Transportation of Radioactive Materials

Transportation is a routine activity

The transportation of radioactive materials and wastes is an integral part of waste management. Radioactive wastes must almost always be moved from where they are generated to another location for interim storage or permanent disposal.

Transportation of diverse materials is common

The types of radioactive materials and wastes that are routinely transported range from wastes generated by the uranium fuel cycle, decommissioning wastes, and medical, industrial, and research sources of radiation.

Routine Transportation

About 4,000 shipments of spent nuclear fuel have been conducted by road, rail and boat since 1964 in the U.S.

About 12,000 shipments of transuranic wastes have been transported to the Waste Isolation Pilot Plant since 1999.

Transportation safety

Transportation must be accomplished as safely as possible to minimize human exposure to radiation, and to reduce potential barriers to the public's acceptance of nuclear energy.

Radiological characterization of waste packages

The greater the potential radiological hazards, the more robust and stringent are the package safety requirements.

The requirements cover the type of package, labeling protocols, radiation shielding, loading and unloading during transport, storage, transportation routes, and the modes of transport.

Low-Specific Activity (LSA)

LSA can be defined as unshielded material that emits a relatively limited specific activity (radioactivity/mass) of radiation from sources that are essential uniformly distributed within the material.

In general, LSA materials pose a relatively small hazard because of their radioactivity.

The three LSA types

Low-specific activity group	Examples and partial characteristics
LSA-I	Uranium and thorium ores, natural and depleted uranium. Radioactive materials with an unlimited A_2.
LSA-II	Water with tritium ≤ 0.8 TBq/L (21.6 Ci/L). Materials with an estimated specific activity that does not exceed$10^{-4}A_2$ per gram of solids, and 10^{-5} A_2/g for liquids.
LSA-III	Solid materials with an estimated specific activity that does not exceed 2 x$10^{-3}A_2$ per gram of material.

Activity values for LSA forms

A_1 (special form) is a solid with limited dispersibility or material inside a sealed capsule that is not in a powdered form.

A_2 (regular form) is the maximum activity of radioactive material permitted in a Type A package and is more restrictive than A_1.

Surface contaminated object (SCO)

An SCO is a solid material, but as the name implies radionuclides are present on the surfaces but are not present at depth within the material. There are three categories of SCO. The criteria for the three categories depend on whether the contamination is fixed or non-fixed.

The three SCO groups

Surface-contaminated object group	Partial characteristics
SCO-I	Non-fixed contamination on accessible surfaces that does not exceed 0.4 Bq/cm^2 (1.08 x 10^{-5} µCi/cm^2) for beta and gamma sources.
SCO-II	Fixed contamination on accessible surfaces that does not exceed 8 x 10^5 Bq/cm^2 (21.6 µCi/cm^2) for beta and gamma sources.
SCO-III	Non-fixed plus fixed contaminants on a large object that do not exceed 8 x 10^5 Bq/cm^2 (21.6 µCi/cm^2) for beta and gamma sources.

Transport Index (TI)

A dimensionless shipping number for labelling packages, overpack, and freight containers. It is intended to communicate to transport crews and first responders the degree of potential radiological hazard in the event of an incident.

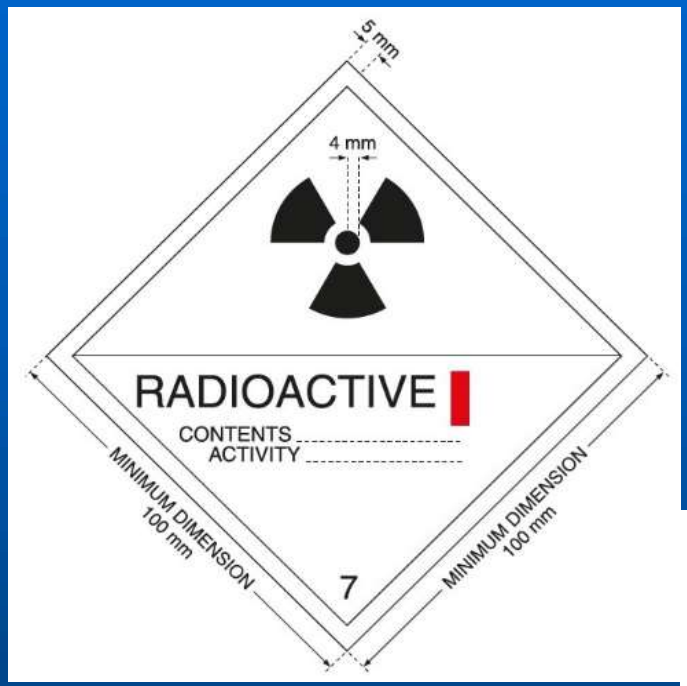
Transport Index (TI)

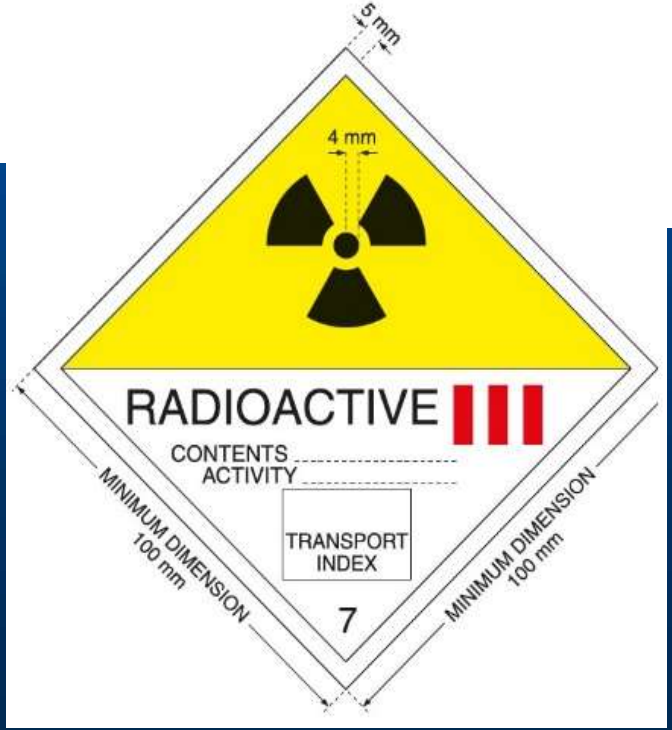
The maximum dose rate at a distance of 1 m from the external surfaces of the package is determined by direct measurement. If the TI is greater than 10, then the package or overpack must be transported by exclusive use meaning that it must be shipped alone without any other radiation sources.

