

**Non-Proprietary Version**



## **10 CFR72 Application of CASTOR® geo69 Dry Storage System**

GNS Gesellschaft für Nuklear-Service mbH

Technical Meeting

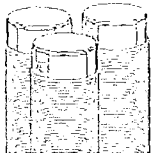


# Agenda – Public Part

- Project Overview
  - Scope and Intention of Part 72 Application
  - Applicable Regulations and Guidelines
  - Comparison with German Storage Regulations
- Status of Application



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version



Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 2

## Project Overview

- GNS aims to obtain approvals for its
  - Transport and storage cask CASTOR® geo69
    - 10 CFR 71 Application on 01/14/2021  
Docket: 71-9383
    - 10 CFR 72 Application on 06/07/2021  
Docket: 72-1052
  - Quality Assurance Program (QAP)
    - QAP Description Application on 07/10/2020  
Docket: 71-0967
    - Taking into account both, the requirements according to
      - 10 CFR Part 71, Subpart H and
      - 10 CFR Part 72, Subpart G



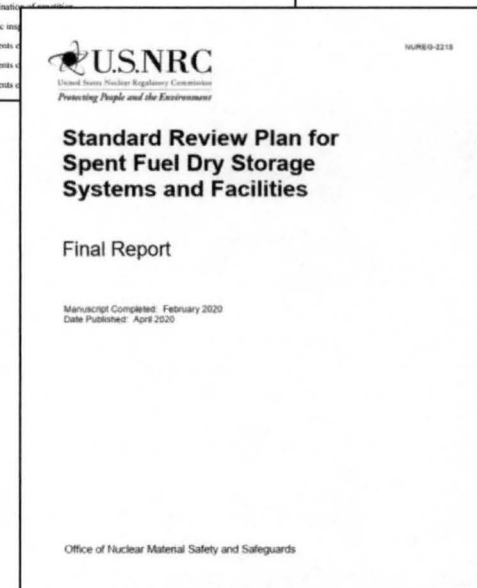
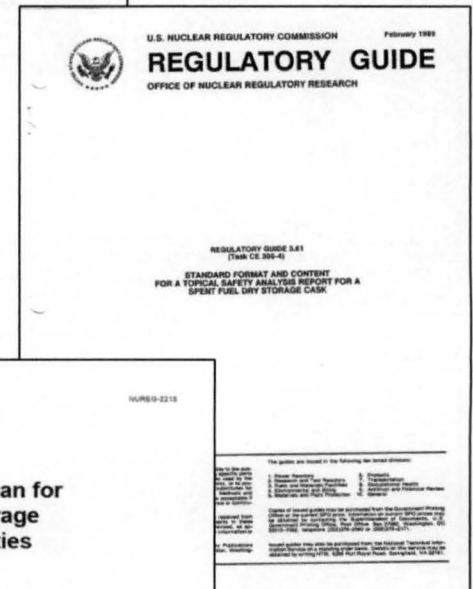
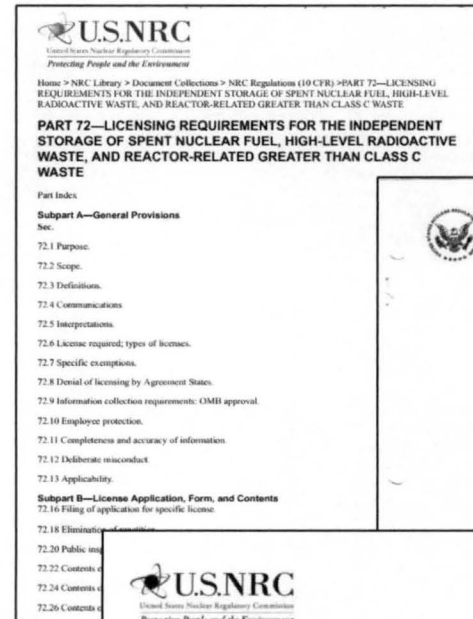
## Scope and Intention of Part 72 Application

- Approval of the DSS for SNF without any connection to a specific storage facility
  - Definition of a generic storage environment
  - Derivation of boundary conditions for DSS evaluation
  - Specification of requirements for storage facilities



## Applicable Regulations and Guidelines

- Approval of the CASTOR<sup>®</sup> geo69 DSS under 10 CFR 72 Subpart L – Approval of Spent Fuel Storage Casks
  - RG 3.61 + Periodic Review conducted in July 2019
  - NUREG 2215
    - With exception of chapters only applicable for specific licenses (SL) of ISFSI
    - Applicable referenced Guidelines



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version



# Applicable Regulations and Guidelines

Applicability	Scope for Certificate of Compliance and Specific License Reviews
<b>Normal Design Event Conditions</b>	Ambient Temperature: (1) Maximum (2) Minimum  Loading: (1) Wet or dry  Storage and Handling (e.g., loading, transfer) Orientation: (1) Vertical or Horizontal  Maximum Lift Height Maximum Cladding Temperature 1% Fuel Rod Rupture Solar Insolation

<b>Off-Normal Design Event Conditions</b>	<ul style="list-style-type: none"> <li>• Temperature Variation Beyond Normal</li> <li>• 10% Fuel Rod Failure Combined with Off-Normal Temperatures</li> <li>• Failure of One of the Confinement Boundaries</li> <li>• Partial Air Flow Blockage</li> <li>• Human Error</li> <li>• Out-of-Tolerance Equipment Performance</li> <li>• Equipment Failure</li> <li>• Instrumentation Failure</li> <li>• Faulty Instrumentation Calibration</li> </ul>
---	---

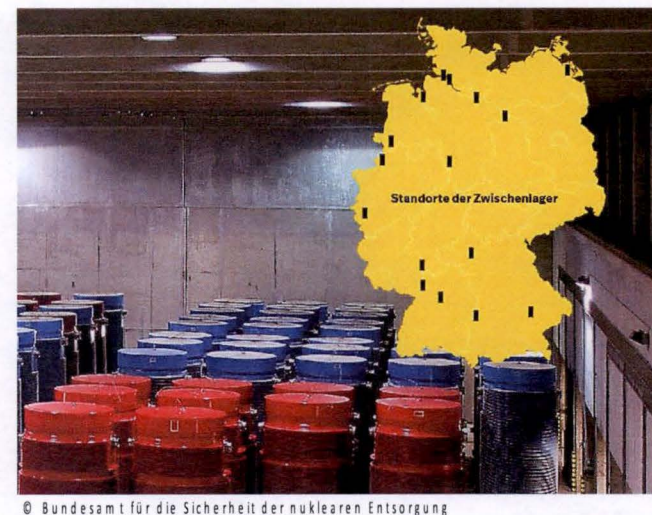
Applicability	Scope for Certificate of Compliance and Specific License Reviews
<b>Design-Basis Accident Design Events and Conditions</b>	End Drop: (1) Lift height (or maximum acceleration)  Side Drop: (1) Lift Height (or Maximum Acceleration)  Tipover: (1) Acceleration (if applicable)  Fire: (1) Duration (2) Temperature  Complete Air Flow Blockage Explosive Overpressure

<b>Design-Basis Natural Phenomena Design Events and Conditions</b>	Flood Earthquake Tornado Burial Under Debris Lightning  Other potentially relevant events identified in 10 CFR Part 72 (see SRP Section 3.5.2.5), as applicable
--	---

(according to NUREG-2215)

## Comparison with German Storage Regulations

- Storage of Spent Nuclear Fuel in either
  - 12 Onsite intermediate storage facilities at the NPP or
  - 2 Central intermediate storage facilities (Ahaus / Gorleben)
- No separate CoC for Dry Storage Systems
- DSS are included in licenses for relevant storage facilities
  - Separate regulatory authorities in each federal state
  - No generally applicable requirements regarding evaluation
  - Storage System related evaluations are individually commissioned by the licensee of the respective storage facility



## Status of Part 72 Application

- Application: 06/07/2021
- Request for supplemental information: 10/18/2021
  - Existing linkage to the Part 71 application only allows subsequent evaluation by NRC
    - GNS intends to separate the Part 72 SAR from the Part 71 SAR during revision.
  - Unspecified storage environment results in the need of further evaluations of the DSS
    - main topic of today's meeting

**Request for Supplemental Information with Observations  
Model No. No. CASTOR® geo69 Storage Cask  
Docket No. 72-1052**

This request for supplemental information (RSI) identifies information needed by the staff in connection with its acceptance review of the application for a certificate of compliance for the Model No. CASTOR® geo69 spent fuel packages, dated June 7, 2021 (Agencywide Document Access and Management System Accession No. ML21188A178). The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the application using the guidance in NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities."

The requested information is listed by technical discipline of review.





# End of Public part



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 9

## Agenda – Closed Part

- Background and schedule requirements
- DSS and CLU
  - Definition and description of configurations
  - Handling operations
- Concepts of safety evaluations
  - Concept for CLU
  - Current concept for DSS
  - Alternative concept for DSS
- Safety evaluations to be performed
  - resulting from concepts and RSI
  - Organized by specialty department:  
Structural, thermal, shielding & radiation protection, criticality, containment and material evaluations, operation procedures, acceptance criteria and maintenance program

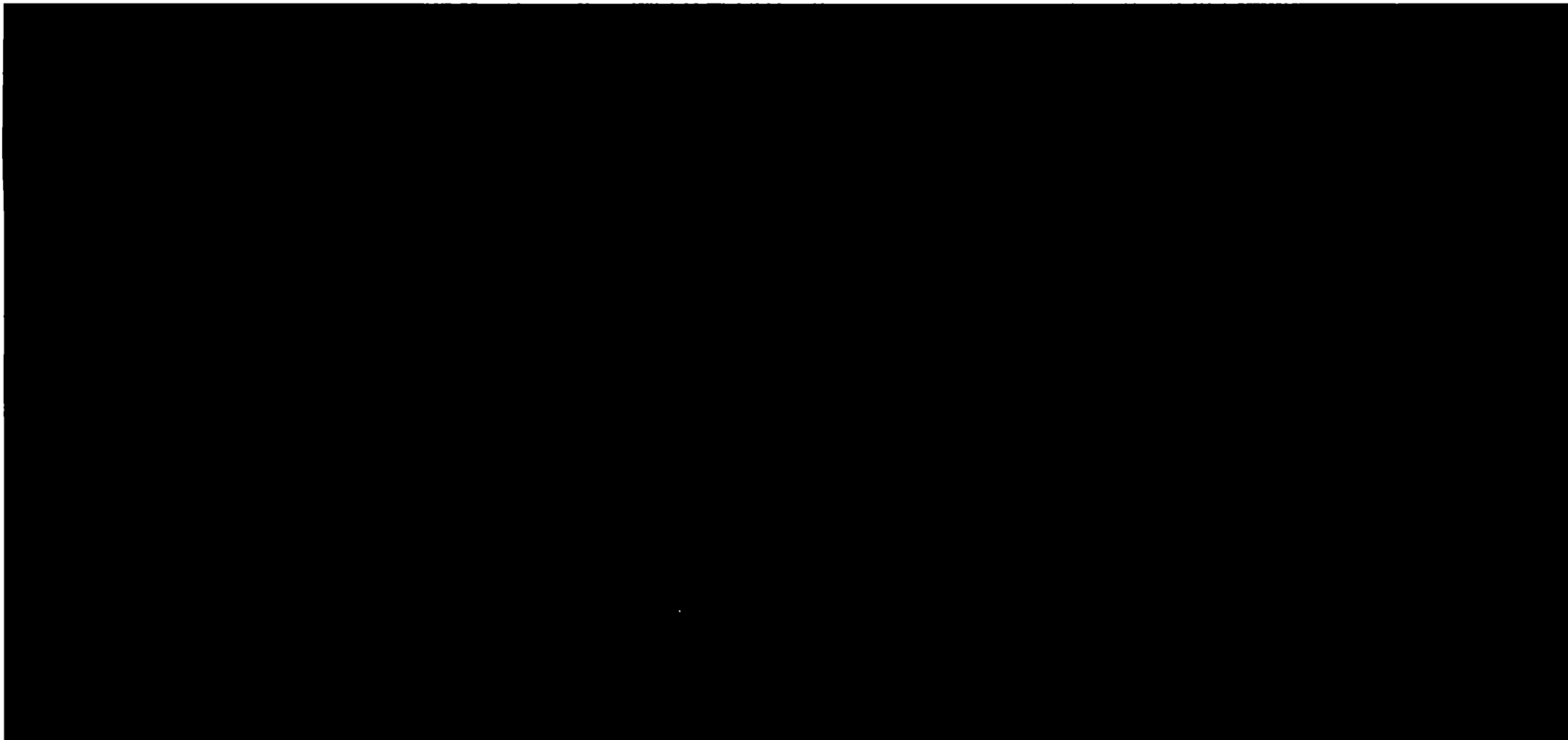


## Agenda – Closed Part

- Background and schedule requirements
- DSS and CLU
  - Definition and description of configurations
  - Handling operations
- Concepts of safety evaluations
  - Concept for CLU
  - Current concept for DSS
  - Alternative concept for DSS
- Safety evaluations to be performed
  - resulting from concepts and RSI
  - Organized by specialty department:  
Structural, thermal, shielding & radiation protection, criticality, containment and material evaluations, operation procedures, acceptance criteria and maintenance program



