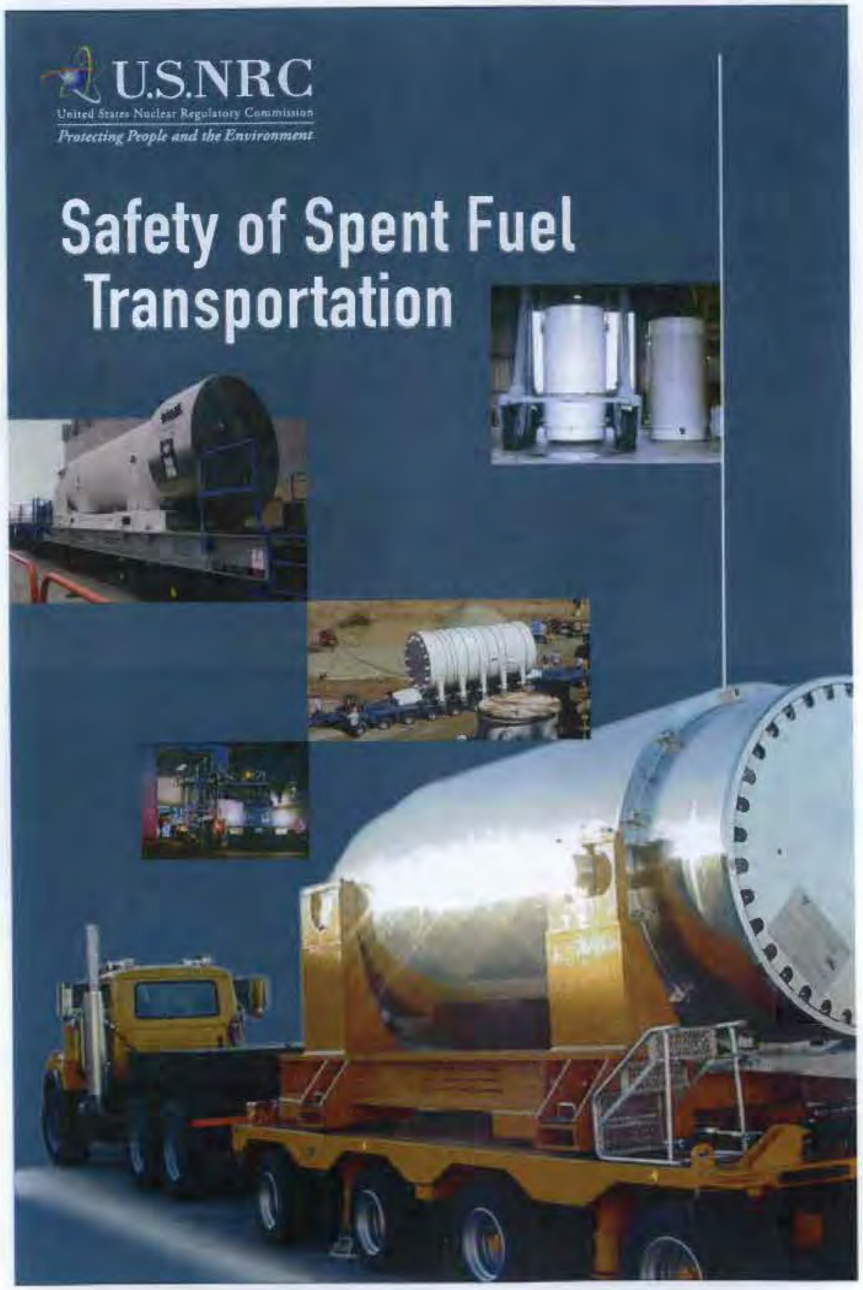

Summary of Comments on Spent Fuel Transport_bro_r1_edited.pdf

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The Agencies: Who Does What?

bold

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that ~~was created by Congress.~~ Its mission ~~is to~~ regulate the nation's civilian use of radioactive materials in a way that protects public health and safety and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

bold

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes, and is responsible for international agreements on the transport of all hazardous materials.

bold

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

bold

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

Page: cvr2

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
Is the word "safety" missing?