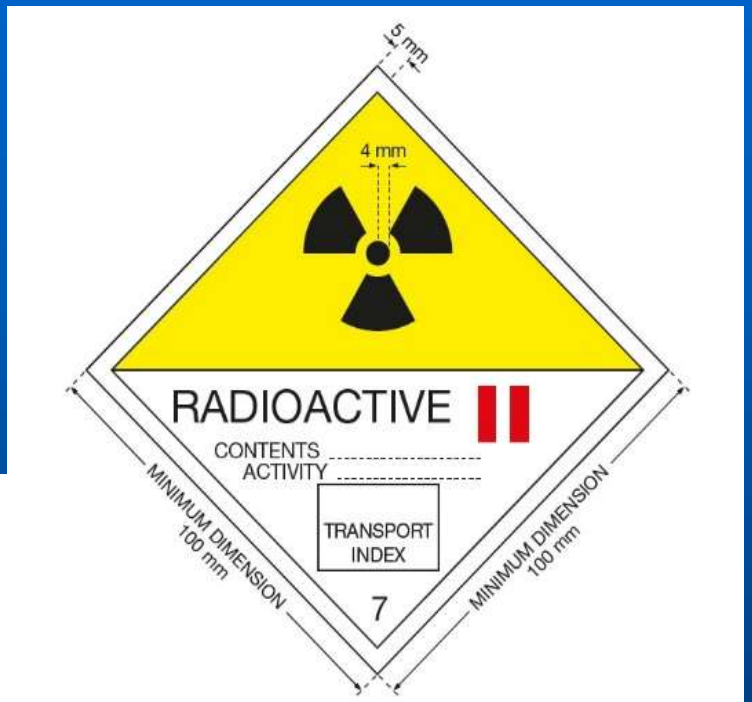
Transport Index (TI)

Maximum dose rate (mSv/hour)	TI (unitless)	Transportation category
≤ 0.005	0	I - White
> 0.005 but ≤ 0.5	> 0 but ≤ 1	II - Yellow
> 0.5 but ≤ 2.0	> 1 but ≤ 10	III - Yellow
> 2.0	> 10	III - Yellow

Transportation Labelling








RADIOACTIVE II
CONTENTS
ACTIVITY
7
Labels on opposite sides of package
THIS SIDE UP
U.S.A. DOT 7A-TYPE A
RADIOACTIVE MATERIAL, TYPE A PACKAGE
UN 2915
RADIOACTIVE II
7

Shipping Packages

The purpose of *all* shipping packages for radioactive materials is to provide adequate shielding from radioactive materials during routine handling and during accidents when transported.

There are five different categories of shipping packages: Excepted, Industrial, Type A, Type B, and Type C.

Excepted Package

This type of container is used for radioactive material exhibiting radiation levels that are regarded as insignificant. Excepted packages are not required to be tested or designed to survive any transportation accidents. It assumed that all of the contents could be released during an accident.

Excepted Packages

NRC EXEMPT RADIOACTIVE MATERIALS "NORM"

This package conforms to UN2910 and 49 CFR 173.421. It contains naturally occurring radioactive materials (NORM) and is exempt from NRC licensing & regulation. The radiation emitted from these samples is small, and presents no known radiation hazard. It is not classified as hazardous material, and may be disposed of in regular waste providing all radiation symbols have been removed.

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Industrial Package

This type of container is used to transport relatively low-level radioactive material such as LSA materials.

Three categories of Industrial Packages (IP): IP-1, IP-2, and IP-3. An IP-1 package has no testing requirements for normal transport conditions.

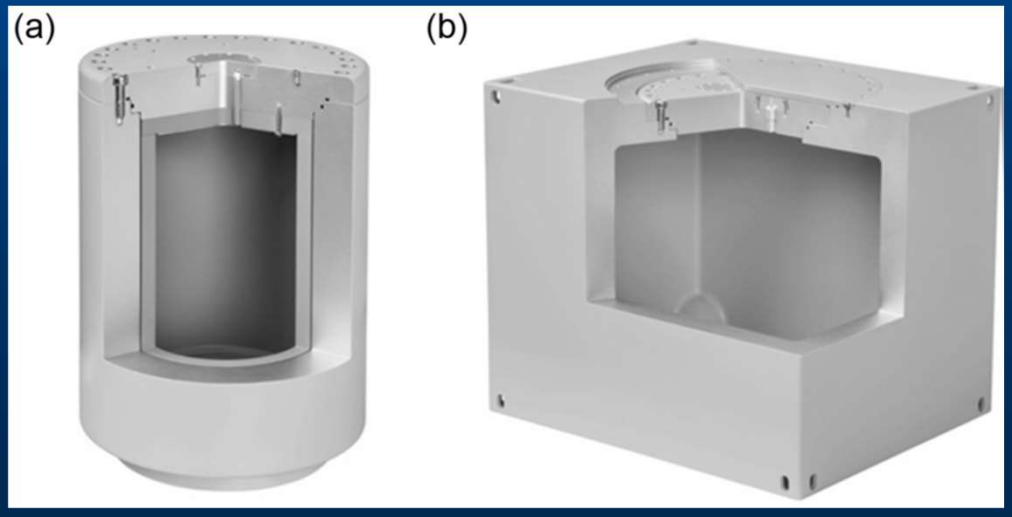
Industrial Package

An IP-2 package must survive a free drop and stacking requirement. The IP-3 package has an additional penetration or compression test requirement. The survival requirements of an IP-3 package are identical to those for a Type A package.