## Background and Schedule Requirements



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 12



## Agenda – Closed Part

- Background and schedule requirements
- DSS and CLU
  - Definition and description of configurations
  - Handling operations
- Concepts of safety evaluations
  - Concept for CLU
  - Current concept for DSS
  - Alternative concept for DSS
- Safety evaluations to be performed
  - resulting from concepts and RSI
  - Organized by specialty department:  
Structural, thermal, shielding & radiation protection, criticality, containment and material evaluations, operation procedures, acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390

Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 13

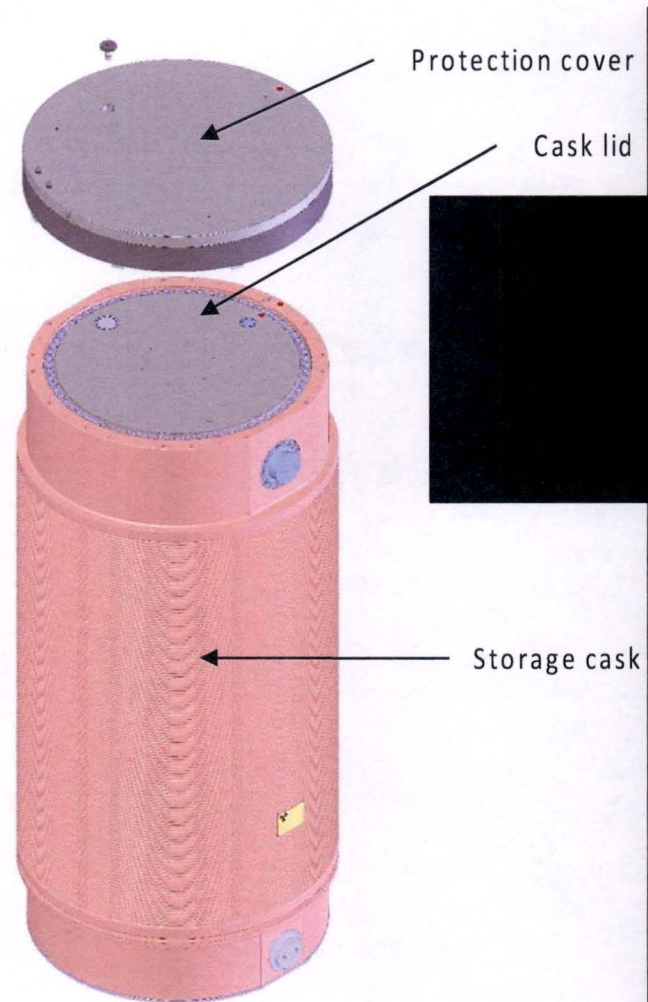
## Configuration of DSS

- CASTOR® geo69 storage cask

- Cask incl. lid system
- [REDACTED]
- Canister incl. lid system
- Basket

- Protection cover

- incl. cable conduit



## Configuration of DSS



Proprietary Information withheld per 10 CFR 2.390

Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 15

# Intended Handling Operations with the storage cask at nuclear facilities

- Horizontal delivery of the storage cask at NPP
- At truck lock inside reactor facility
  - Tilting between horizontal and vertical position (load attachment to trunnions by crane)
  - Open/closure and dispatch of cask lid system (installing pressure switch)
  - Accepting transfer cask, transfer lock and canister transshipment
- Vertical onsite transfer between reactor and storage facility
- Inside building of storage facility
  - (Installing pressure switch, if not already done, dispatch of cask lid system)
  - Vertical transfer to/from storage position, e.g. by crane using trunnions
  - (Dis-)connecting pressure switch to monitoring system of storage facility
  - Placing/removing protection cover (incl. cable conduit) on top of cask
  - Maintenance operations during long-term storage



## Configuration of CLU



Proprietary Information withheld per 10 CFR 2.390

Non-Proprietary Version

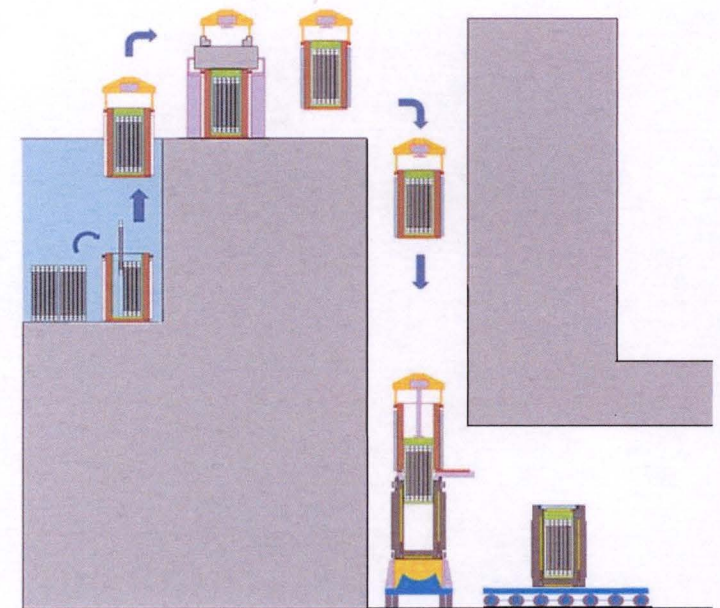
Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 17

## Agenda – Closed Part

- Background and schedule requirements
- DSS and CLU
  - Definition and description of configurations
  - Handling operations
- Concepts of safety evaluations
  - Concept for CLU
  - Current concept for DSS
  - Alternative concept for DSS
- Safety evaluations to be performed
  - resulting from concepts and RSI
  - Organized by specialty department:  
Structural, thermal, shielding & radiation protection, criticality, containment and material evaluations, operation procedures, acceptance criteria and maintenance program

## Intended Handling Operations with CLU components inside the reactor facility

- Any CLU handling provided exclusively inside NPP facility
- Existing CoC for NPP facility (e.g. acc. 10 CFR 50) required
- Loading of FA into canister positioned inside transfer cask on ground of SNF pool
- Crane transfer of transfer cask out of pool on trunnions
- Crane transfer of transfer cask to the truck lock
- Mounting transfer lock on storage cask
- Positioning transfer cask on top of transfer lock
- Opening and closure of bottom lid
- Lowering canister into storage cask
- Removal of CLU components



# Concept of Safety Evaluations - CLU

Compliance with safety objectives ensured by NPP building

## Normal conditions:

- Solar insolation
- Snow & ice
- Max. lift height  
(single failure proof crane)

## Off-normal conditions:

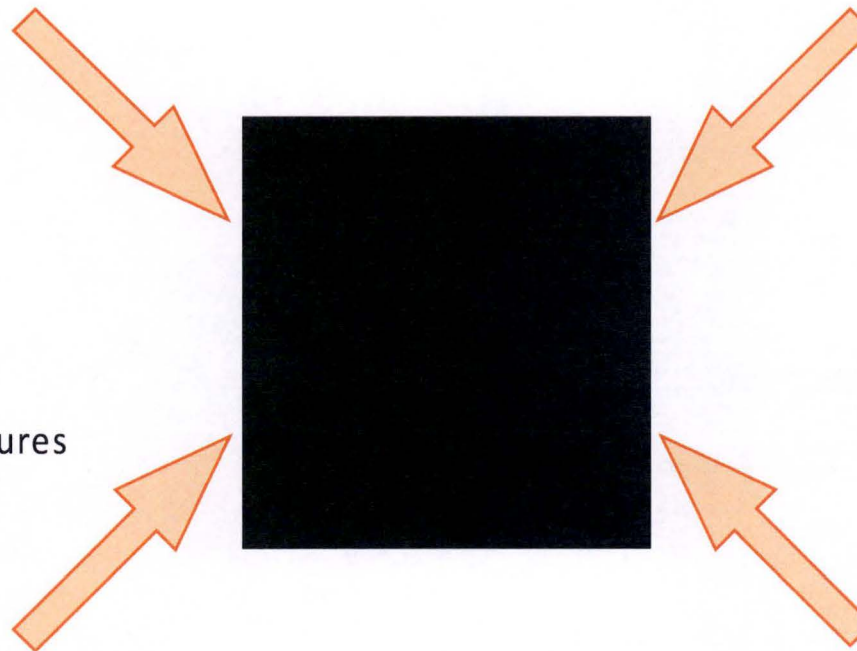
- Off-normal ambient temperatures

## Accident conditions:

- Transfer cask drops  
(single failure proof crane, etc)
- Transfer cask tipover  
(anchoring to the building)
- Fire  
(no combustible materials)
- Explosive Overpressure  
(no combustible materials)

## Natural phenomena:

- Flood
- Tornado wind & missiles
- Burial under debris  
(closed, non-collapsing DSF building)
- Lightning





# Concept of Safety Evaluations - CLU

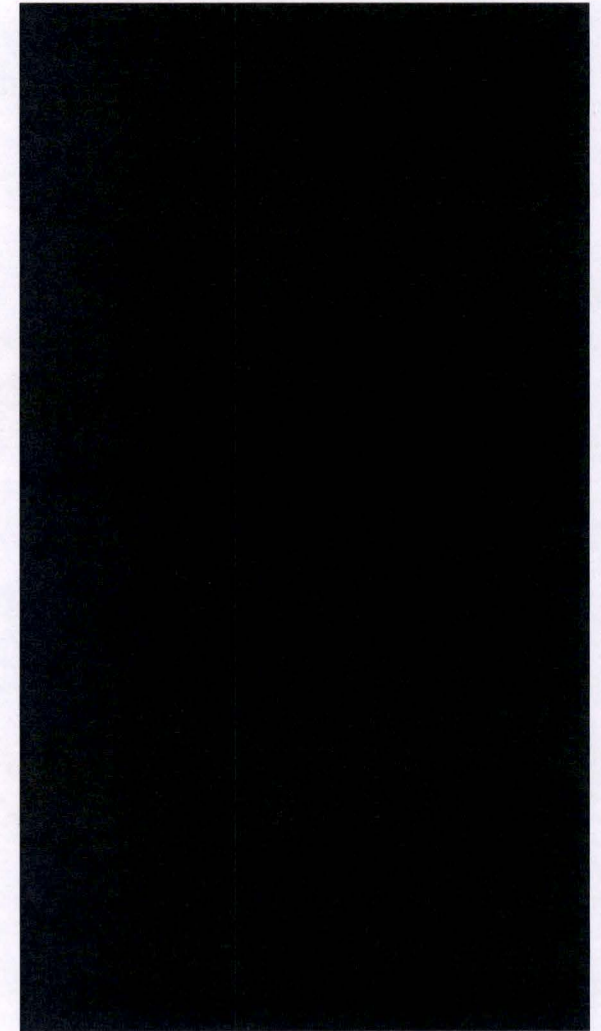
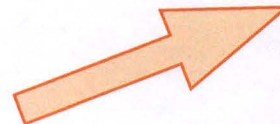
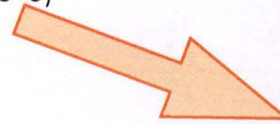
Compliance with safety objectives ensured by CLU

## Normal conditions:

- Ambient temperatures  
(usage for  $T < 0^{\circ}\text{C}$  not permitted,  $T_{\text{max}}$  (pool water)  $< 50^{\circ}\text{C}$ ,  $T_{\text{max}}$  (reactor hall)  $< 35^{\circ}\text{C}$ )
- Loading, Handling
- Max. lift height  
(single failure proof trunnions)
- 1% fuel rod rupture
- Cladding Temperature

## Off-normal conditions:

- Off-normal ambient temperatures
- Small release of radioactive material  
(due to contamination of canister or transfer cask during underwater loading)
- Human error, equipment or instrumentation failure, misalignment, loss of power for a limited duration, Unintended mechanical loads