Author: NRC Tech Editing Subject: Sticky Note Date: 12/8/2015 9:38:28 PM
The logos are not readily identifiable as belonging to the agencies to casual readers. Suggest calling out the agency name more clearly in each paragraph. For example by bolding the agency name in the first line or making the name blue.

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
Capital S in States (GPO Style Manual)

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "routes, an is..."

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. ~~The NRC also plays a role in ensuring~~ the safe transportation, storage, and permanent geologic disposal of used fuel.

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Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT, the DOE in the U.S., and ~~internationally~~ with the IAEA. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

United States internationally

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

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Page: 1

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add "U.S." The U.S. Nuclear Regulatory Commission

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete semicolon

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "storage,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "environment,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "efficient,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete "; and"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
Suggest reword the sentence as: In the United States, the NRC works with the U.S. Department of Transportation and the U.S. Department of Energy to ensure proper handling of nuclear materials. Internationally, the NRC works with the IAEA on this issue.

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete period

Author: NRC Tech Editing Subject: Sticky Note Date: 12/8/2015 9:38:28 PM
Please add captions explaining what these photos are showing.

these photos are placeholders

What is Spent Fuel?

> **Radiation**
>
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It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

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Page: 2

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Delete quotes around spent fuel

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Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add comma after "rocks,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete quotes and add ~~"radiation"~~

[redacted] (b)(5)

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
[redacted] (b)(5)

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
change "U.S." to "United States"

The Key to Ensuring Safety: the Spent Fuel Shipping Container

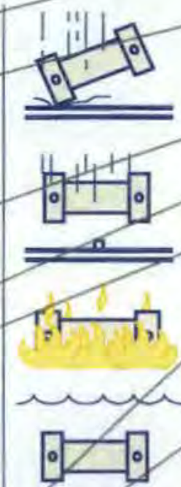
Spent fuel is highly radioactive and must be shielded and contained to be transported safely. Safe shipment requires a large, robust spent fuel container called a "cask."

The NRC regulates the design and construction of these casks to ensure the public is protected. Containers used to move spent fuel by rail or highway are designed to withstand severe accidents. In the U.S. and internationally, these ~~containers~~ designs must pass a series of tests that mimic accident forces. The NRC reviews spent fuel containers very carefully to ensure they meet the design standards and test conditions in the regulations.

These containers must be able to survive four tests involving impact, puncture, fire, and submersion in water. During and after the tests, the casks must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear chain reaction.

To protect workers and the public, a cask has walls of steel and shielding materials 5- to 15-inches thick and a massive lid. Truck containers weigh about 25 tons when loaded with one to two tons of spent fuel. Rail containers can weigh as much as 150 tons and can carry up to 20 tons of spent fuel. The ends of these transportation containers are encased in structures called impact limiters. In an accident, these impact limiters would crush and absorb the impact forces, protecting the package and its contents.

Spent fuel containers are tightly sealed and provide heavy shielding. But it is not possible to shield all the radiation. The containers must have enough shielding to protect anyone who might be near the cask during transport.



~~... tests are considered in sequence to determine their cumulative effects on a given package.~~

Page: 3

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
remove the quotation marks around cask.

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
[redacted] (b)(5)

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add comma after "fire,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add comma after "acceptable levels,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
change to "5- to 15-inches thick"

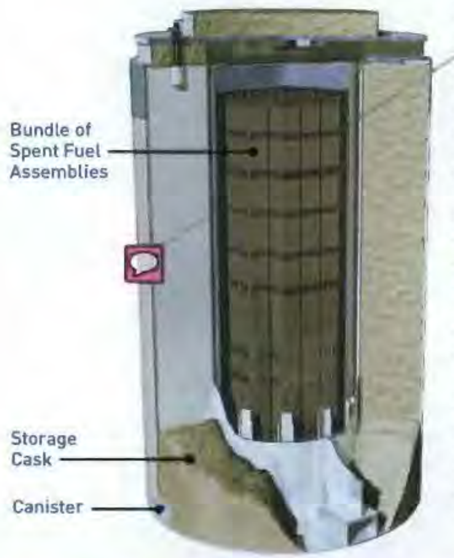
Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
Suggest reword to: The NRC requires spent fuel shipping containers, called casks, to survive four tests in sequence: (1) free-drop impact, (2) puncture impact, (3) fire, and (3) water immersion.

