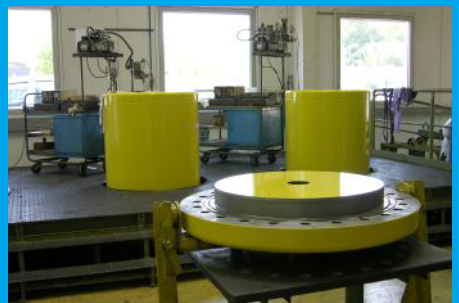
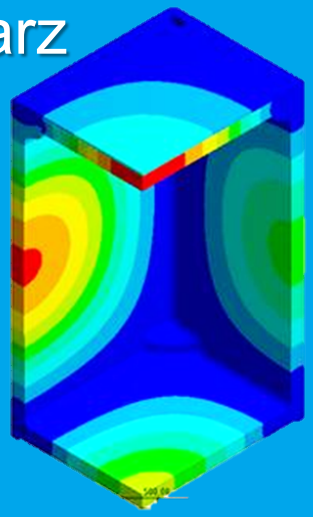
Siempelkamp
Nukleartechnik

DSFM REG CON 2014
20.11.2014, Rockville, Maryland

Experience with Ductile Cast Iron Fuel Casks

Dr. Wolfgang Steinwarz

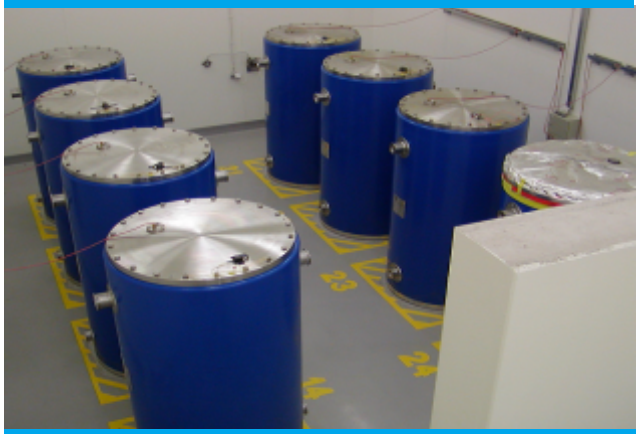
Transport and Storage Containers for SNF

Surry/USA

Würenlingen/Switzerland

Dukovany/Czech Republic

Koeberg/South Africa



Mol/Belgium

Gorleben/Germany

Source GNS

Transport and Storage Containers for SNF

Castor ® - Design

CASTOR® V/19 (PWR)
CASTOR® V/21 (PWR)
CASTOR® V/52 (BWR)

CASTOR® X/28 (PWR)
CASTOR® X/33 (PWR)
CASTOR® X/74 (BWR)