# Concept of Safety Evaluations - CLU

Compliance with safety objectives ensured by CLU

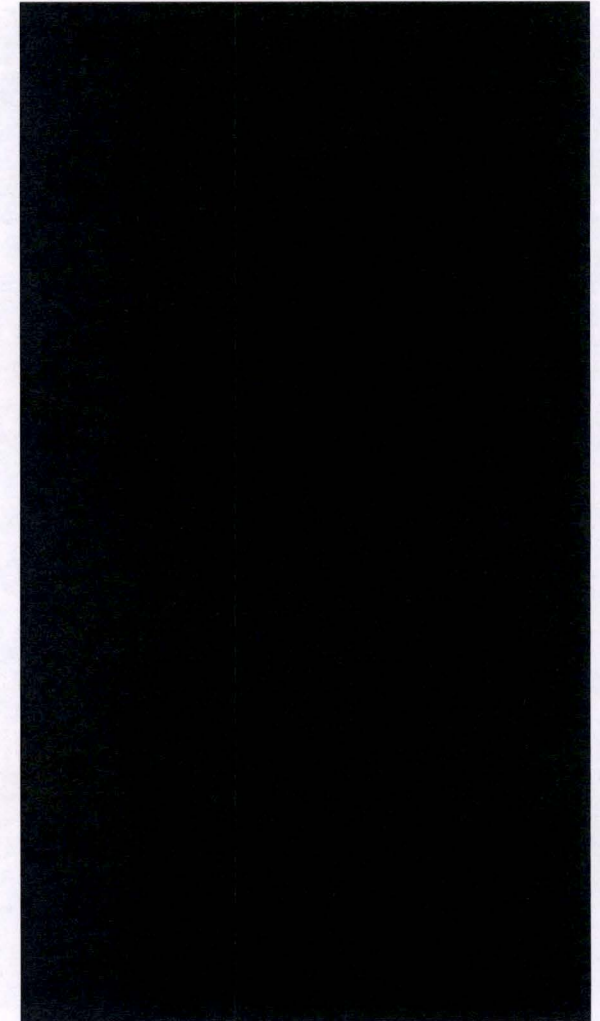
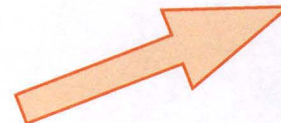
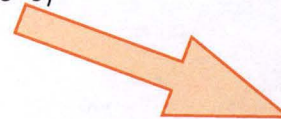
## Normal conditions:

- Ambient temperatures  
(usage for  $T < 0^{\circ}\text{C}$  not permitted,  $T_{\text{max}}$  (pool water)  $< 50^{\circ}\text{C}$ ,  $T_{\text{max}}$  (reactor hall)  $< 35^{\circ}\text{C}$ )
- Loading, Handling
- Max. lift height  
(single failure proof trunnions)
- 1% fuel rod rupture
- Cladding Temperature

## Off-normal conditions:

- Off-normal ambient temperatures
- Small release of radioactive material  
(due to contamination of canister or transfer cask during underwater loading)
- Human error, equipment or instrumentation failure, misalignment, loss of power for a limited duration, Unintended mechanical loads

**In Rev. 1 of the SAR off-normal conditions will be assessed according to RSI-sh-2**



# Discussion



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 23

## Agenda – Closed Part

- Background and schedule requirements
- DSS and CLU
  - Definition and description of configurations
  - Handling operations
- Concepts of safety evaluations
  - Concept for CLU
  - Current concept for DSS
  - Alternative concept for DSS
- Safety evaluations to be performed
  - resulting from concepts and RSI
  - Organized by specialty department:  
Structural, thermal, shielding & radiation protection, criticality, containment and material evaluations, operation procedures, acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390

Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 24



# Current Concept of Safety Evaluations - DSS

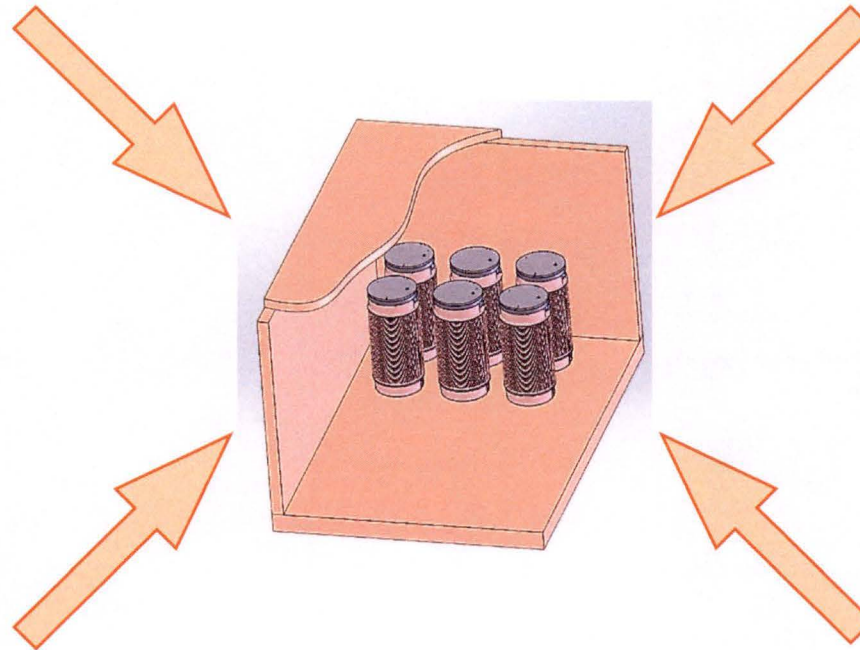
Compliance with Safety objectives ensured by DSF (building)

## Normal conditions:

- Solar insolation
- Snow & ice
- Max. lift height  
(single failure proof crane)

## Off-normal conditions:

- n.a.



## Accident conditions:

- Cask end and side drops  
(single failure proof crane)
- Tipover  
(excessively high seismic loads  
excluded)
- Blockage of ventilation  
openings of storage building

## Natural phenomena:

- Flood
- Tornado wind & missiles
- Burial under debris  
(closed, non-collapsing DSF building)
- Lightning

# Current Concept of Safety Evaluations - DSS

Compliance with Safety objectives ensured by DSS

## Normal conditions:

- Ambient temperatures
- Storage, Handling, Orientation
- Loading
- Max. lift height  
(single failure proof trunnions)
- 1% fuel rod rupture
- Cladding Temperature

## Off-normal conditions:

- Off-normal ambient temperatures
- Off-normal pressure (10% fuel rod rupture with release of 100% fill and 15% fission gases)
- Pressure switch alert
- Human error, equipment or instrumentation failure, misalignment, loss of power for a limited duration, Unintended mechanical loads



## Accident conditions:

- Fire  $\leq 5$  min and  $\leq 800^{\circ}\text{C}$   
(max. 200 liters transporter fuel)
- Explosive overpressure
- Tipover  
(out of balance with no initial velocity bounded by cask end and side drop)
- Cask end and side drops  
(single failure proof trunnions)

## Natural phenomena:

- Earthquake



## Current Concept of Safety Evaluations - DSS

- DSS without connection to any specific storage facility
- Postulating a generic storage facility
  - Current application assumes that the DSS will be housed in the building of a fictitious, non-existent storage environment
- Definition of boundary conditions for DSS safety evaluation
- Design of the DSS
- Safety evaluations



Inclusion of restrictions in the CoC

“DSS may only be operated in storage facilities that ensure...”

# Discussion



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 28

## Agenda – Closed Part

- Background and schedule requirements
- DSS and CLU
  - Definition and description of configurations
  - Handling operations
- Concepts of safety evaluations
  - Concept for CLU
  - Current concept for DSS
  - Alternative concept for DSS
- Safety evaluations to be performed
  - resulting from concepts and RSI
  - Organized by specialty department:  
Structural, thermal, shielding & radiation protection, criticality, containment and material evaluations, operation procedures, acceptance criteria and maintenance program



## Alternative Concept of Safety Evaluations - DSS

- If current evaluation concept is not accepted by NRC ...
- Alternative approach by GNS:

- Free-field storage of DSS:

DSS extended by a storage frame anchored on reinforced concrete foundation

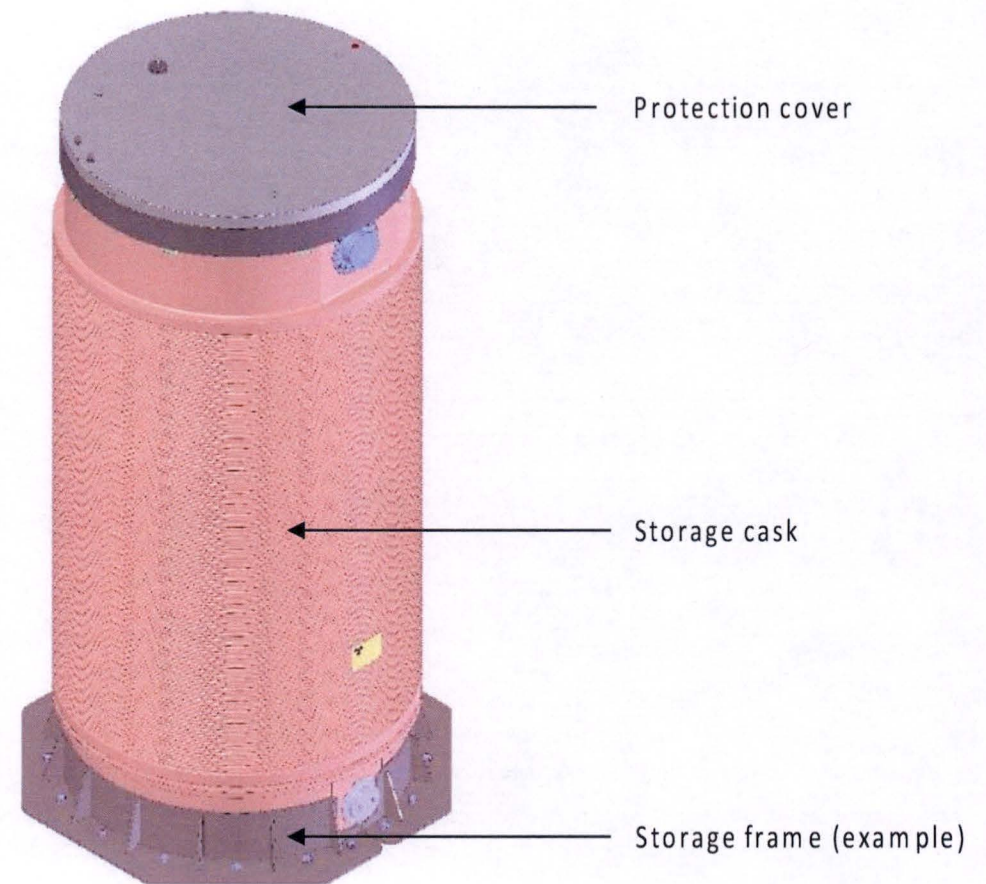
⇒ Fully comprehensive safety evaluations ...

- according to NUREG-2215, Section 3.5.2.4
      - Normal
      - off-normal
      - accident conditions
      - natural phenomena

⇒ ... without taking credit of any installations of the storage facility (building, pad, etc.) are to be performed.

## Extended configuration of DSS

- CASTOR® geo69 storage cask
  - Cask incl. lid system
  - [REDACTED]
  - Canister incl. lid system
  - Basket
- Protection cover
  - Incl. cable conduit
- Storage frame
  - extends the current DSS design





# Alternative Concept of Safety Evaluations - DSS

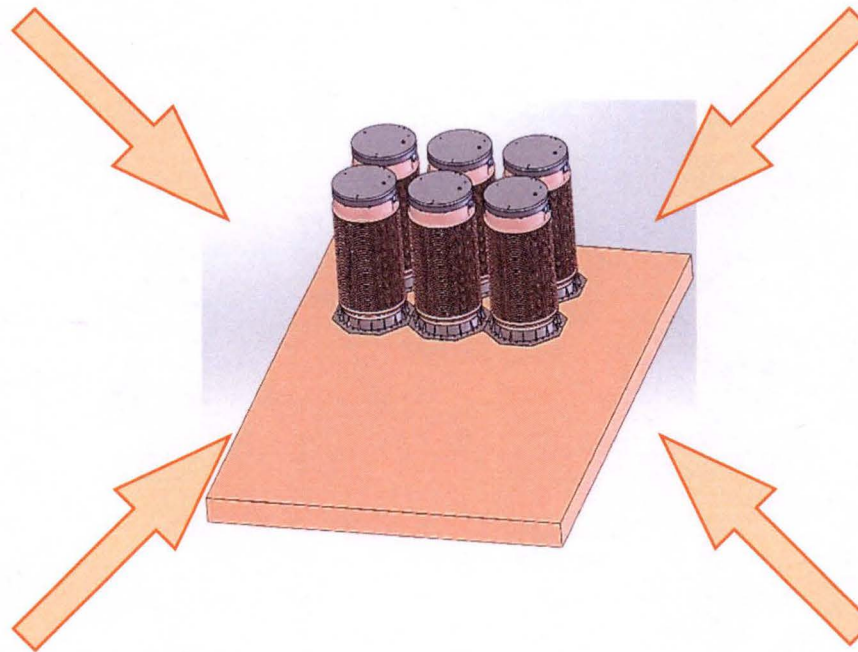
Compliance with Safety objectives ensured by DSF

## Normal conditions:

- Max. lift height  
(single failure proof crane)

## Off-normal conditions:

- n.a.