Author: NRC Tech Editing Subject: Sticky Note Date: 12/8/2015 9:38:28 PM
add a caption describing this photo

The NRC requires spent fuel shipping casks to survive four tests in sequence: (1) free-drop impact, (2) puncture impact, ~~(3)~~ (3) fire, and (4) water immersion.

Cask designers may use several techniques to demonstrate their containers are safe. They can use computer analyses, comparisons with other designs, component testing and physical testing of a scale model or a combination of these techniques. Most often, they combine analyses and physical testing. They meet with technical review staff from the NRC, explain their design and provide supporting documents in an application. The NRC evaluates each design, examines the information in depth, and performs its own calculations. NRC reviewers are experts in different areas of science and engineering. They include structural and materials engineers and safety specialists with advanced degrees and many years of experience.

Once the NRC is satisfied that a design meets the requirements, it issues a Certificate of Compliance through a public rulemaking process. This certificate describes the approved design, including what materials must be used, the authorized contents, and the dimensions of the container. Then the containers can be manufactured and used. Manufacturers and shippers have programs in place to ensure the containers meet design specifications throughout fabrication and transportation. These programs are known as quality assurance. To ensure the casks meet the certificates, NRC staff inspects both the manufacturer and the facilities that will use them.



But just having a certificate does not mean a cask can be used. Both NRC and DOT regulations also require a number of safety determinations before each spent fuel shipment. These include checks for leaks and tests to ensure radiation levels are within safe limits. These actions are designed to ensure that all aspects of every spent fuel shipment meet all the safety standards.

Page: 4

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete "and"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "scale model,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "design,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
lowercase: certificate of compliance

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
place in paretheses and delete commas. OK

Author: NRC Tech Editing Subject: Sticky Note Date: 12/8/2015 9:38:28 PM
Add a label/caption for the whole thing. Example: Cross section of a spent fuel storage and transportation cask.

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
Change to "U.S. Department of Transportation"

A Brief History of Spent Fuel Shipments and Studies

United States

More than 1,300 spent fuel shipments have been completed safely in the U.S. over the past 35 years. Four were involved in accidents. But none resulted in a release of radioactive material or a fatality due to radiation exposure.

of the shipments

This experience confirms that the safety system is sound. But will this hold true when shipments increase to move spent fuel to a future repository or a storage facility?

The NRC looks at the risks associated with spent fuel transport in a methodical and scientific way. Several NRC-sponsored studies over the years have focused on the risk related to spent fuel transport on highways and railroads. The results provide additional confidence in the current regulations to assure the safety of spent fuel transport.

In a 1977 study, the NRC found the risk from transporting spent fuel to be low. The study gave the NRC confidence that existing regulations are adequate to protect the public.

In separate studies in 1987 and 2000, the NRC looked more closely how shipping containers would perform in accidents. Each study used more advanced research methods than in the earlier studies. These studies both found the risk posed by spent fuel shipments would be even smaller than estimated in 1977. That finding holds true even if the number of spent fuel shipments were to increase greatly.

The latest risk study, published in January 2014, modeled the radiation doses people might receive from spent fuel shipments. This study again confirmed that NRC regulations for spent fuel transport ensure safety of the public and the environment.

The 2014 study looked at how three NRC-certified packages would behave during both normal shipments and transportation accidents. The study modeled a variety of transport routes using population data from the U.S. Census Bureau. It used statistics from actual highway and rail accidents and state-of-the-art computer models. The study considered doses from normal shipments to people living along transportation routes. It also looked at doses to occupants of vehicles sharing the route, vehicle crews and other workers, and anyone present at a stop. The risk assessment found:

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Add a caption describing what is shown in this picture.