CASTOR® HAW28M
CASTOR® HAW20CG
CASTOR® HAW28CG

CASTOR® KNK
CASTOR® 1000/19 (WWER)
CASTOR® 440 (WWER, 84 SFA)
CASTOR® RBMK
CASTOR® THTR/AVR
CASTOR® MTR

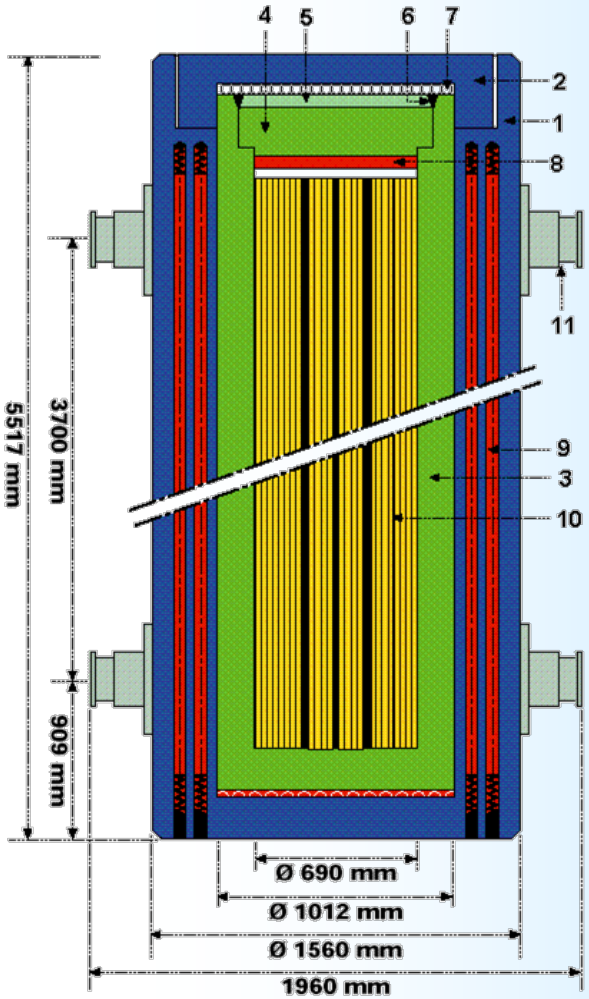
Source GNS/BAM

Transport and Storage Cask and Containers

Reference list
(per 31 December 2013)

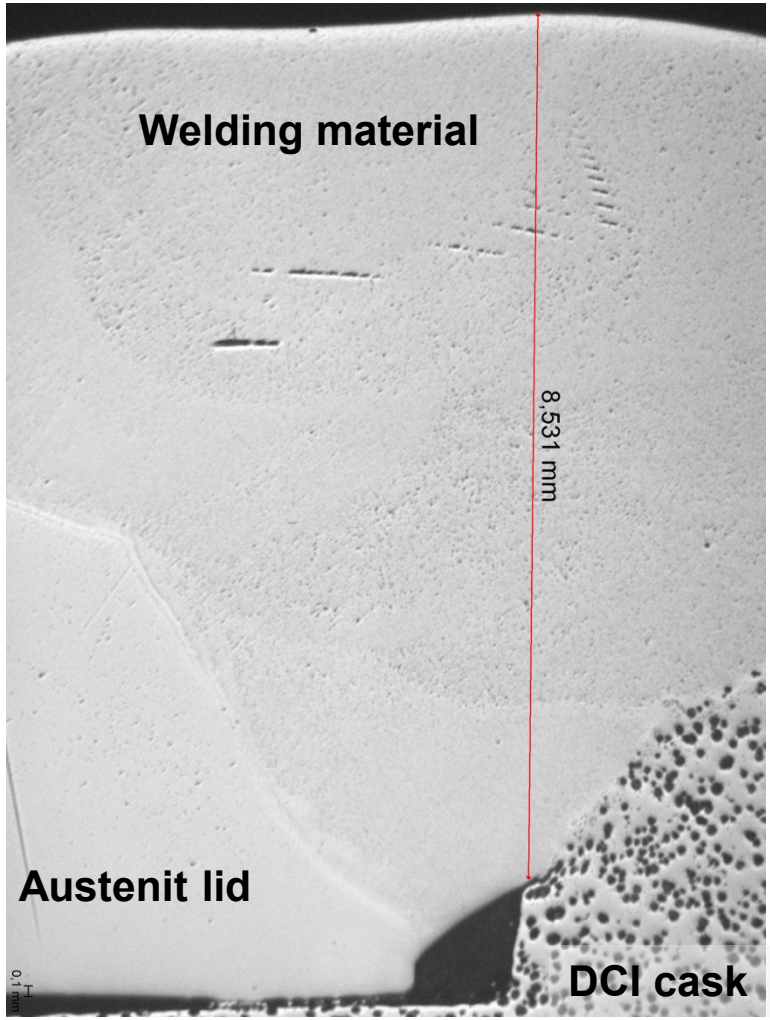
Type	Number of pieces
CASTOR®	653
MOSAIK®	6,846
Cast Iron Container (incl. BlueBox)	405
Granulate Concrete Container	2,802
Special Container	208
TUK-141, TUK-153	7
Total	10,921

Final Storage DCI Design: POLLUX®



1 DCI Cask
2 Shielding Lid
3 Inner Cask
4 Primary Lid
5 Welded Secondary Lid
6 Weld Seam
7 Damping Element
8 Moderator Plate (Graphite)
9 Moderator Rods
10 Fuel Rods
11 Trunnion

Final Disposal of DCI Casks



- For final disposal an additional lid can be welded on top of the existing double lid system of the DCI cask (encapsulation).

