Attachment 2

Open Session Presentation Slides
(Non-Proprietary)

LAR 1014-3
HI-STORM 100U

Holtec International

February 16, 2005

HOLTEC
INTERNATIONAL

Presentations

- Non-Proprietary
  - Overview — Dr. Stefan Anton
  - Nuclear Analysis — Dr. Everett Redmond
  - Structural Analysis — Chuck Bullard
- Proprietary
  - Design Features — Dr. K.P. Singh
  - Thermal Analysis — Dr. Debu Majumdar

HOLTEC INTERNATIONAL

LAR 1014-3 Overview

- Added New Overpack HI-STORM 100U
- Increased Heat Load
  - 38 kW for PWR
  - 35.5 kW for BWR
- Proposed two minor CoC/Tech Spec Changes

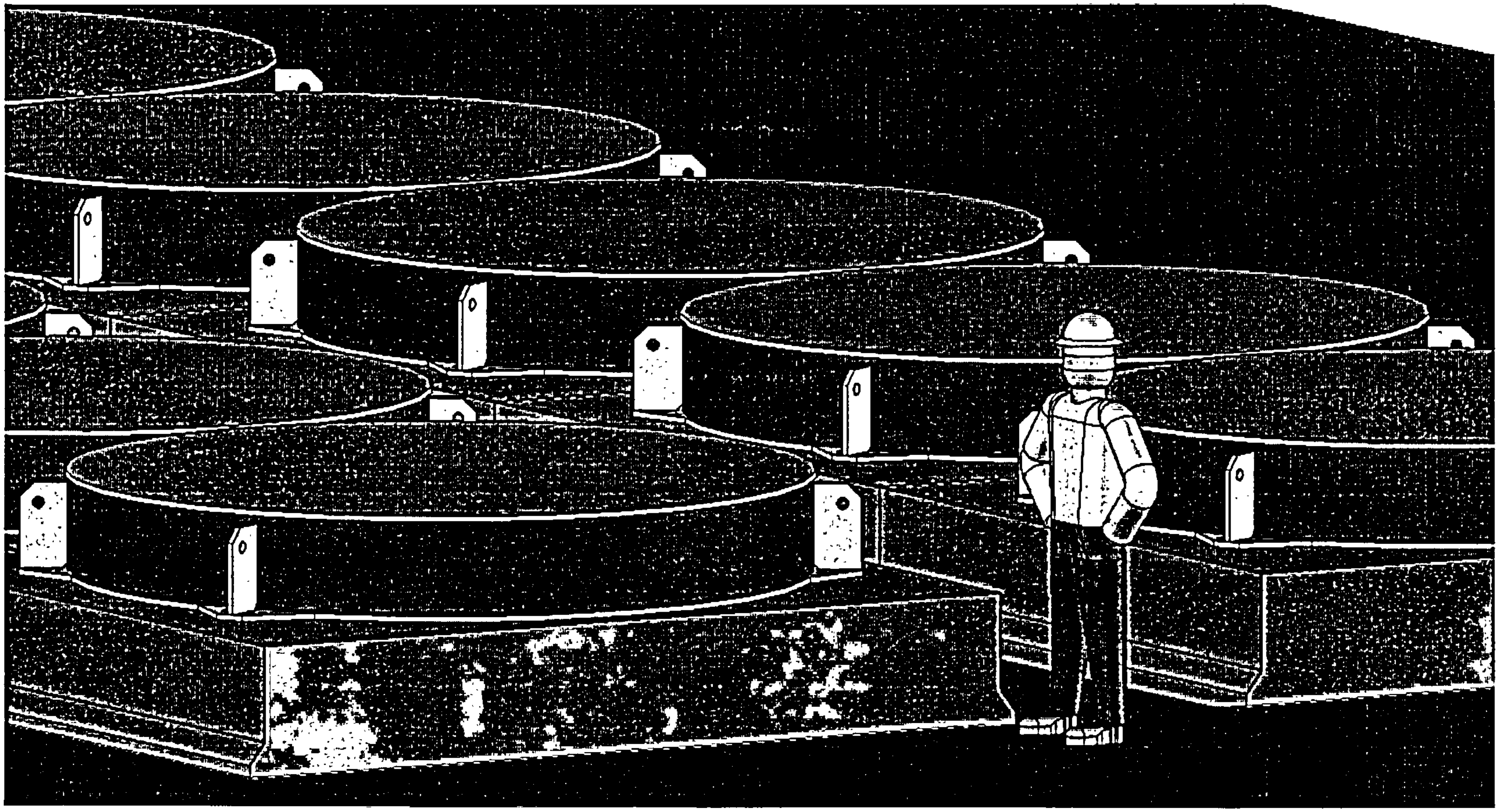
HOLTEC INTERNATIONAL

HI-STORM 100U

- Underground Design
  - About 42 Inches above ground
- Ventilated System
  - VVM = Ventilated Vertical Module
- MPC-based
  - Same MPCs as aboveground systems
- Heavy Lid
  - Physical Protection