Industrial Package

Commonly used Industrial Packages are steel drums and boxes. The relatively familiar 200-L drum (or the 55-gallon drum in the U.S., and the 44-gallon drum in the U.K.) are often used to ship low- and intermediate-level radioactive wastes.

Industrial Packages



Industrial Packages

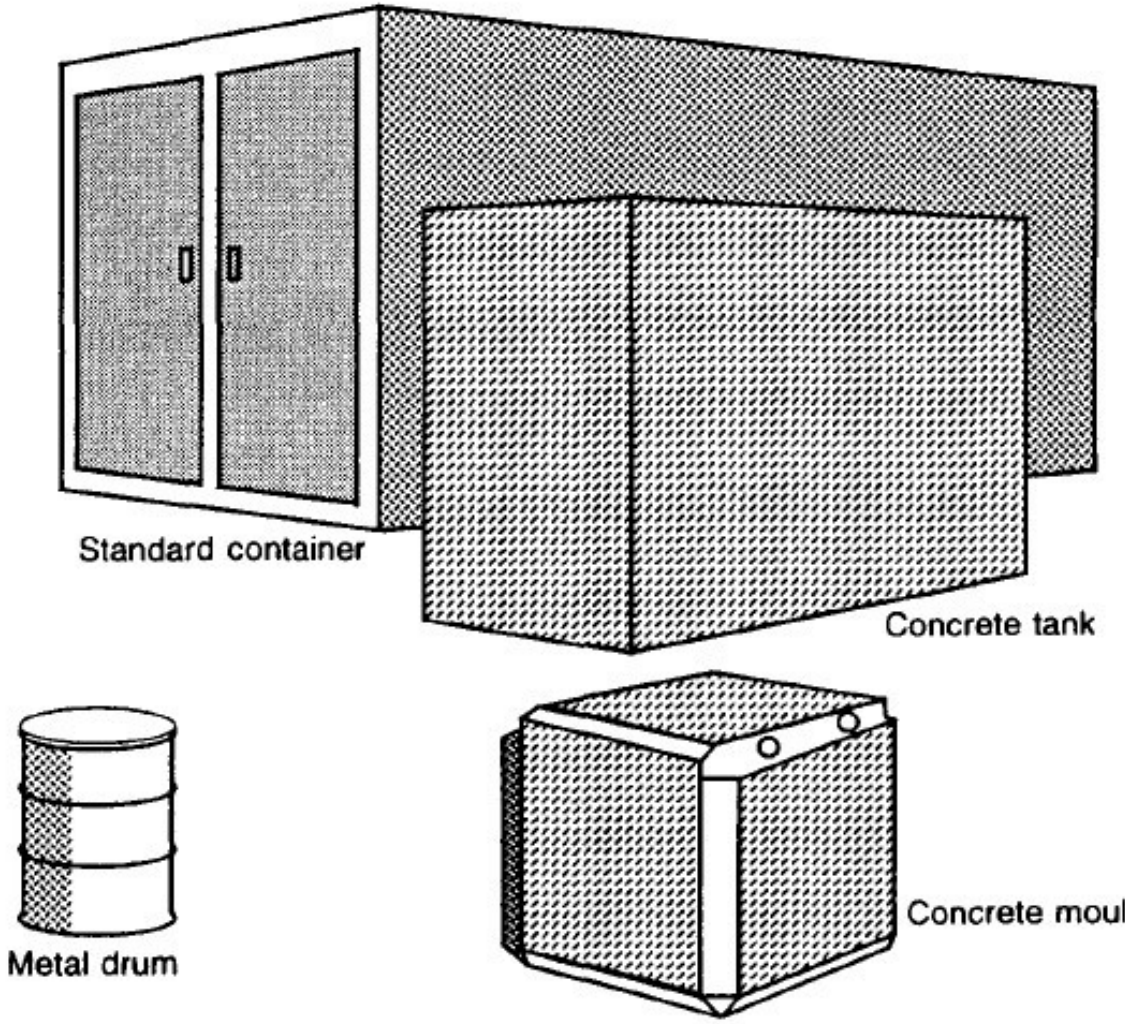


FIG. 15. Waste package types to be disposed of in the SFR repository at Forsmark, Sweden.

Type A Package

Used to transport a relatively small but significant source of radiation. It is assumed that a Type A package will maintain its physical integrity under conditions of normal transport and during rough handling or minor accidents. A Type A package may be damaged in a *severe* accident resulting in the release of some of its contents.

Endurance tests for Type A packages

Test	Intended scenario
Water Spray 5 cm per hour for at least 1 hour	Sitting uncovered on a loading dock or road exposed to heavy rain.
Free Drop Package is dropped 0.3 to 1.2 m (depending on its weight) onto a hard surface.	Falling off a vehicle or loading dock during loading/unloading or an accident.
Stacking A weight 5 times heavier than the package is placed on the package for 24 hours.	Being crushed at the bottom of a stack of heavier packages.
Penetration A 6 kg bar is dropped 1 m onto the upper surface of the package.	Being struck by a loose object or by heavy freight with a sharp corner during loading/unloading or an accident.