## Accident conditions:

- Cask drops  
(excluded by single failure proof crane)

## Natural phenomena:

- n.a.

# Alternative Concept of Safety Evaluations - DSS

Compliance with Safety objectives ensured by DSS

## Normal conditions:

- Ambient temperatures
- Solar insolation
- Snow & ice
- Loading, Handling Transport, Storage
- Max. lift height (single failure proof trunnions)
- 1% fuel rod rupture
- Cladding temperature

## Off-normal conditions:

- Off-normal ambient temperatures
- Off-normal pressure (10% fuel rod rupture with release of 100% fill and 15% fission gases)
- Pressure switch alert
- Human error, equipment or instrumentation failure, misalignment, loss of power for a limited duration, Unintended mechanical loads



## Accident conditions:

- Fire  $\leq 5$  min and  $\leq 800^{\circ}\text{C}$  (max. 200 liters transporter fuel)
- Explosive overpressure (max. 200 liters transporter fuel)
- Tipover (excluded by storage frame)
- Cask drops (excluded by single failure proof trunnions)

## Natural phenomena:

- Lightning
- Flood
- Earthquake
- Burial under debris (e.g. by mud flow)
- Tornado wind & missiles



# Concept of Safety Evaluations – Onsite Transfer

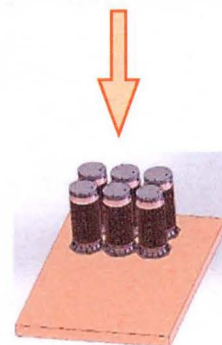
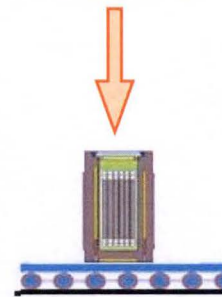
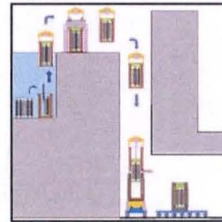
Compliance with safety objectives ensured by storage cask

## Normal conditions:

- Ambient temperatures
- Solar insolation
- Transfer
- Max. lift height  
(single failure proof trunnions)
- 1% fuel rod rupture
- Cladding Temperature

## Off-normal conditions:

- Off-normal ambient temperatures
- Off-normal pressure  
(10% fuel rod rupture with release of 100% fill and 15% fission gases)
- Human error, misalignment, Unintended mechanical loads



## Accident conditions:

- Fire  $\leq 5$  min and  $\leq 800^{\circ}\text{C}$   
(max. 200 liters transporter fuel)
- Explosive overpressure  
(max. 200 liters transporter fuel)
- Tipover and drop from vehicle

## Natural phenomena:

- Lightning
- Earthquake
- Tornado wind & missiles

# Discussion



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 35

## Agenda – Closed Part

- Background and schedule requirements
- DSS and CLU
  - Definition and description of configurations
  - Handling operations
- Concepts of safety evaluations
  - Concept for CLU
  - Current concept for DSS
  - Alternative concept for DSS
- Safety evaluations to be performed
  - resulting from concepts and RSI
  - Organized by specialty department:  
Structural, thermal, shielding & radiation protection, criticality, containment and material evaluations, operation procedures, acceptance criteria and maintenance program

## **Safety evaluations**

- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 37

## Safety evaluations

- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390

Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 38



## Structural evaluation – Safety Evaluations – DSS

### ▪ NCS

- Dead weight
- Handling
- Normal pressure
- Normal environmental temperatures
- Snow and ice loading

### ▪ off-NCS

- Temperatures beyond normal
- Off-normal pressure

### ▪ ACS

- Cask drop
- Tipover (DSS & onsite-transfer)
- Fire
- Explosive overpressure

### ▪ Natural phenomena

- Tornado winds and missiles
- Flood (only DSS)
- Earthquake
- Lightning



## Structural evaluation – Safety Evaluations – CLU

- NCS:

- Dead Weight
- Handling
- Environmental Temperatures

- off-NCS:

- Temperatures beyond Normal
- Off-normal Pressure
- Human error during handling (e.g. slight collision of CLU with service platform)
- Equipment failure (e.g. failure of electric cylinder in transfer lock)



## Structural evaluation – RSI-St-1: Storage Frame

- Storage frame is not part of the current application!
  - Structural evaluation
    - Determines maximum loads resulting from a design basis earthquake that the storage cask can withstand
    - At sites where stronger earthquakes may occur, a storage frame is to be used. It must then be designed according to the requirements of the storage facility and the storage cask, and corresponding evaluations must be carried out.
  - Thermal evaluations
    - Conservatively, a generic storage frame is assumed to demonstrate that even then no temperatures limits are exceeded.
- In case of free field storage, storage frames as ITS component will be designed to increase the stability of the casks in the event of a tornado or earthquake.
- → Either removal or consequently consideration in the entire SAR Rev. 1 depending on the chosen safety evaluation concept.

## Structural evaluation – RSI-St-2: ACS & natural phenomena

- Subject already discussed before.
- Current concept:
  - Cask are placed in a storage facility hall without any particular assessment
  - GNS requests CoC with restrictions on instead of specifications of a storage facility hall
- Alternative concept
  - In case of free field storage all relevant accidents and natural phenomena and their impacts on the casks' performance and safety functions will be assessed.

## Safety evaluations

- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

## Thermal evaluation – Safety Evaluations – DSS

### ■ NCS & off-NCS:

- Current concept:
  - Ambient temperature [REDACTED]  
[REDACTED]
- Alternative concept:
  - Ambient temperatures covered by 10 CFR 71: “cold (-40°C)” and “warm (38°C)”
  - Insolation according to 10 CFR 71.71 (full values, not averaged over 24 hours)
- Current and alternative concept:
  - Cask standing in an array of casks of the same type with the same heat power; thereby the heat emission by thermal radiation is reduced accordingly



## Thermal evaluation – Safety Evaluations – DSS

- ACS

- Current and alternative concept: Fire  $\leq 5$  min and  $\leq 800^{\circ}\text{C}$  (max. 200 liters transporter fuel)
- Alternative concept: Tipover

- Natural phenomena

- Alternative concept: Burial under debris, flood
  - Transient heat-up under adiabatic conditions (outer cask surface)
  - Designating the time remaining for countermeasures until the limit temperatures are reached.

## Thermal evaluation – Safety Evaluations – CLU

- NCS:

- Temperatures during short term operations

- off-NCS:

- Off-normal ambient temperatures combined with
- 10 % fuel rod failure
- Evaluations of short interruptions during operations

## Thermal evaluation – RSI-Th-1: short-term, off-normal conditions and ACS

- Requested additional thermal conditions will be analyzed as follows and provided in Rev. 1 of the SAR:
  - a. *the unloading condition,*
  - b. *blockage of storage hall ventilation openings*  
→ obsolete in case of free field storage (alternative concept)
  - c. *fire while the canister is within the transfer cask,*  
→ obsolete, fire is not a credible accident for transfer cask handled exclusively in reactor facility
  - d. *burial under debris,*  
→ Transient heat-up under adiabatic conditions (outer cask surface) (alternative concept)
  - e. *tip-over (e.g., thermal effects due to horizontal cask orientation) (alternative concept)*
  - f. *effect(s) of a collapsed storage hall that encloses the CASTOR® storage system.*  
→ obsolete in case of free field storage (alternative concept)

## Thermal evaluation – RSI-Th-2: Failed Fuel Rods at maximum decay heat

- Thermal analyses that demonstrate the effect of failed fuel rods at the maximum design decay heat value will be provided in Rev. 1 of the SAR

## Thermal evaluation – RSI-Th-3: Thermal Model Validation

- Rev. 1 of the SAR will provide the validation reports

[REDACTED]

[REDACTED]



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 49

## Thermal evaluation – RSI-Th-4P: Effective Thermal Properties of FA

- Rev. 1 of the SAR will provide the calculation methods and results for determining effective thermal properties of the FA



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 50



## Thermal evaluation – Obs-Th-1: Surface Treatments – cask & transfer cask

- Thermal evaluations assume certain thermal properties for e.g. emissivity of transfer casks or storage casks [REDACTED]  
[REDACTED]
- I.e., thermal designs of DSS and CLU makes certain demands on the thermal properties of the materials used, to be specified in a fabrication specification
- Inner and outer surfaces the cask body and the transfer cask are to be coated to provide defined thermal specifications as required by thermal evaluation.
- Qualified products shall be used  
(typically used for transport and storage casks are e.g. [REDACTED])
- In Rev. 1 of the SAR a qualification report for possibly used coatings will be provided.

## Thermal evaluation – Obs-Th-2: Vapor and Helium Pressure

- Pressure during vacuum drying
  - Canister and Cask: [REDACTED]
- At this pressure level, the heat conductivity is not dependent on the pressure so that the heat removal is not affected
- At a reduced pressure of [REDACTED] in case of a vacuum equipment failure, the heat conductivity is still not dependent on the pressure
- The helium pressure is discussed in the chapters about the containment evaluation and operating procedures
  - Canister: [REDACTED]
  - Cask: [REDACTED]

## Thermal evaluation – Obs-Th-3: Input and Output Files of Thermal Analyses

- The input and output files of the bounding thermal analyses will be provided.



## Thermal evaluation – Obs-Th-4P: Ambient Temperature



## Safety evaluations

- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

## Shielding & radiation protection evaluation – Safety Evaluations – DSS

### ■ NCS:

- Shielding evaluations are performed for both generic building and open-air storage
- Ambient temperature – “cold” and “warm” casks are considered
- Instead of 1 % fuel rupture a covering scenario of 3 % fuel rupture is considered
- Occupational exposure (cask dispatch, storage site)
- Occupational exposure (preparation of DSS for storage)

### ■ off-NCS:

- The only relevant scenario to be considered is 10 % fuel rupture
- For high burn up fuel a credit of an additional 20 a cooling has been taken for the rupture scenario only (according to NUREG-2224: rupture due to storage)
- Evaluations of short interruptions during operations

### ■ ACS and Natural Phenomena regarding shielding result in:

- Loss of moderator – very conservative assumption, considered in SAR
- 100 % fuel damage – considered in SAR

## Shielding & radiation protection evaluation – Safety Evaluations – CLU

- NCS:

- Near-field evaluation of the CLU during loading, dispatch, transshipment, etc.
- Annual dose at the site boundary

- off-NCS:

- Consequences of the equipment failure or/and human error:
  - No influence on the CLU shielding capabilities
- Annual dose at the site boundary with 10 % fuel rupture
  - No increase of the dose rates is expected due to the axially homogeneous shielding design

## Shielding & radiation protection evaluation – RSI-Sh-1: Drawings - Storage cask

- For design parts lists and drawings the SAR storage refers to the transport application.
- GNS intends to resolve references to the SAR (transport) in the Rev. 1 of the SAR (storage)
- Thus, in Rev. 1 of the SAR, all relevant design parts lists and drawings will be included in the Appendix to Chapter 1.



## Shielding & radiation protection evaluation – RSI-Sh-2: Drawings - Basket

- For design parts lists and drawings the SAR storage refers to the transport application.
- GNS intends to resolve references to the SAR (transport) in the Rev. 1 of the SAR (storage)
- Thus, in Rev. 1 of the SAR, all relevant design parts lists and drawings will be included.
  