- Welding of DCI is an established procedure.
- Welding processes are clearly regulated in European standards, equally to the well-known steel-welding.
- Through meeting the strict regulations of welding in nuclear applications Siempelkamp is permitted to weld nuclear components.
- Processes and welders are specially qualified for these leakproof weldings on a CASTOR® cask.
- Periodically test pieces must be welded under permanent control of BAM-Supervisors to demonstrate the welding-quality.

Final Disposal: POLLUX®

Corrosion Studies on the Material Combination Used for the POLLUX Cask for Direct Disposal of SFA in Rock Salt Formations; KfK 4552, 1989

The corrosion rates are about 65 µm/a in the NaCl-rich brine and for 200-210 µm/a in the $MgCl_2$-rich brines.

The scenario taken in the studies delivered extreme conditions

Consequence:
Storage time: 100 a
Multiplied by the corrosion rate:
100 a * 210 µm/a = 21 mm in 100 a
Wall thickness: 400 mm

Corrosion does not degrade the safety or functionality of the cask

DCI – Use in Maritime Atmosphere

Example: Wind Turbines

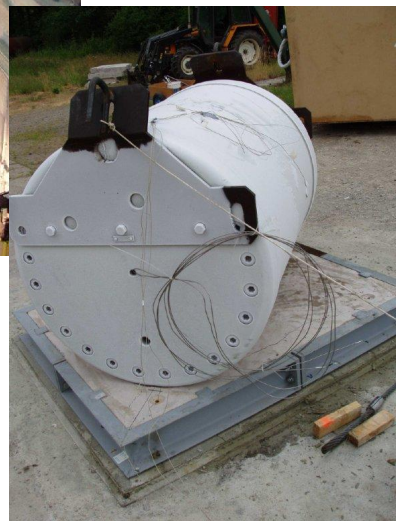
DCI components in wind turbines

- **since 1997 on-shore**
- **since 2004 off-shore**

No degradation effects detected

Embrittlement

Drop Test



Projekt: FORM III, 2005
Location: Siempelkamp SNT (Krefeld, D)- test hall

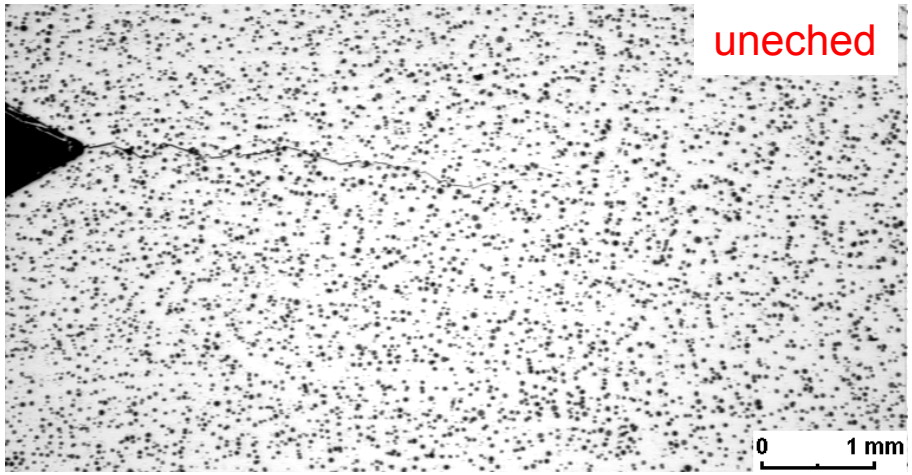
Characteristics:

- **Target: unyielded / reinforced concrete area**
- **Drop height: 5 m**
- **Cylinder drop**
- **Use of normal recycling material (CARLA)**
- **Artificial flaw (bottom side) with**
  L = 124 mm, D = 15 mm
  (15% of wall thickness, inner surface)
- **Container temperature: -20°C**

RESULT: no crack initiation

Embrittlement

Drop Test



Project: FORM III, 2005

Location: BAM, Lehre

Characteristics:

- **Target: unyielded / reinforced concrete area**
- **Drop height: 0.8 m (0.96 m)**
- **Use of very high content of embrittel elements (in particular Cr, Cu, Ni)**

  → high portion of pearlite: ca. 95%

  → low elongation: 4%
- **Artificial flaw (bottom side) with L = 105 mm, D = 15 mm**
- **Container temperature: -20°C**

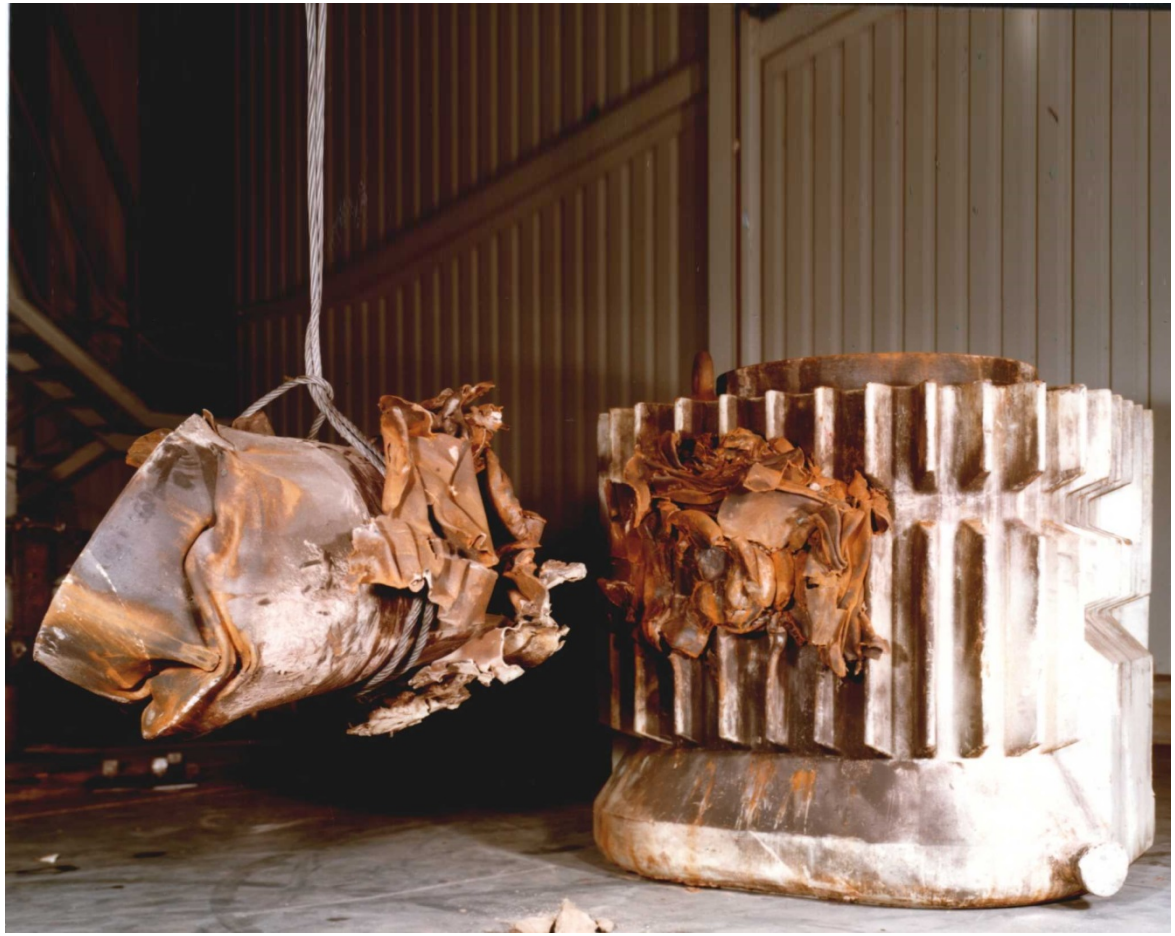
<u>RESULT:</u> self-controlled arrest; stabel propagation after a short initiation process