Type A Packages

Type B Package

Designed to transport material with the greatest radioactivity. These packages are designed to survive severe accidents. Type B packages must pass all the Type A tests but are also required to endure additional tests that are intended to simulate worst-case scenarios such as a train derailment with a subsequent fire.

Endurance tests required of Type B packages

Test	Intended scenario
Free Drop I The package is dropped 9 m onto an unyielding surface such that the weakest surface (such as a corner) impacts first.	Presumedly simulating impact during a major accident such as a traffic or rail incident.
Free Drop II (Puncture) The package is dropped 1 m onto a mounted 15-cm diameter, 20-cm long steel rod.	Presumedly simulating impact during an accident against a sharp corner or being struck by a high-velocity loose object during a major accident.
Free Drop III (Dynamic Crush) A 500-kg mass is dropped 9 m onto the package.	Presumedly simulating impact during an accident possibly with other freight packages present.

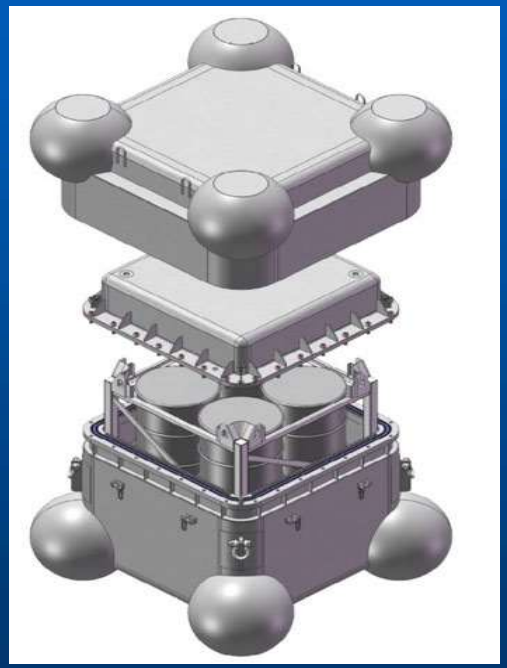
Endurance tests required of Type B packages

Thermal (engulfing flames) **The package is subjected to at least 800º C for at least 30 minutes.**	**An accident results in the ignition of flammable liquids such as diesel fuel or flammable chemicals in railroad tank cars.**
Thermal (solar insolation) **The package is exposed to direct sunlight at 38º C.**	**The generation of heat from within the package by radioactive decay contributes excessively to the overall temperature of the package.**
Water Immersion **The package is submerged in water that is at least 15 m deep for at least 8 hours.**	**The package is separated from the mode of transportation and falls into a river, lake, or the sea.**

Type B Packages

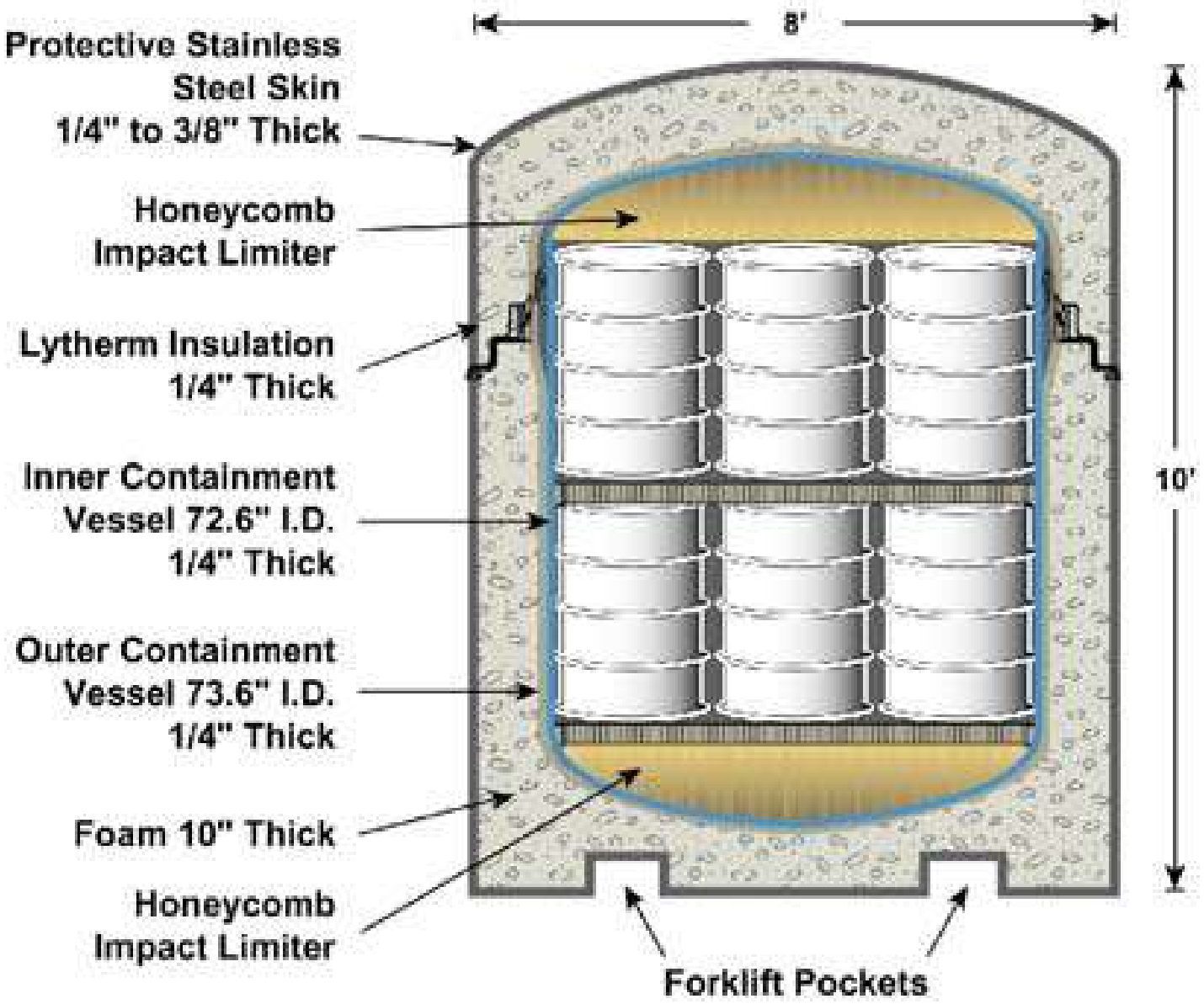
Type B packages are diverse and can vary from hand-held instruments to heavily shielded steel casks. Type B shipping casks are used to transport transuranic (TRU) wastes from U.S. DOE sources to the Waste Isolation Pilot Plant in New Mexico. The Transuranic Package-Transporter Model 2 (TRUPACT-II) and the HalfPACT casks are used to transport Contact-Handled TRU wastes.