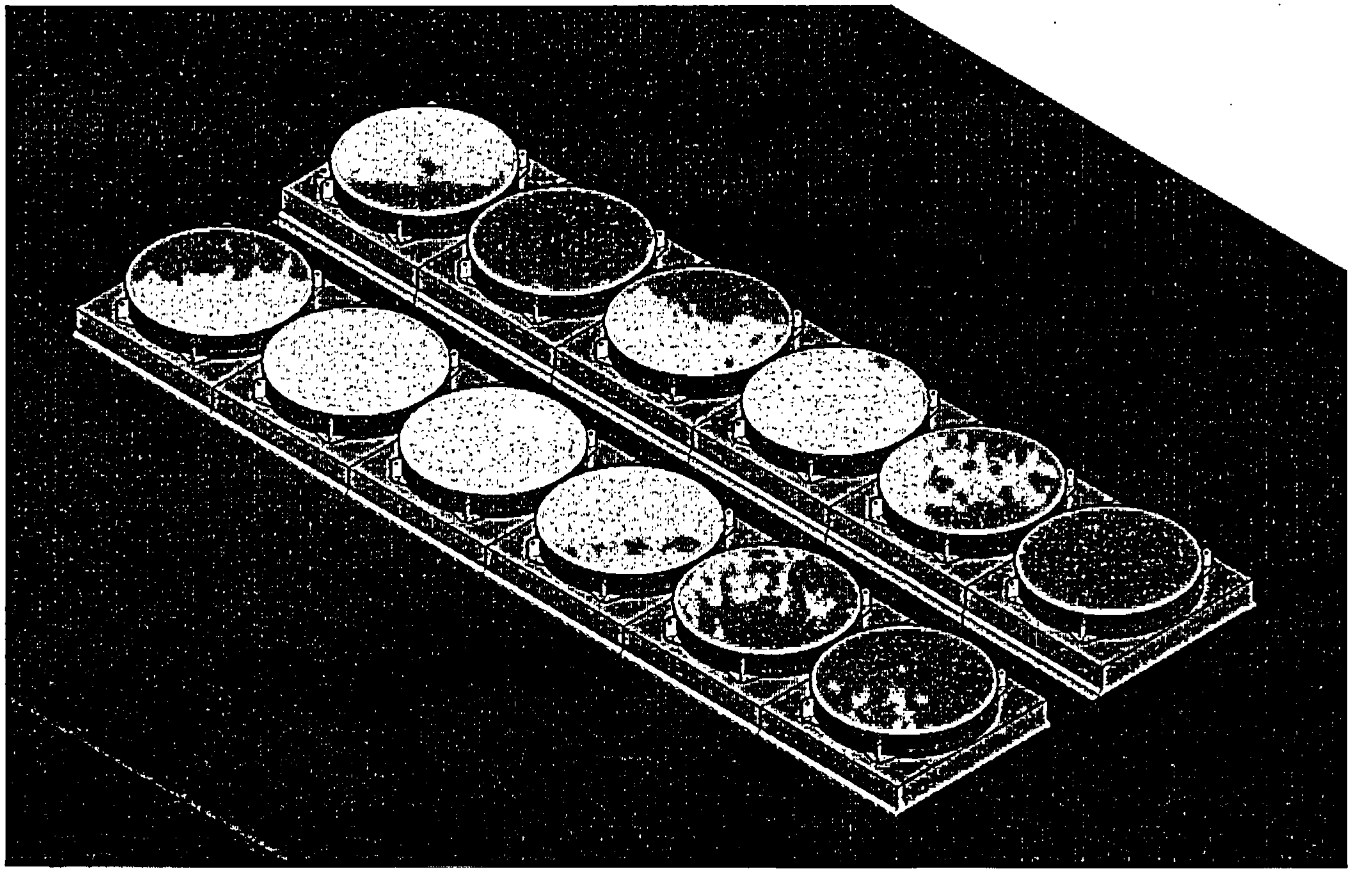
HOLTEC INTERNATIONAL

HI-STORM 100U



HOLTEC INTERNATIONAL

HI-STORM 100U



HOLTEC INTERNATIONAL

HI-STORM 100U Design

- Carbon Steel and Concrete Construction
- All sub-surface steel structures have a protective surface coating
- Sub-surface load-bearing components have a 1/8 inch corrosion allowance
- Basemat made of reinforced concrete