Licensing / Certification

1981:	Licensing CASTOR® was approved in Germany
1983:	CASTOR® permission for storage was received
1985:	Final certification for the use of the GJS-400 material was issued by the BAM (German federal agency of material testing)
	Licensing concept was based on a set of requirements
1987:	Type B licensing for MOSAIK®
2005:	DCI-certification by ASME (Code case N-670)
2012:	Licensing TUK “family”
2012/13:	LoC procedures for multiple DCI ILW containers

Safety Analyses and Tests for CASTOR® Casks

Residual risk incidents (1/2)



- CASTOR® mock-up after impact of a supersonic missile – deformed cooling fins

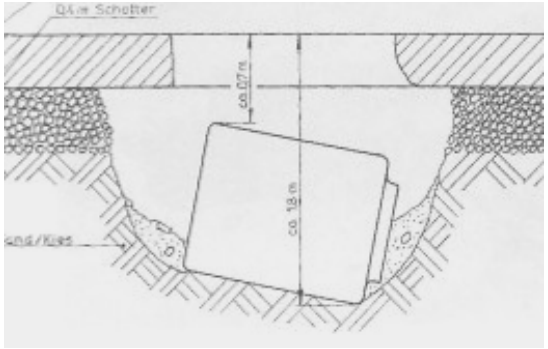
Safety Analyses and Tests for CASTOR® Casks

Residual risk incidents (2/2)