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
Suggest providing a footnote or link to 1977 study OK

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
suggest providing footnotes or links to the 1987 and 2000 studies. OK

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
Suggest providing footnote or link to the January 2014 study OK

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
This line should be kept with the bulleted list below. OK

- **Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.**
- **There is less than a 1 in 1 billion chance that radioactive material would be released in an accident.**
- **If an accident did release radioactive material, the dose to the most affected individual would not cause immediate harm.**

In addition to these risk studies, the NRC has looked closely at real-world transportation accidents involving fires. The NRC did a series of case studies on the most severe accidents to see how well an NRC-certified spent fuel package would have performed. These studies show the current regulations protect the public even in the most severe fires. The case studies include the Howard Street tunnel chemical fire that burned for five days in Baltimore in 2001; the 1982 Caldecott tunnel fire and the 2007 MacArthur Maze fire, both sparked by gasoline tankers outside Oakland, Cal. and a 2007 brush fire in the New Hall Pass tunnel outside Los Angeles.

CA

CA.

Rail Cask

Truck Cask

Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

Additional NRC studies identified the conditions in an accident that could produce a fire severe enough to engulf a spent fuel transport package.

On the basis of these studies, plus operational experience and its own reviews, the NRC believes spent fuel can continue to be shipped safely. The evidence shows this will be true even if hundreds of shipments are made each year. The NRC is continuing to track spent fuel shipping, including more analyses and testing of spent fuel casks, to ensure that the risks remain low.

Page: 6

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add period at the end of this sentence.

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add a period at the end of this sentence.

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
change "would have performed" to "would perform."

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
change "Cal" to "CA" and keep on one line "Oakland, CA; and..."

Understanding the Risks

United States

Risk is generally understood to be the chance of injury, damage or some kind of loss. The spent fuel shipment record in the U.S. has been outstanding to date. Many more shipments have been successfully completed internationally under the same basic safety standards.

While shipping spent fuel does involve risk, NRC studies show this risk is low. As a part of its safety effort, the NRC aims to manage the hazards to minimize the risk. To evaluate the risks, the NRC asks the following three questions and then converts the answers into numbers:

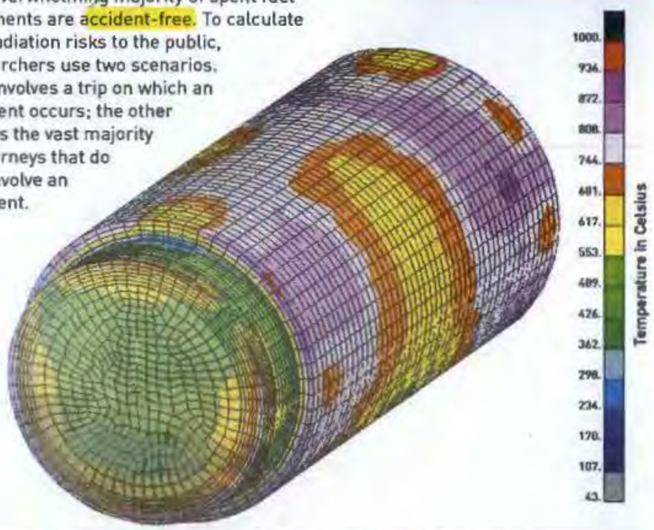
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

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Change "U.S." to "United States"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "fires,"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete hyphen: accident free.

improvised compound

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

engineers

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

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Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
use a nonbreaking hyphen. "long-term"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
change "them" to "engineers"

This information allows engineers to estimate the size...

The Bottom Line

United States

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design ~~and~~ performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions ~~and~~
  - Doing inspections to ensure casks are built, maintained and used properly.
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes and other factors, ~~and~~
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Armed escorts, and**
- **Devices that allow drivers and escorts to shut the vehicle off**

~~Since September 11, 2001, the NRC has taken additional steps to protect the public.~~

The NRC strengthened these rules after September 11, 2001.

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Change "U.S." to "United States"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete "and"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete the period

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
add a comma after "routes,"

serial comma → ?