Type B Packages



The HalfPack (left) and two TRUPACT-II casks

TRUPACT-II



Weight

12,705 lbs. empty

19,250 lbs. loaded

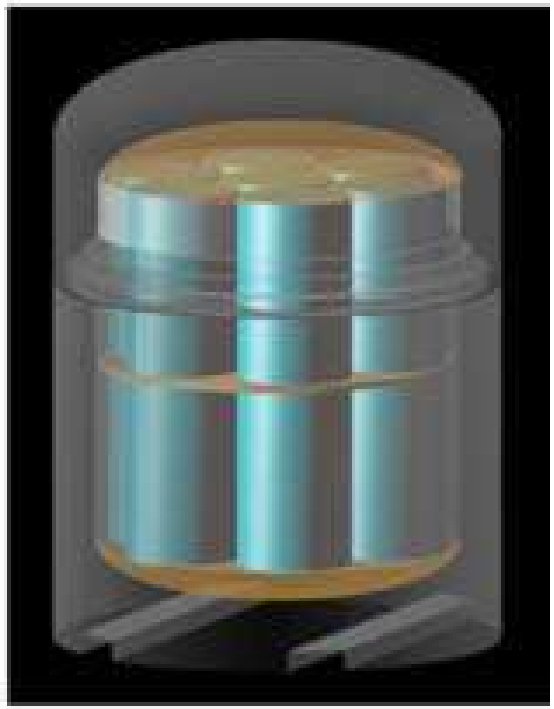
Material

Stainless Steel

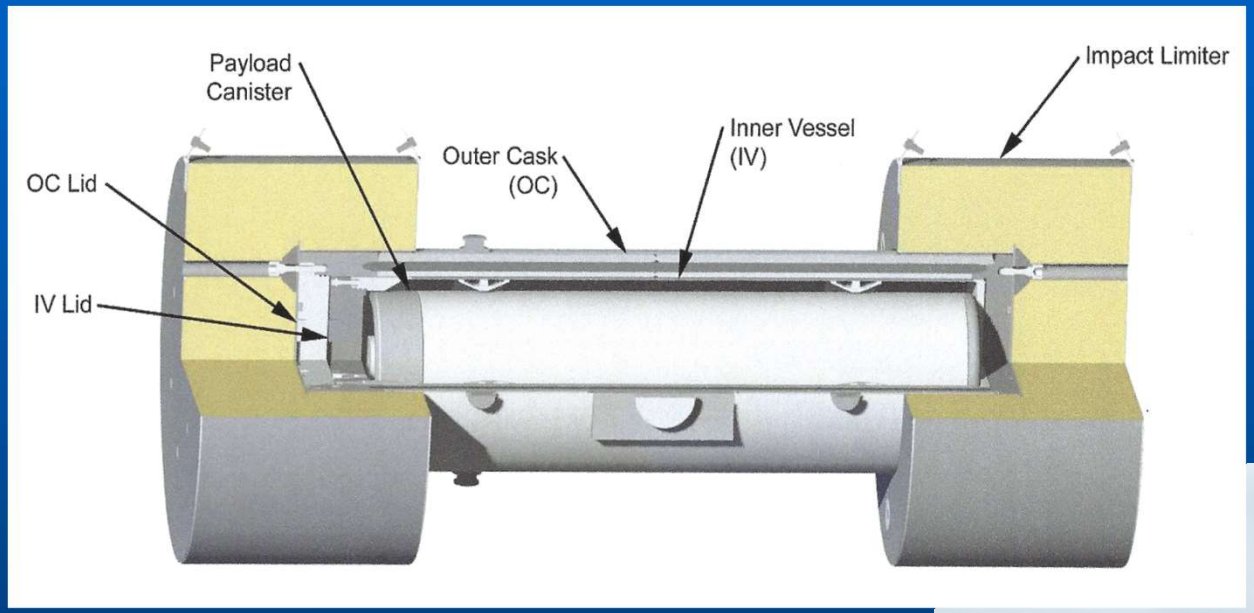
Polyurethane Foam

Ceramic Fiber

Insulation



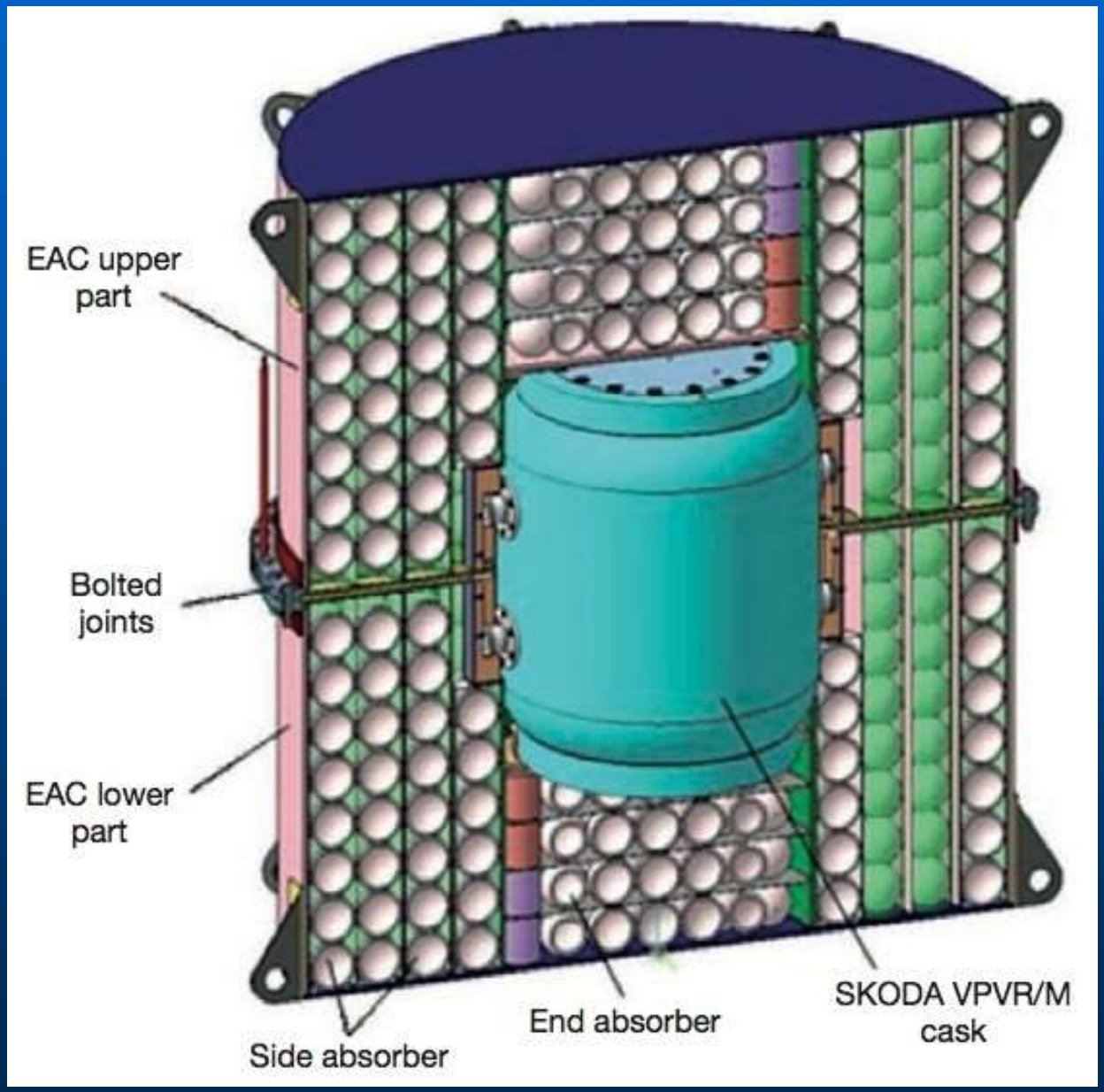
The RH TRU 72B Type B transport cask



The Type C Package

It is envisioned that the Type C package will be used for air transport of highly radioactive material. Type C packages would need to meet the durability tests for Type A and B packages, and some additional tests. This type of package has not yet been fully developed. A type C package, however, has been developed in Russia.

The Type C TUK-145/C package



The PMATP, a Type C Prototype Package

Sandia National Laboratories designed and tested a prototype package for air transport of plutonium. It was designed to transport 7.6 kg of plutonium and to survive a "worst case" airplane crash. The package is called the Perforated Metal Air Transportable Package (PMATP).