- Rev. 1 of the SAR will provide a material qualification report for the basket material  
[REDACTED]

## **Shielding & radiation protection evaluation – RSI-Sh-3: Off-normal, accident and natural phenomena conditions on the CLU**

- Subject already discussed before.
- CLU exclusively handled with SNF inside the reactor facility.
- Only normal and off-normal conditions to be considered during handling.
- Accident and natural phenomena conditions are not credible conditions.
- Rev. 1 of the SAR will provide the requested evaluations for off-normal conditions

## **Shielding & radiation protection evaluation – RSI-Sh-4: Acceptance & maintenance tests, acceptance criteria**

- Rev. 1 of the SAR will provide
  - further information regarding acceptance tests and criteria of the components in
    - basket plates
    - moderator rods and platestargeting the shielding and criticality safety functions
  - material qualification reports for
    - the basket material [REDACTED]
    - the moderator material [REDACTED]



## **Shielding & radiation protection evaluation – RSI-Sh-5P: Occupational dose assessment**

- Rev. 1 of the SAR will provide an assessment of the occupational dose during
  - the preparation of the storage cask for long-term interim dry storage
  - the set-up of the CASTOR<sup>®</sup> geo69 DSSat the storage facility

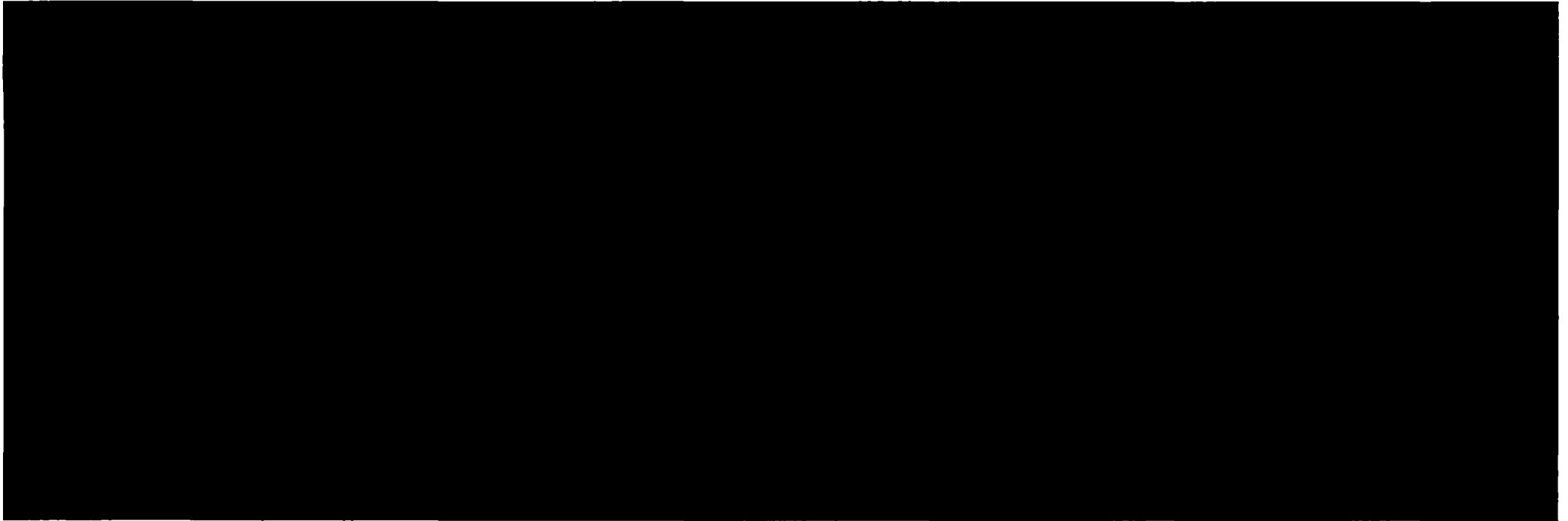
## Shielding & radiation protection evaluation – RSI-Sh-6P: Description of Basket Material

- In Rev. 1 of the SAR, a sufficient description of the basket material [REDACTED] will be added to Chapter 1
- For design parts lists and drawings the SAR storage refers to the transport application.
- GNS intends to resolve references to the SAR (transport) in the Rev. 1 of the SAR (storage)
- Thus, in Rev. 1 of the SAR, all relevant design parts lists and drawings will be included.
- Rev. 1 of the SAR will provide a material qualification report for the basket material [REDACTED]

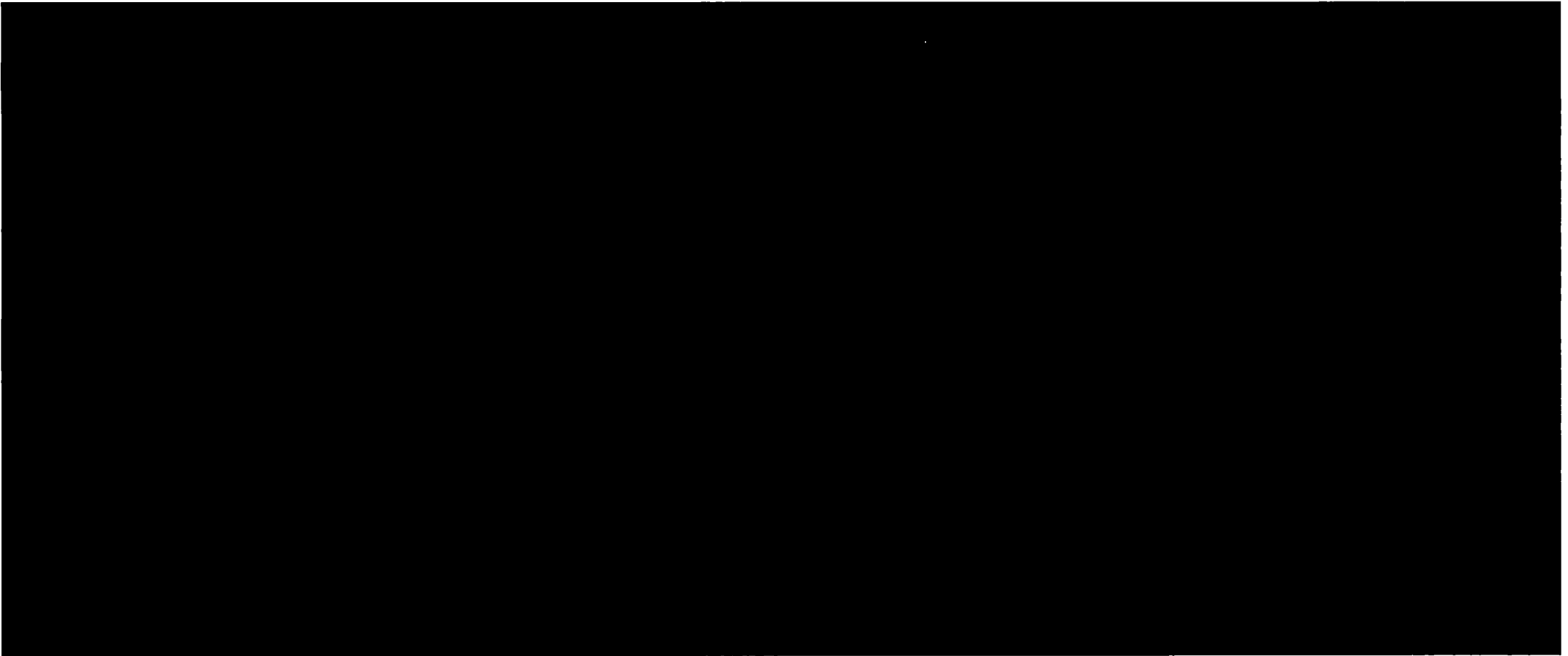
## **Shielding & radiation protection evaluation – Obs-Sh-1: Operating Procedures**

- GNS intends to resolve references to the SAR (transport) in the Rev. 1 of the SAR (storage)
- In Rev. 1 of the SAR all operating procedures will be provided in Chapter 9
- In Rev. 1 of the SAR Section 9.3 will be reviewed with regard to completeness and supplemented if necessary

## Shielding & radiation protection evaluation – Obs-Sh-2P: Normalized burnup profiles



# Shielding & radiation protection evaluation – Obs-Sh-3P: Specifications of Contents



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 66



## Safety evaluations

- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 67

## Criticality evaluation – Safety Evaluations – DSS

- Evaluated configurations within the criticality safety analysis:
  - infinite array of flooded storage casks
  - infinite array of dry storage casks
  - single, fully reflected storage cask
  
- NCS, off-NCS and ACS:
  - The evaluated configurations are bounding.

## Criticality evaluation – Safety Evaluations – CLU

- Evaluated configurations within the criticality safety analysis:
  - single, fully reflected transfer cask
- Normal conditions during handling
  - The evaluated case is bounding.



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 69

## **Safety evaluations**

- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 70

## Containment evaluation – Safety Evaluations – DSS

- NCS:
  - No dedicated activity release and corresponding dose calculations (acc. to NUREG-2215) since structural evaluation states that containment remains leak tight acc. to ANSI N 14.5 (design leakage rate  $< 10^{-7}$  ref·cm<sup>3</sup>/s)
  - Activity mobilization inside the canister
  - Pressurization of Containment Vessel
- off-NCS:
  - In analogy to NCS, but with adjusted failure and release fractions taken into account.
- ACS
  - In analogy to NCS, but with adjusted failure and release fractions for ACS Fire and ACS impact (acc. to NUREG-2224) taken into account.
  - If applicable, adjustments as a result of e.g. changed temperatures inside of cask and/or canister.
- Natural phenomena
  - If applicable, adjustments as a result of e.g. changed temperatures inside of cask and/or canister.

## Containment evaluation – Safety Evaluations – CLU

- The components of the CLU (especially the transfer cask) provide no containment function for the SNF. The canister as primary containment for the fuel is not part of the CLU and is evaluated within the DSS containment evaluation.



## **Containment evaluation – Obs-Co-1: Pressure Switch and Pressure Monitoring System**

- Use of pressure switches is established in Germany (and also in other European countries)
- Pressure switches are usually commercially purchased and provided by the storage facility
- In Rev. 1 of the SAR Section 1.2 will be supplemented by detailed information (description, functionality, performance specifications and operational requirements) of
  - The pressure switch
  - The pressure monitoring system
  - Corrective actions in case of an pressure switch alert





## **Safety evaluations**

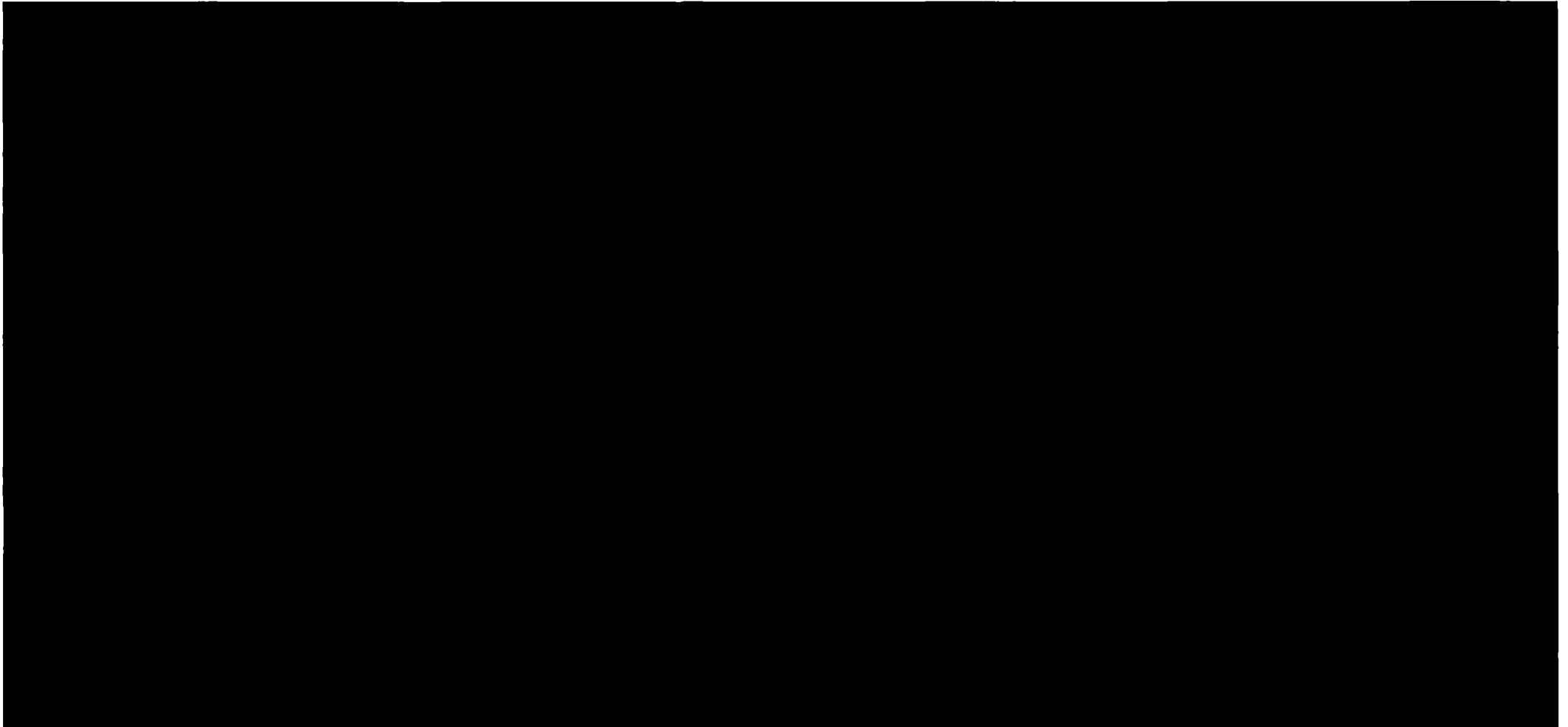
- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 74