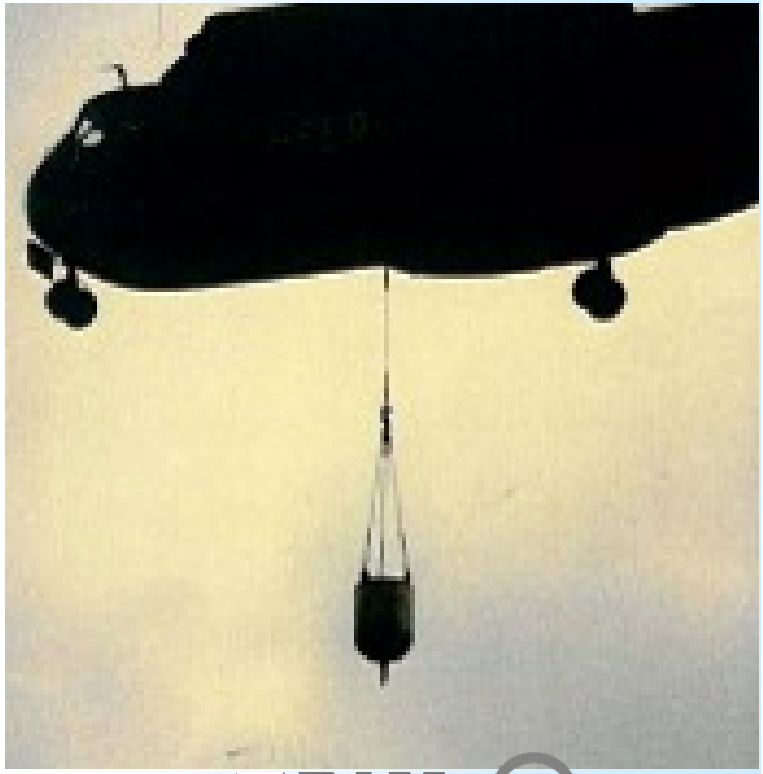
- **Explosion of a liquid gas tank**

Safety Analyses and Tests for CASTOR® Casks

Extreme Tests



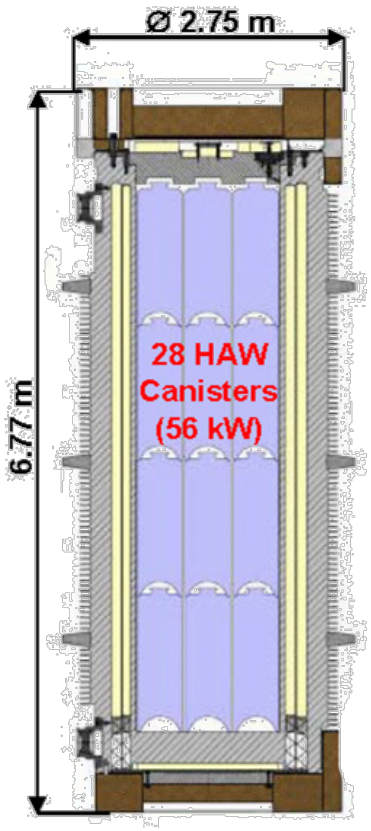
- Drop test of a MOSAIK® (GNS)
- Height of drop: 800 m