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete ",and"

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
delete period

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
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Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
Change to: "Using devices that allow both the driver and escorts to shut the vehicle off" (parallel list structure)

Author: NRC Tech Editing Subject: Highlight Date: 12/8/2015 9:38:28 PM
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For Additional Information Contact:

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Phone: (301) 415-8200
Email: OPA@NRC.GOV
Internet Home Page: http://www.nrc.gov

U.S. Nuclear Regulatory Commission
NUREG/BR-0292, Rev. 2
March 2015

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This page contains no comments

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Safety of Spent Fuel Transportation

OK

IF-300 ←

French
German
U.K.
Michele'll pulse
U.S. vendors

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TN LC Navy M290
NAC LWT Hi-Star 180

The Agencies: Who Does What?

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency that was created by Congress. Its mission is to regulate the nation's civilian use of radioactive materials in a way that protects public health and the environment. The NRC regulates commercial nuclear power reactors; research, test, and training reactors; nuclear fuel cycle facilities; and medical, academic, and industrial uses of nuclear materials. The NRC also regulates packaging for the transport, storage, and disposal of nuclear materials and waste. And it licenses the export and import of radioactive materials.

The U.S. Department of Transportation (DOT) coordinates with the NRC to set rules for the packaging of nuclear materials. DOT also works with the NRC and affected states to regulate their transport. DOT regulates carriers, sets standards for routes and is responsible for international agreements on the transport of all hazardous materials.

The U.S. Department of Energy (DOE) is responsible by law for disposal of spent fuel from the nation's nuclear power reactors.

The International Atomic Energy Agency (IAEA) is a forum for scientific and technical cooperation in the nuclear field. Part of the United Nations, the IAEA sets global regulations in many areas of the nuclear industry. IAEA's regulations for materials packaging and transport serve as a model for the United States and other nations.

The Nuclear Regulatory Commission

The NRC regulates the nuclear fuel cycle from beginning to end. Starting when the uranium is taken from the ground, the NRC oversees its processing and manufacture into fuel to be used in reactors. The NRC also plays a role in ensuring the safe transportation, storage and permanent geologic disposal of used fuel.

The NRC works to protect public health and safety, the environment and our national security. To keep the public's confidence, the NRC aims to do its work openly and to be effective, efficient and realistic.

Proper handling of nuclear materials will help to protect the safety of the public and plant workers. To achieve this aim, the NRC works with the DOT and DOE in the U.S., and internationally, with the IAEA. Together, these agencies help to make sure nuclear materials are packaged and transported safely.

This brochure explains the NRC's role in the safe packaging and transport of spent nuclear fuel from commercial nuclear power plants. The NRC oversees the design, manufacture, use and maintenance of containers for these radioactive shipments.

The NRC has three main functions:

1. *To set standards and develop regulations;*
2. *To issue licenses for nuclear facilities and nuclear materials users; and*
3. *To inspect facilities to ensure that NRC regulations are being met.*

What is Spent Fuel?

Nuclear reactors make electricity and, as a waste product, spent fuel. Uranium fuel can power a reactor for a number of years until it needs to be replaced. The used fuel is then known as "spent fuel." It must be stored safely until it can be shipped offsite.

The Nuclear Waste Policy Act sets a policy for safe, permanent disposal of spent fuel and other high-level radioactive wastes. Congress in 1987 selected Yucca Mountain in Nevada as the site to be studied for a repository deep underground. DOE applied to the NRC in 2008 for a permit to construct the repository there. But DOE withdrew its application in 2010. The NRC's role is to assess whether the facility would meet NRC regulatory requirements. Other policy considerations are up to DOE and Congress.

It will be some time before a repository is available. All nuclear power reactors move their spent fuel first into pools for storage on site. As the amount of spent fuel in the pool increases, many reactors are also using dry casks for storage. The NRC reviews and approves the designs for these systems.

Once a central location for storage or disposal is approved, spent fuel will need to be transported there from sites around the country. These shipments would likely be made by rail or on public highways.