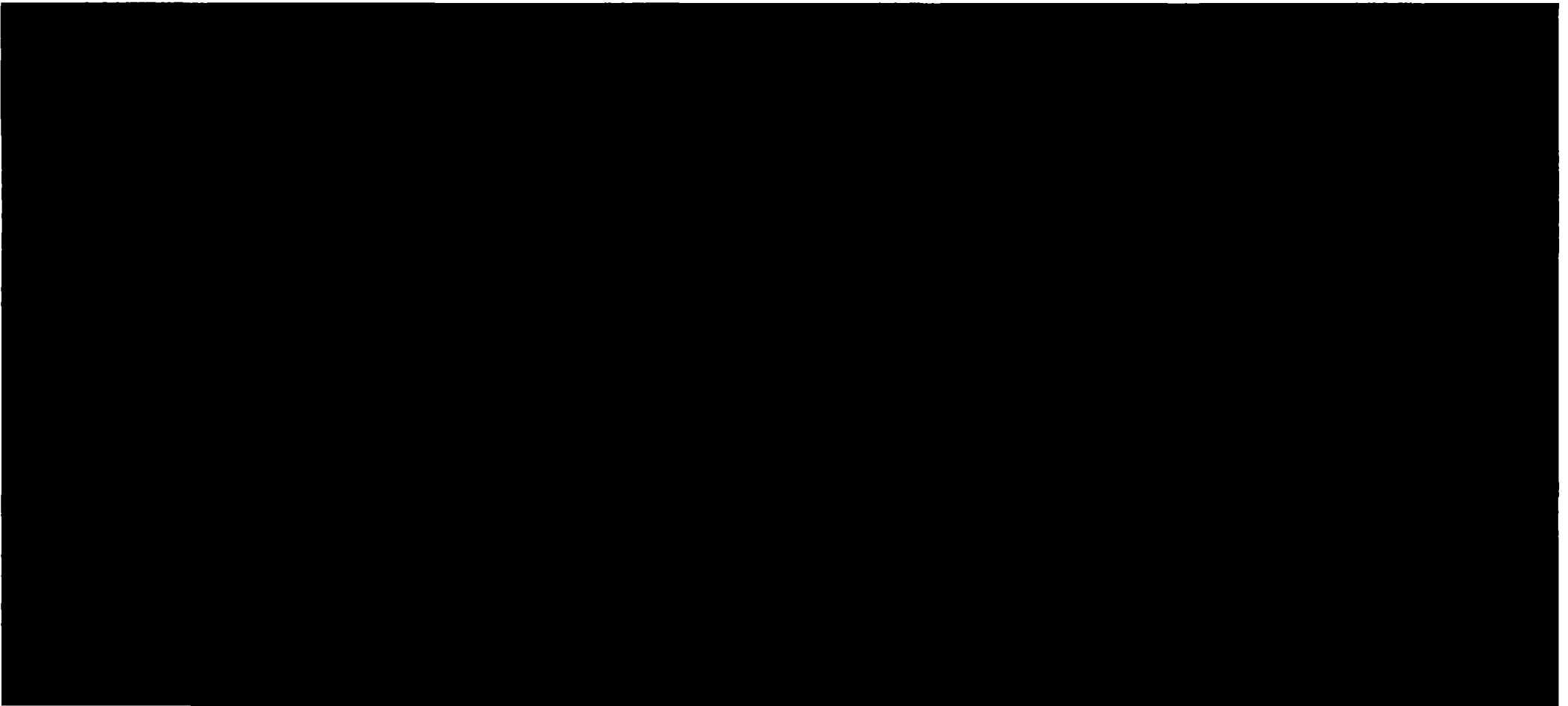
## Materials evaluation – RSI-MA-1: Basket Material Qualification



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 75

## Materials evaluation – RSI-MA-1: Basket Material Qualification



Proprietary Information withheld per 10 CFR 2.390

Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 76

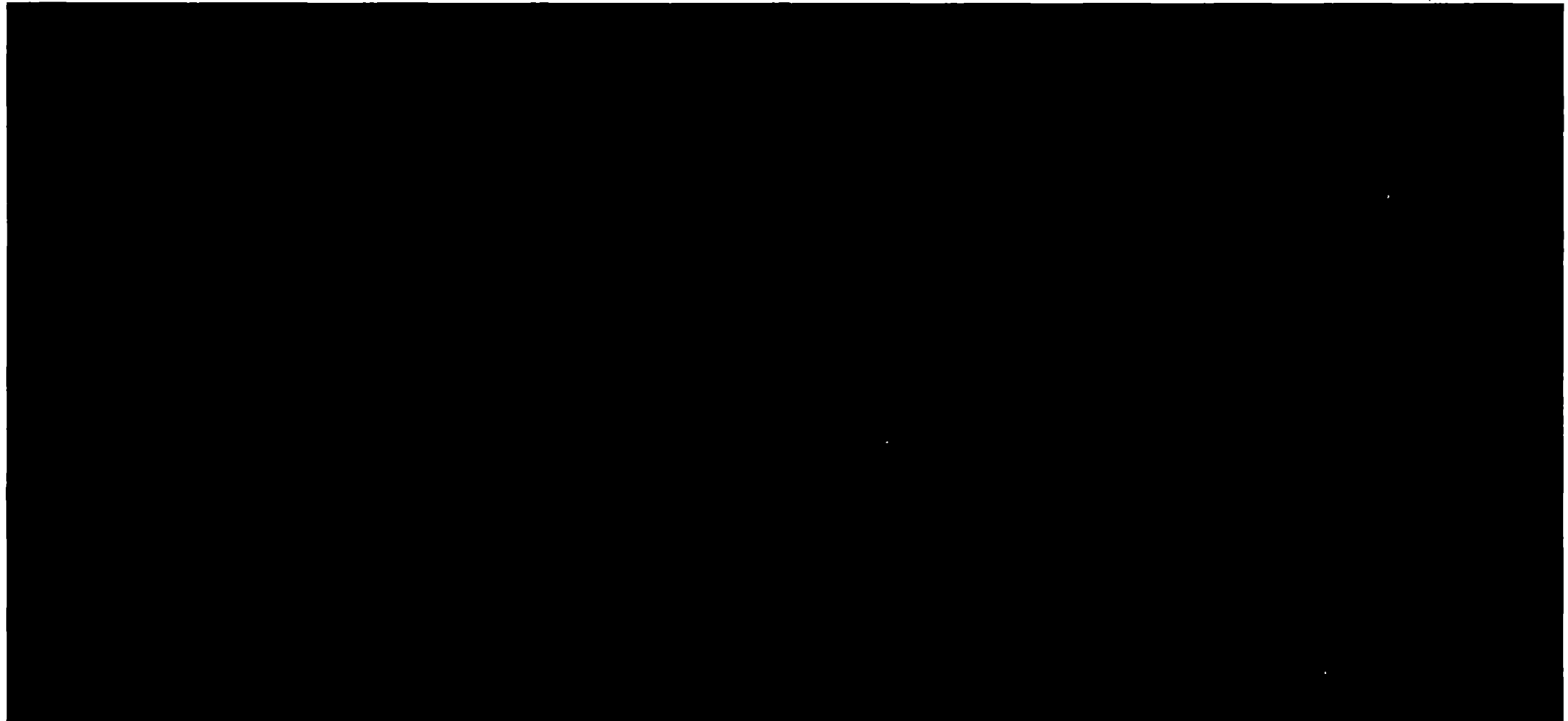
## Materials evaluation – RSI-MA-1: Basket Material Acceptance Tests



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 77

## Materials evaluation – RSI-MA-1: Basket Material Acceptance Tests



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 78

## Materials evaluation – RSI-MA-2: FA Alloys

- The fuel rod cladding is made of Zircaloy-2. Internal water rods and channels as well as outer channels are made of Zircaloy-2 and Zircaloy-4.
- In Rev. 1 of the SAR Table 2.1-1 is adjusted accordingly



## Materials evaluation – Obs-Ma-1: Technical Drawings - Storage cask

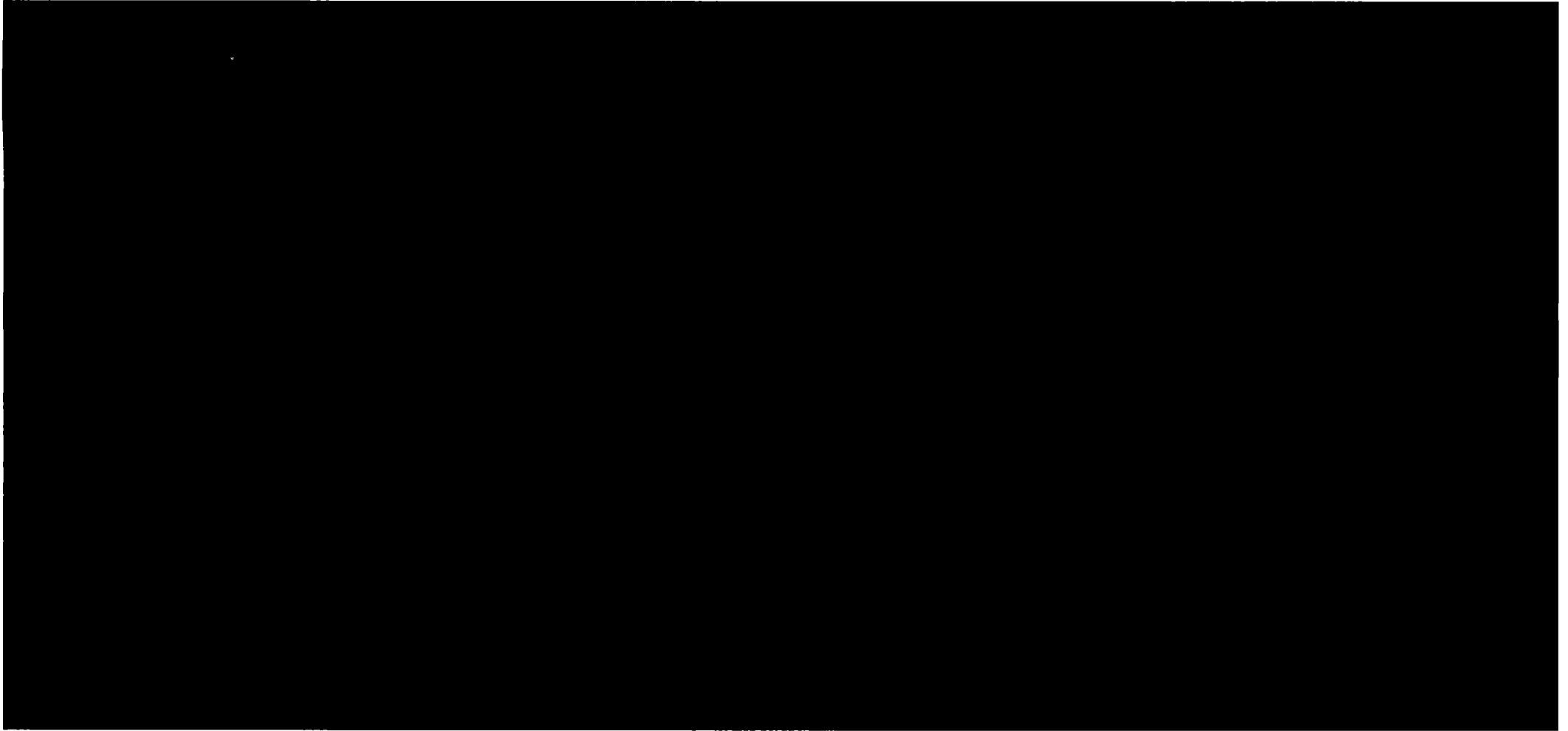
- For design parts lists and drawings the SAR storage refers to the transport application.
- GNS intends to resolve references to the SAR (transport) in the Rev. 1 of the SAR (storage)
- Thus, in Rev. 1 of the SAR, all relevant design parts lists and drawings will be included in the Appendix to Chapter 1.