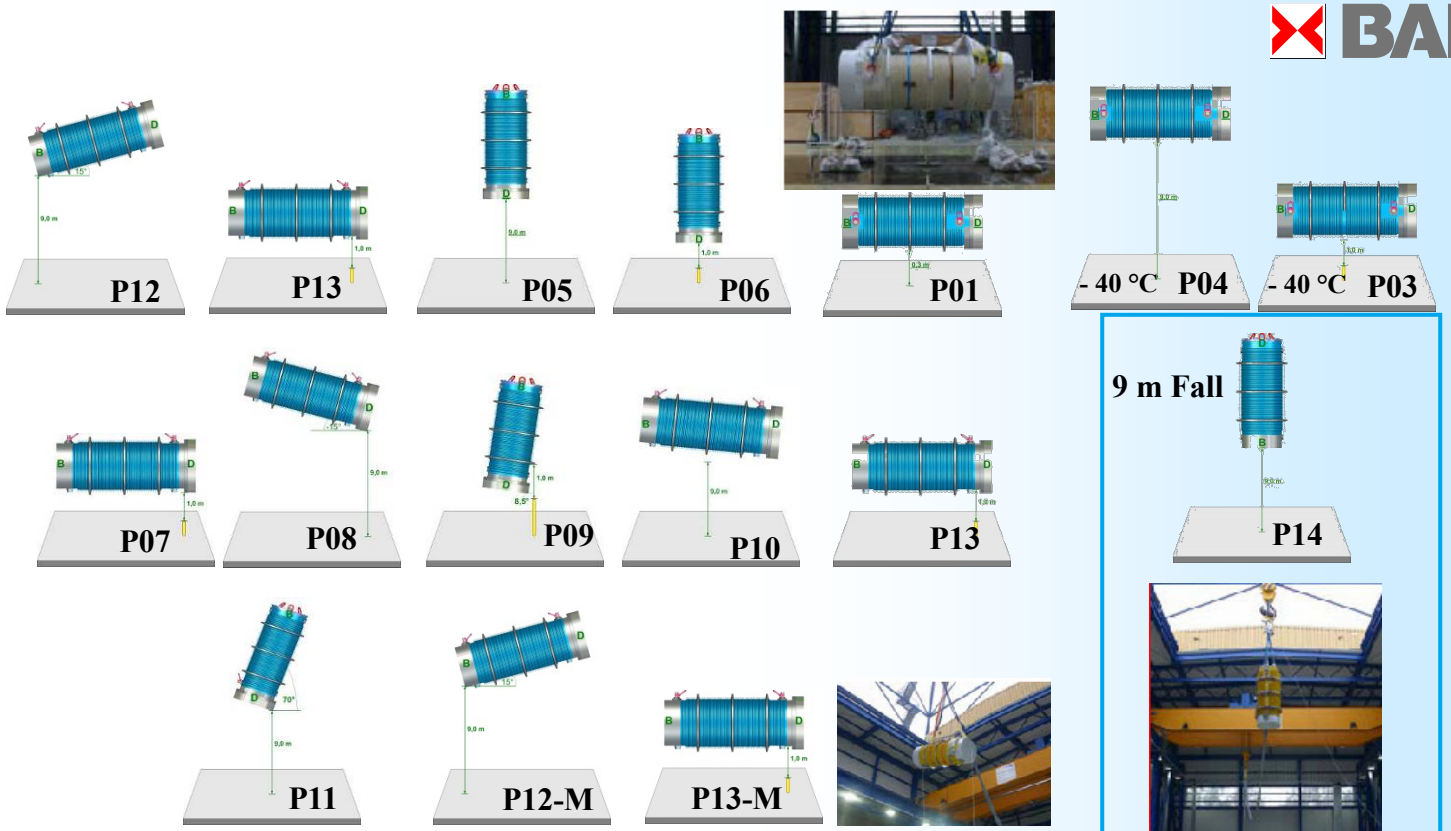


BAM GNS

Safety Analyses and Tests

IAEA requirement: drop form 9 m on an unyielding target





PATRAM
Bernhard Droste, BAM, 2013

Long-term behavior of DCI cask materials

CASTOR ® Ic-Diorit (ZWILAG, CH) 1983
CASTOR ® V/21 (Surry, UAS) 1985
CASTOR ® THTR/AVR (TBL Ahaus) 1992
CASTOR ® THTR/AVR (Jülich) 1993
CASTOR ® V/19 (TBL Gorleben) 1997
CASTOR ® Ic (TBL Gorleben) 1997
CASTOR ® HAW 20/28CG (TBL Gorleben) 1997

Over 30 years operational experience in the field and no issues for degradation of the package

Source GNS/BAM

Long-term behavior of DCI cask materials

CASTOR V/21 Cask Opening and Examination

1985 : **Loading** of a CASTOR V/21 cask with 21 Westinghouse 15x15 PWR spent fuel assemblies from the Surry Nuclear Power Plant. **Outside storage** of the cask at INEEL (Idahoe National Engineering and Environmental Laboratory).

1999 : Transport of CASTOR V/21 to the INEEL TAN Hot Shop facility. **Opening** the cask and performance of **examination and testing** (cask body, lid and seals, bolts, cask internals, etc.) with view to long-term integrity.

2001 : **Radiation survey** to evaluate the performance of the cask shielding.

15 years operation without any degradation effects!

INEEL/EXT-01-00183 Rev.1 report August 2001

Summary

- **The design of DCI casks utilizes the advantageous casting process for realization of a compact cask body without any weldings.**
- **The material DCI is able to withstand extreme external loads based on its unique microstructure.**
- **Manufacturing of DCI casks is a well established standardized production process with a long –term experience.**
- **DCI casks provide flexibility in storage and transport of SFE and radioactive waste material without any principle modifications.**