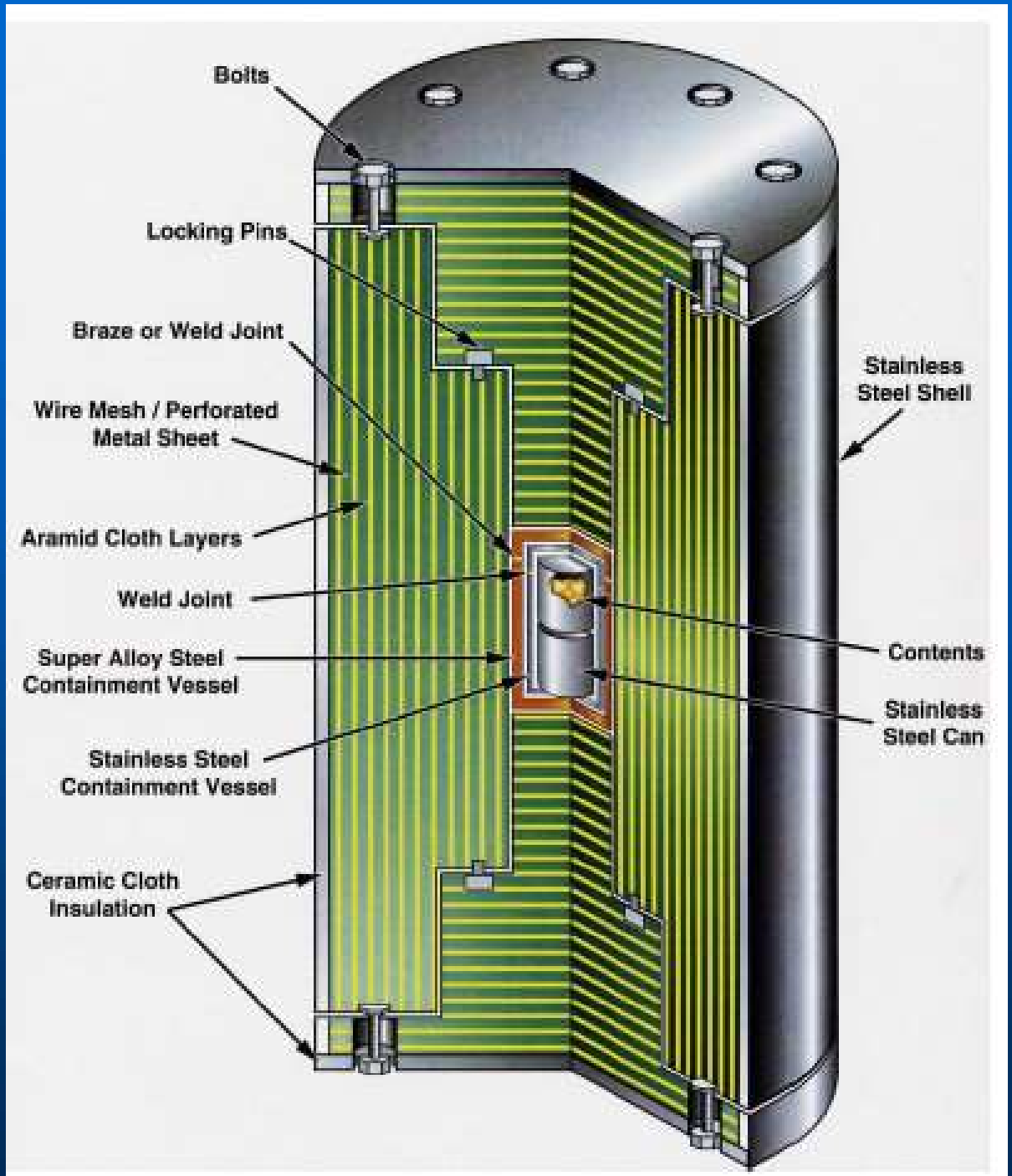


Figure 2.1. Perforated Metal Air Transportable Package (PMATP).

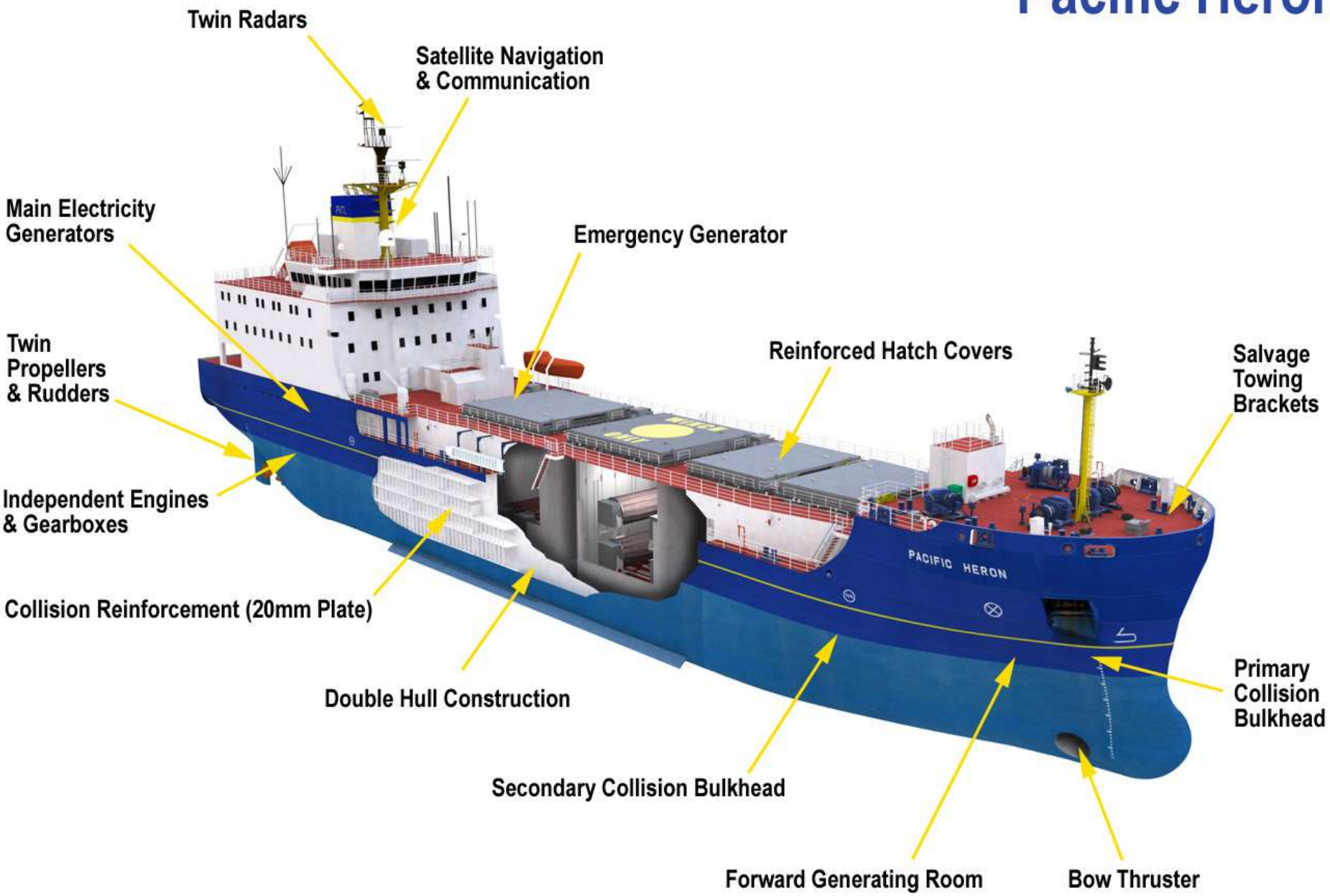
Marine Transportation of Radioactive Materials