Because spent fuel is highly radioactive, people may wonder:

- **How does the NRC protect the public from radiation during transport?**
- **What is the likelihood one of these shipments will be involved in an accident?**
- **How well can the shipping containers withstand an accident and prevent the release of nuclear materials?**

The NRC addresses these and other questions as a part of its ongoing efforts to ensure safe transport. As new technology and real-world information become available, the NRC evaluates its regulations. It is important to know that spent fuel has been shipped safely within the U.S. and abroad for more than 40 years.

Radiation

About half of the public's average annual radiation exposure comes from natural sources. These sources include radon, the human body, outer space, rocks and soil. This natural radiation is called "background" and can vary greatly from place to place. Nearly all of the rest of an average person's exposure comes from medical sources, such as x-rays and diagnostic tests that are used in health care. Radiation that can be traced to radioactive materials transport makes up a tiny fraction of an average person's overall exposure. Such low levels of exposure are very unlikely to have any biological effect, but if they did they would be too small to be detectable. The human body responds to radiation in the same way whether it comes from natural or manmade sources.

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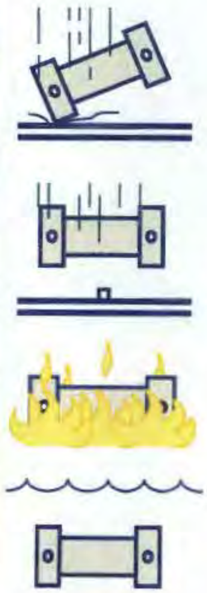

The impact (free drop and puncture), fire, and water immersion tests are considered in sequence to determine their cumulative effects on a given package.

?

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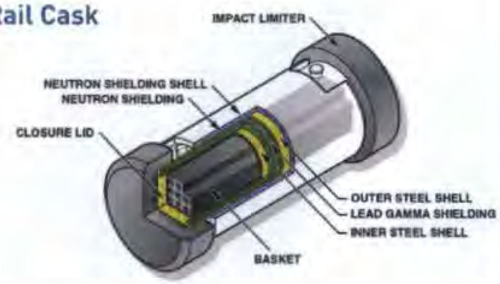
Rail Cask



Truck Cask

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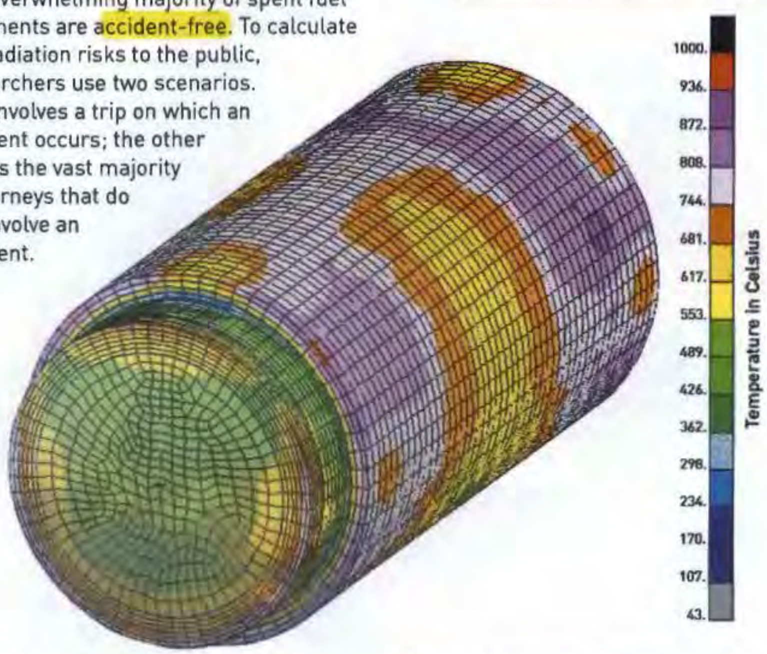
- **What can go wrong?**
- **How likely is it to occur?**
- **If something goes wrong, what are the consequences?**

Researchers use a four-step process to study actual and potential accidents and their effects.

Step 1. Experts determine what might happen.