Siempelkamp
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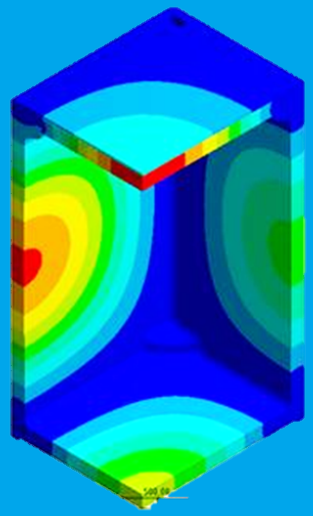
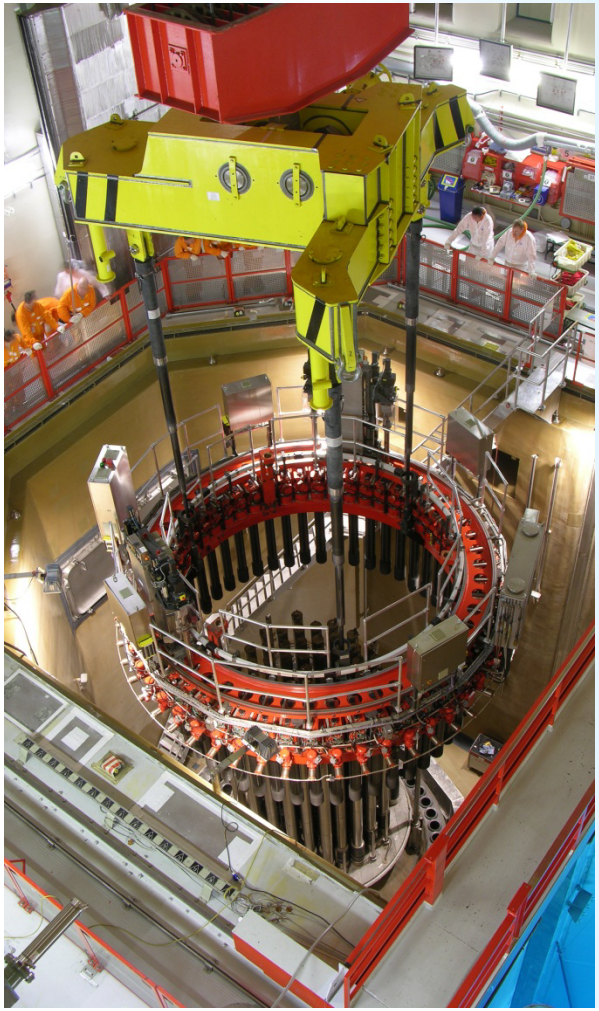
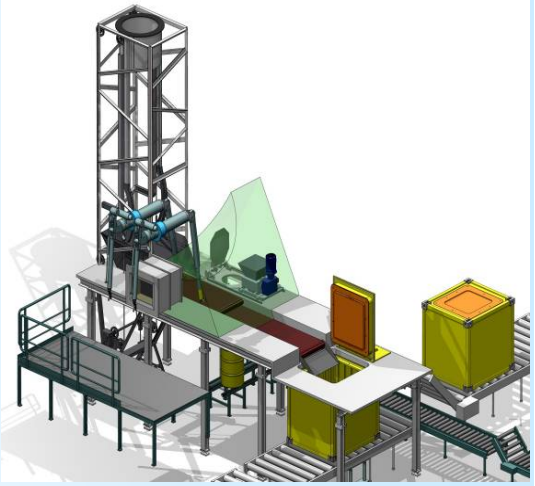
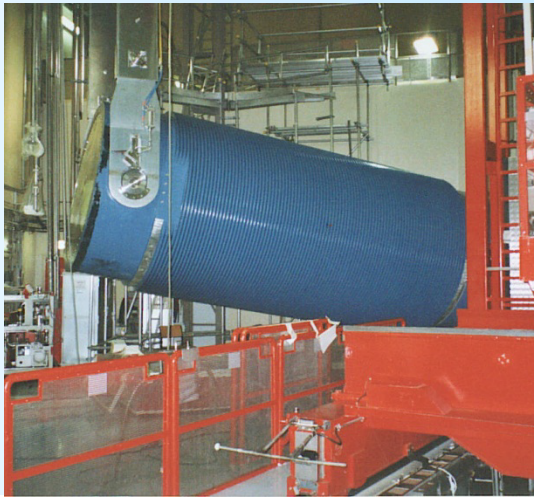
DCI casks - the option for the highest margin of safety to protect the people and the environment



Information







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