In order to meet national requirements for re-fueling, Japan has to ship used nuclear fuel to France and the U.K. for chemical reprocessing and had to accept the vitrified high-level reprocessing waste for disposal.

Pacific Nuclear Transport Limited (PNTL) has been engaged to ship used nuclear fuel, MOX fuel, and the vitrified wastes since 1969.

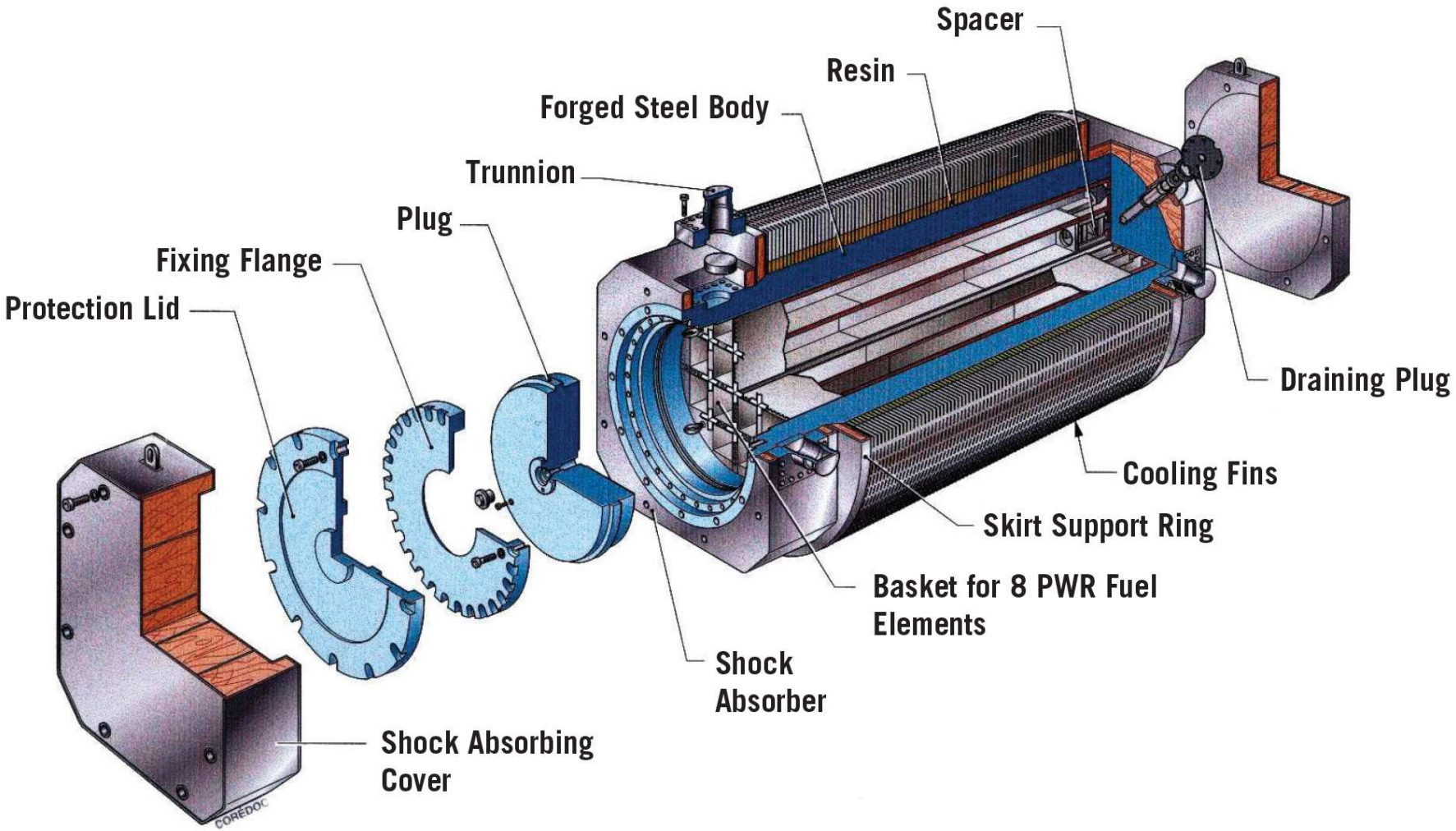
https://www.pntl.co.uk/

Pacific Heron




PACIFIC

TN 12/2 Transport Cask



A routine activity

About 7,137 tonnes of used fuel have been shipped to Europe for reprocessing. About 635 tonnes of vitrified waste have been shipped to Japan from France. Sea shipping between France and Japan is on-going. To date, there have been no incidents or lost shipments while in transport.

Questions?

Class Assignment 9

Uranium Diffusion from Old Rifle Sediments.
Not in the textbook.

Rubric:
The assignment is worth 20 points.
There are 2 questions. Each is worth 10 points.