## Materials evaluation – Obs-Ma-2: Classification of Fuel Assemblies

- Intact (undamaged) fuel assembly means a fuel assembly without known or suspected cladding defects greater than pinhole leaks and hairline cracks, and which can be handled by normal means. Partial fuel assemblies, that is fuel assemblies from which fuel rods are missing, shall not be classified as intact fuel assemblies unless dummy fuel rods are used to displace an amount of water greater than or equal to that displaced by the original fuel rod(s).
- SAR assumes that the fuel rod failure for different storage conditions from NUREG 2224 are valid for intact (undamaged) fuel rods only. Higher fuel rod failure rates which had to be assumed for damaged fuel are not covered at least for normal and off-normal conditions of storage.
- The statement regarding fuel qualification based on requirements for criticality safety, decay heat removal, radiological protection, and structural integrity might be misleading. SAR Section 8.4.1 describes procedures to ensure that only intact (undamaged) fuel assemblies are loaded.

## Materials evaluation – Obs-Ma-3: Procurement of Cast Iron Cask Body



Proprietary Information withheld per 10 CFR 2.390

Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 82

## Safety evaluations

- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390

Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 83

## Operating Procedures – RSI-Op-1: (Un-)Loading Procedures

- GNS intends to resolve references to the SAR (transport) in the Rev. 1 of the SAR (storage)
- Thus, in Rev. 1 of the SAR, loading and unloading procedures will be supplemented to Chapter 10



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 84

## Safety evaluations

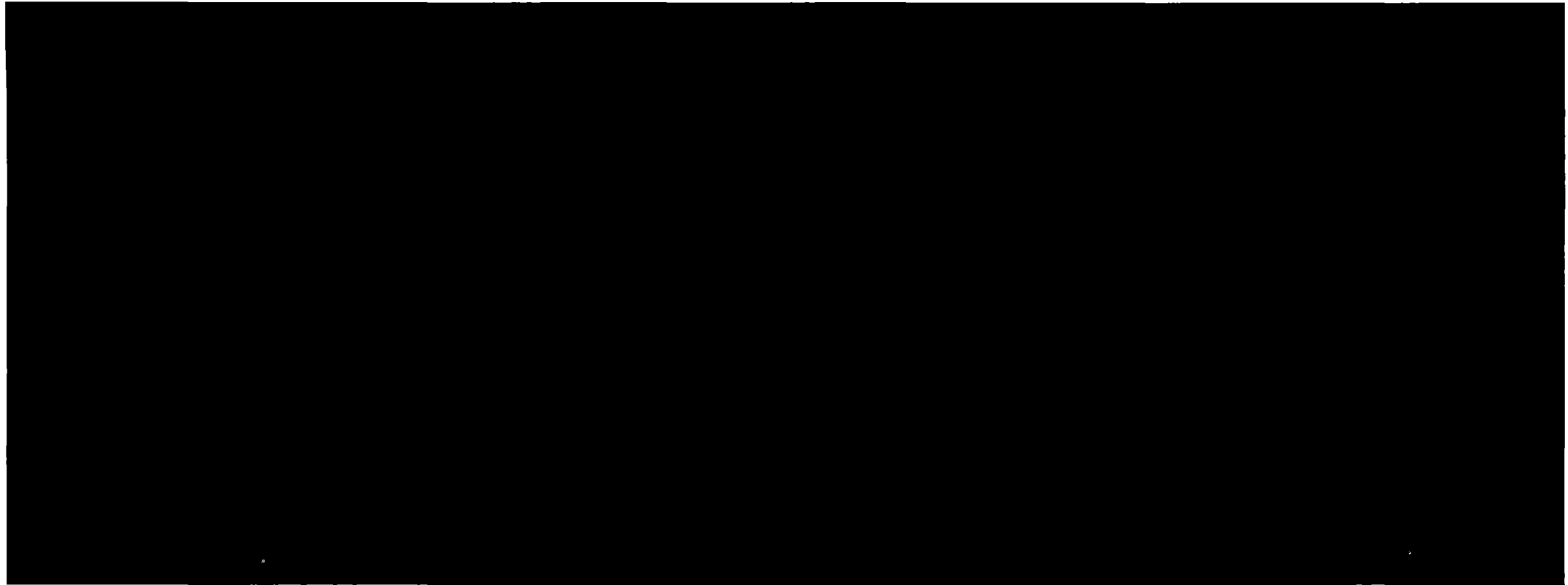
- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 85

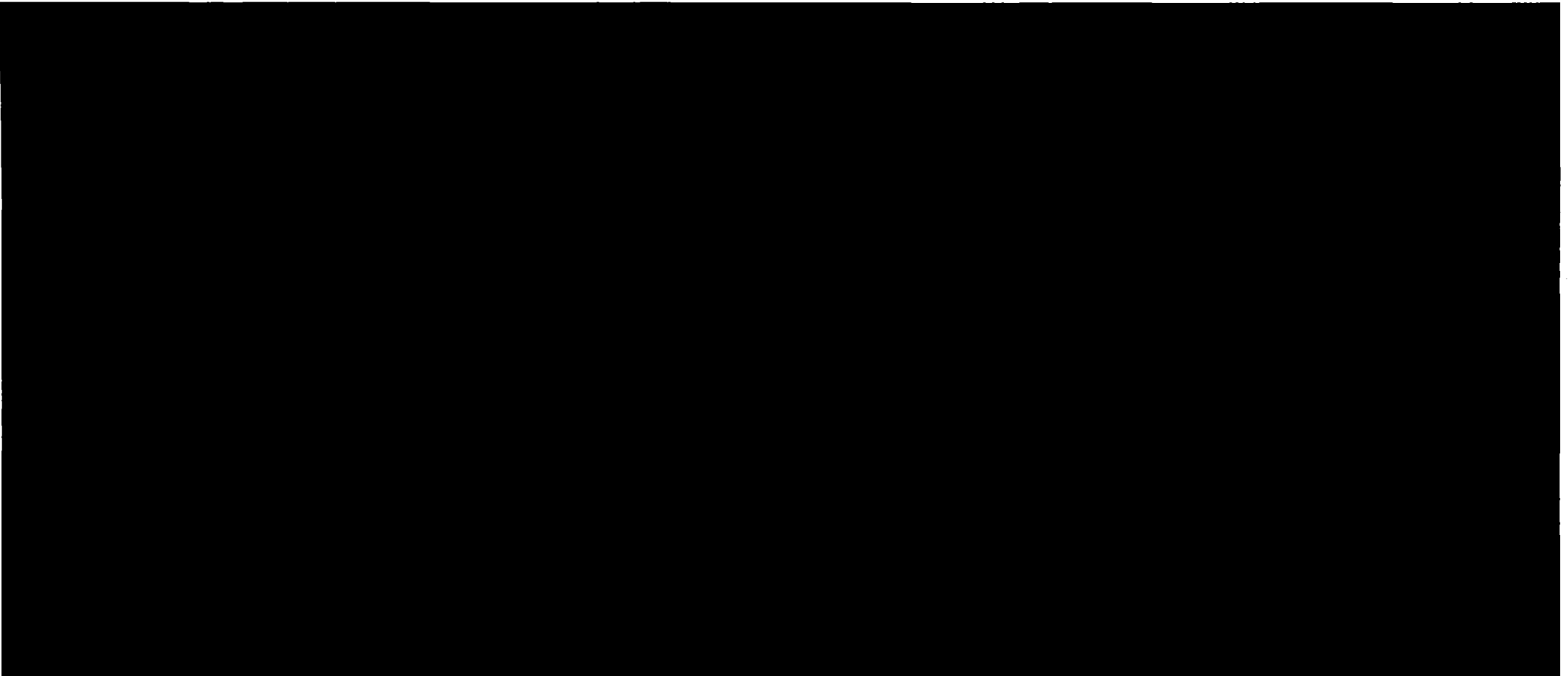
## **Acceptance Criteria and Maintenance Program – RSI-Ac-1: Pressure & leakage tests of confinement boundaries**



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 86

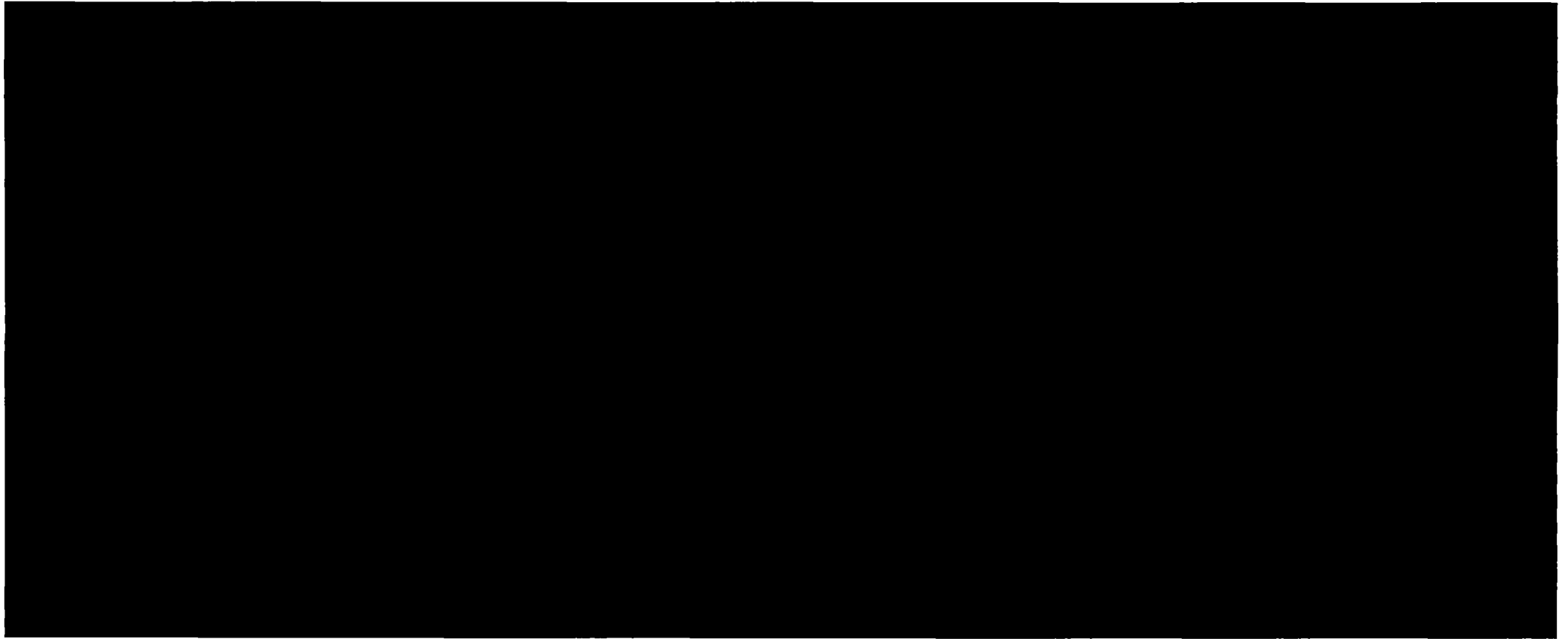
## Acceptance Criteria and Maintenance Program – RSI-Ac-1: Pressure & leakage tests of confinement boundaries



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

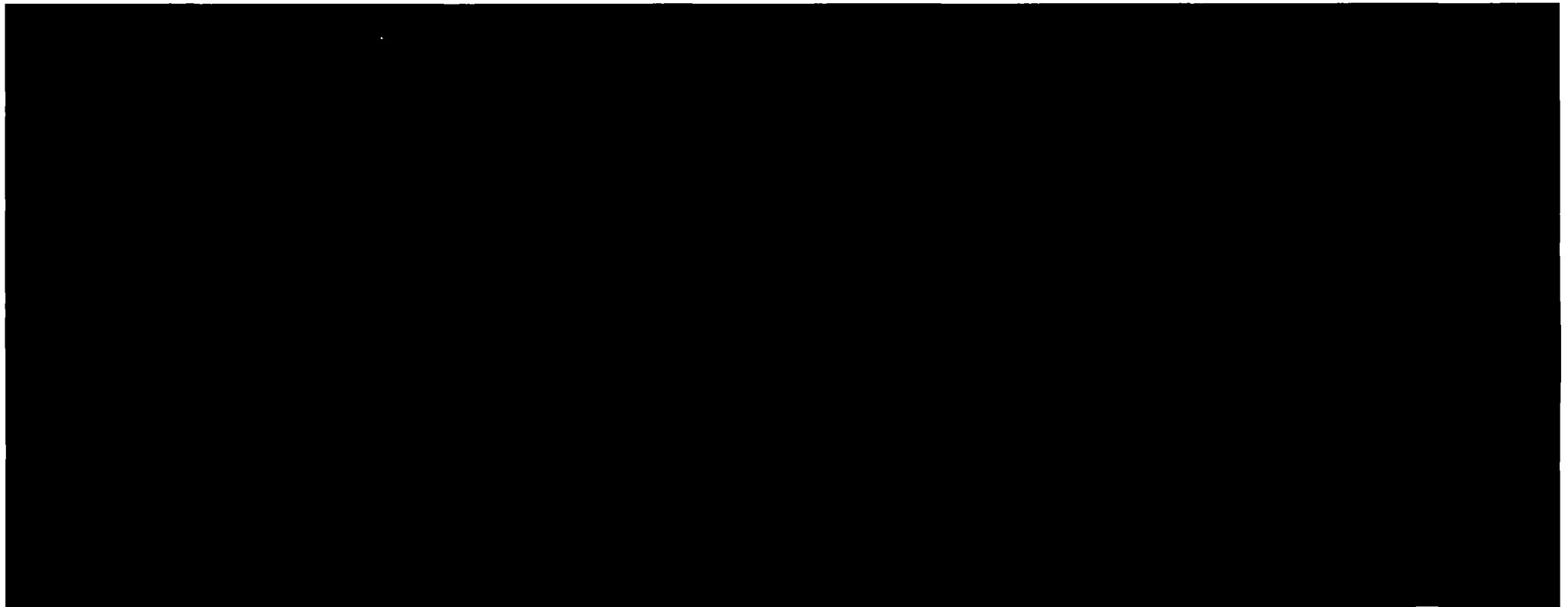
Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 87