- *They gather historic records.*
- *They also put together data on how many spent fuel shipments are likely each year.*
- *They look at the rate of accidents for rail and highway shipments.*
- *They look at a large number of accidents that are credible.*
- *They also look at the effects of crash impact forces, fires or punctures on the shipping container. They pick forces that are more severe than those covered by NRC standards.*

The overwhelming majority of spent fuel shipments are accident-free. To calculate the radiation risks to the public, researchers use two scenarios. One involves a trip on which an accident occurs; the other covers the vast majority of journeys that do not involve an accident.



Shown is a computer simulation of the response of a cask to a severe fire environment. Analyses like this and tests are used by NRC to assure safe transportation of spent fuel.

Step 2. Engineers use complex computer programs to estimate how the parts of a shipping container might be damaged by collisions or fires.

- *They gather data on how much spent fuel each container will carry.*
- *They analyze how the spent fuel might respond in a given type of accident.*
- *They calculate the temperature of the container and the spent fuel itself during a long-term fire.*

This information allows them to estimate the size of a potential leak and how much nuclear material might escape.

Step 3. Researchers match accident scenarios from Step 1 with the analyses from Step 2. This tells them the likelihood that there would be severe damage to the container or its contents.

Step 4. A special computer program computes a risk estimate. The program takes accident probability estimates, expected numbers of shipments, route data (like population densities), weather data (to estimate how any release might be spread by wind), and radiological dose data to produce a risk estimate.

The Accident Scenario

NRC studies show that the likelihood of an accident is low. Fewer than 1 in 100 accidents involving a spent fuel container will be more severe than the conditions defined in the design standards. However, if a very unlikely chain of events occurs, an accident might be severe enough to cause a radioactive release.

To estimate the risk of these severe accidents, researchers use a multi-step approach. They use data and their experience with past highway and rail accidents involving other hazardous materials. Part of this step is to determine what kinds of accidents could happen and look at what their effects might be.

Using this method, the chance that an accident would be serious enough to lead to a small release is about 1 in 1,000. The chance of a large release is less than one in 1,000,000,000.

The Accident-Free Scenario

For most spent fuel shipments, nothing will go wrong and no nuclear material will be released. For these shipments, experts calculate the total radiation dose that all people along the route could receive. They use information on routes and local populations to determine how many people may be affected and the dose they could receive.

The risk to the public from an accident-free journey results from the very low levels of radiation that may come through the cask walls. A person standing along the highway or railroad track might receive a brief exposure that is well below regulatory limits. Exposure will vary depending upon the speed of the vehicle and how far away the person is standing. Doses from routine transport would be less than 1/1000 the amount of radiation people receive from background sources each year.

The Bottom Line

The NRC believes that shipments of spent fuel in the U.S. are safe. This belief is based on the NRC's confidence in the shipping containers that it certifies and its ongoing research in transportation safety.

- **The NRC ensures that shipping containers are robust by:**
  - Defining strict requirements for package design and performance
  - Reviewing designs and independently checking a container's ability to meet accident conditions and
  - Doing inspections to ensure casks are built, maintained and used properly.
- **The NRC also looks at the risks involved in spent fuel shipments. The agency:**
  - Analyzes spent fuel transport records to fully understand any safety issues
  - Evaluates new transportation issues, such as projections for the number of shipments, changes in population along some routes and other factors, and
  - Keeps up with technology as it evolves to refine estimates of current and future risk to the public.

There will always be a slight chance that an accident will cause a release of nuclear material. But the NRC has found the likelihood of such an event and the risk to the public to be extremely low. Even so, the NRC will continue to be vigilant about public safety as an essential part of its mission.

Spent Fuel Transport Security

The NRC also regulates how spent nuclear fuel is protected in transit against sabotage or theft. The NRC's current rules for the physical protection of spent fuel transport include:

- **Coordinating with law enforcement agencies before the shipment**
- **Requiring advance notice to States, Indian tribes, and the NRC**
- **Using a communications center and other means to monitor shipments while in route**
- **Armed escorts, and**
- **Devices that allow drivers and escorts to shut the vehicle off**

Since September 11, 2001, the NRC has taken additional steps to protect the public.

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