# Acceptance Criteria and Maintenance Program – RSI-Ac-1: Pressure & leakage tests of confinement boundaries





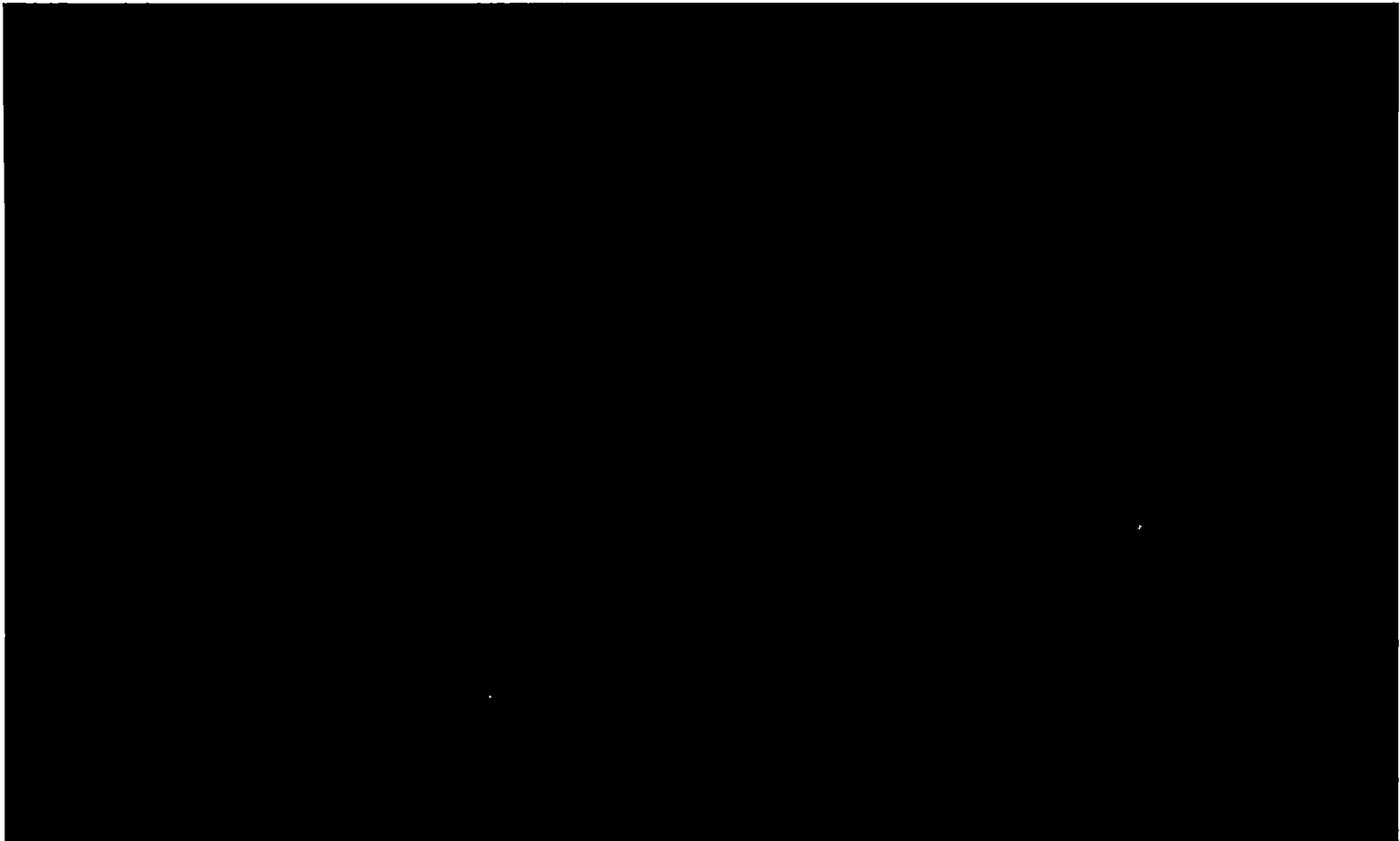
# **Acceptance Criteria and Maintenance Program – RSI-Ac-1: Acceptance Leakage Test - Cask Body**



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 89

# Acceptance Criteria and Maintenance Program – RSI-Ac-1: Acceptance Leakage Test - Cask Body



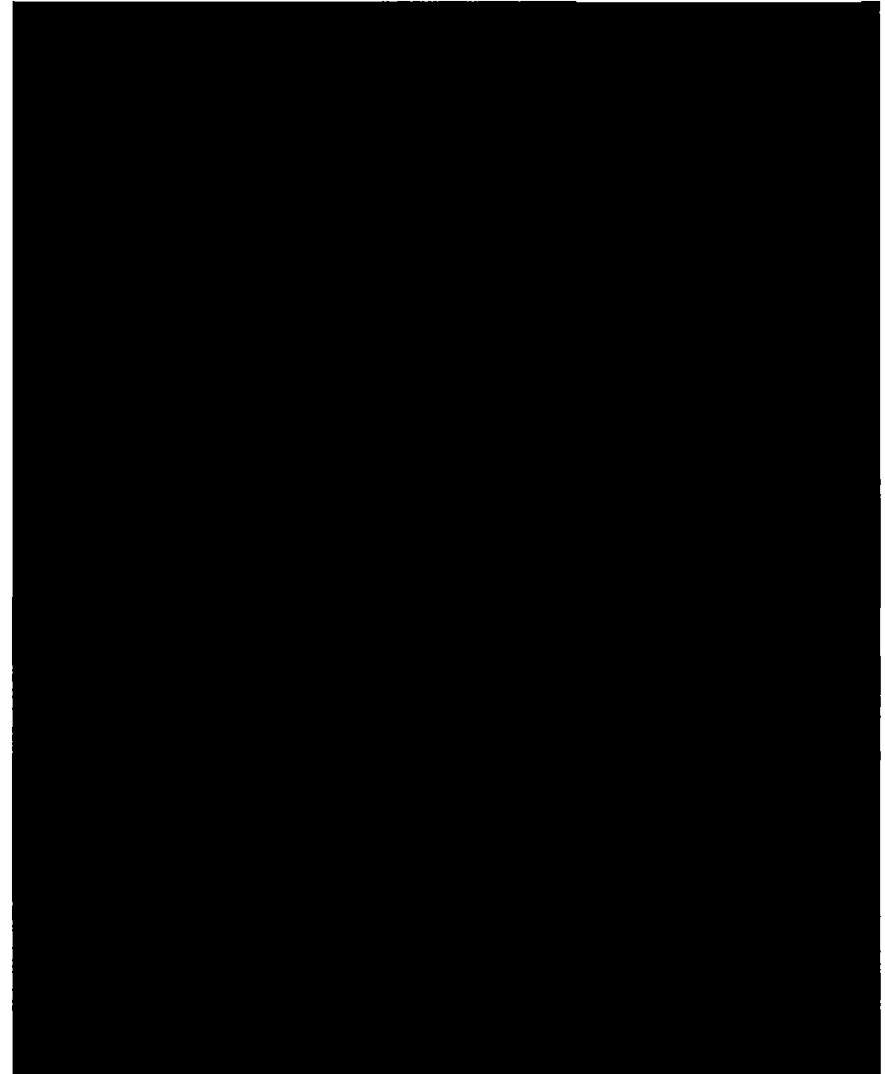
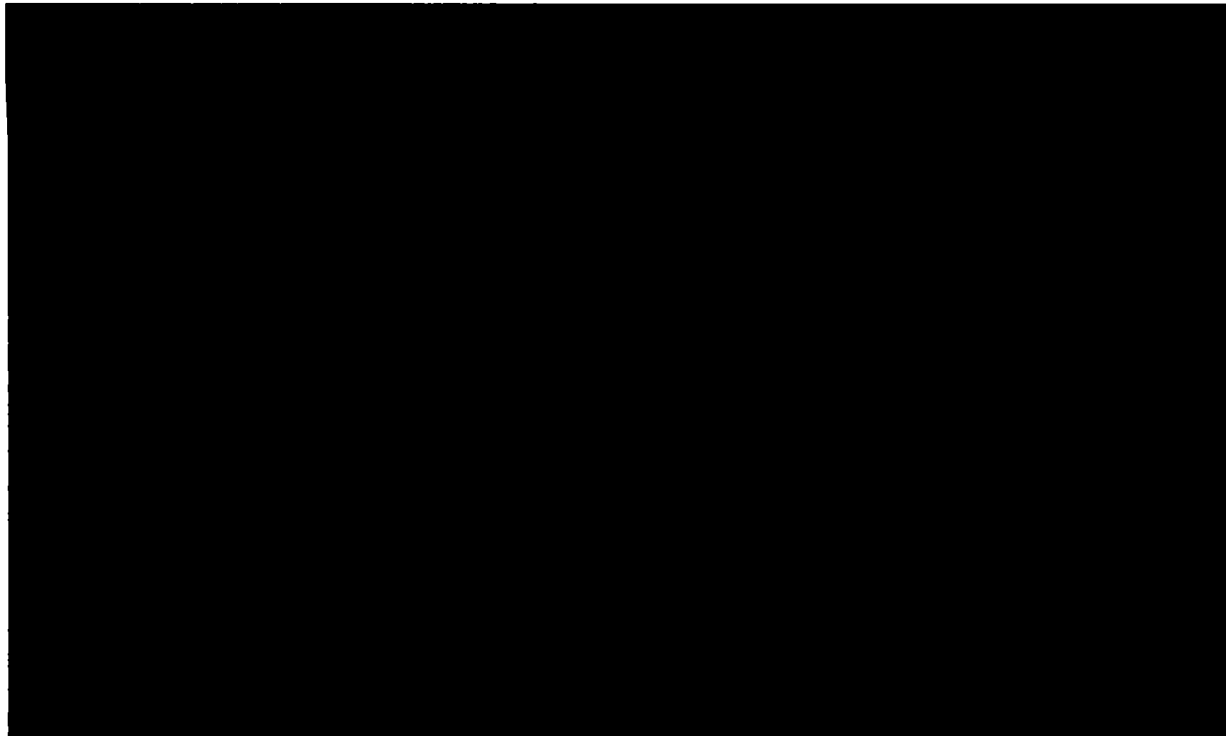
# Acceptance Criteria and Maintenance Program – RSI-Ac-1: Acceptance Leakage Test - Cask Body



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 91

# Acceptance Criteria and Maintenance Program – RSI-Ac-1: Acceptance Leakage Test - Cask Body



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 92

## Safety evaluations

- Structural evaluation
- Thermal evaluation
- Shielding & radiation protection evaluation
- Criticality evaluation
- Containment evaluation
- Material evaluation
- Operation procedures
- Acceptance criteria and maintenance program



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 93

## Agenda – Closed Part

- Background and schedule requirements
- DSS and CLU
  - Definition and description of configurations
  - Handling operations
- Concepts of safety evaluations
  - Concept for CLU
  - Current concept for DSS
  - Alternative concept for DSS
- Safety evaluations to be performed
  - resulting from concepts and RSI
  - Organized by specialty department:  
Structural, thermal, shielding & radiation protection, criticality, containment and material evaluations, operation procedures, acceptance criteria and maintenance program

## Further Topics?



Proprietary Information withheld per 10 CFR 2.390  
Non-Proprietary Version

Technical Meeting / 10 CFR 72 CASTOR® geo69 DSS/ 95

**Non-Proprietary Version**



## **10 CFR72 Application of CASTOR® geo69 Dry Storage System**

GNS Gesellschaft für Nuklear-Service mbH

Technical Meeting