HI-STORM 100U Performance

- Comparison to aboveground HI-STORMs
  - Thermal: Same as aboveground
  - Criticality and Confinement: Same as aboveground
  - Shielding: Substantially lower dose rates at the site boundary
  - Structural: Substantially improved physical protection
  - Operational: Convenient ground-level loading operations using same ancillaries
  - Inspections / Tests / Maintenance: Essentially same as aboveground

HOLTEC INTERNATIONAL

Thermal-Hydraulic Evaluations

- Modeling
  - Three-dimensional with minimal simplifications
  - Model allows evaluation of wind effects (direction and speed)
- Scenarios
  - Normal Storage
  - Partial and Full Blockage of Inlet
  - Flood
  - Wind

HOLTEC INTERNATIONAL

Thermal-Hydraulic Evaluations (cont.)

- Results
  - All temperatures below allowable limits with at least 50°F margin
  - Performance essentially the same as aboveground system, therefore, only one MPC analyzed (MPC-68)
  - Wind direction and speed has effect on temperatures

HOLTEC INTERNATIONAL

HI-STORM 100U
Inspections, Testing and Maintenance

- Test to confirm protection against rainwater intrusion
- Concrete and weld inspections per applicable codes
- Shielding test per TS Radiation Protection Program
- TS surveillance to verify ventilation operability
- No other maintenance required for operability

LAR 1014-3
CoC and Tech Spec Changes

- HI-STORM 100U
  - Editorial changes throughout CoC
  - References to "overpack" apply to VVM unless otherwise specified
  - Specific Inlet/Outlet surveillance requirements
- Increased Heat Loads
  - Variable ratio of inner and outer heat loads for regionalized loading
  - Revised completion times
  - Revised threshold for vacuum drying
  - Revised backfill requirements

LAR 1014-3
CoC and Tech Spec Changes (cont.)

- Thermal Validation Tests removed
  - Currently validation tests required up to 16 kW
  - Loaded systems have surpassed the 16 kW limit (up to 22.5 kW)
- Fixed Dose Rate Limits removed from Radiation Protection Program
  - Site specific dose rate limits ensure site boundary dose limits are met

HOLTEC INTERNATIONAL

Nuclear Analysis for the HI-STORM 100U

by

Everett Redmond II, Ph.D.

Holtec International
555 Lincoln Drive West
Marlton, NJ 08053

February 16, 2005

HOLTEC
INTERNATIONAL

Criticality and Confinement

- The MPC design has not been altered. Therefore, the confinement evaluation is not affected.
- The HI-STORM 100U and the above ground HI-STORM overpacks are identical in regards to the criticality evaluation. Therefore, no new criticality calculations have been performed.

Shielding Codes and Source Terms

- The same versions of MCNP, SAS2H, and ORIGEN-S were used for the analysis of the HI-STORM 100U.
- Design basis fuel assembly identical to previous analysis.
- No new source terms calculated in this amendment.

HOLTEC INTERNATIONAL

MCNP Models

- MPC model identical to the model previously used in the above ground HI-STORM casks.
- A single Vertical Ventilated Module (VMM) was modeled in full three dimensional detail.

HOLTEC INTERNATIONAL

Shielding Benefits

- Only a small portion of the HI-STORM 100U is positioned above the ground and the exposed surface area is minimal compared to the HI-STORM 100S.
- The MPC is predominantly positioned below the surface of the ground.
- As a result, the offsite dose from a HI-STORM 100U is bounded by the offsite dose from an above ground HI-STORM.

Dose Rate Calculations

- Only the MPC-32 was analyzed in the HI-STORM 100U.
- Dose rate at the surface and 1 meter from the above ground portions of the HI-STORM 100U were calculated with MCNP.
- Off-site dose calculations were not performed since the above ground HI-STORM is bounding.

HOLTEC INTERNATIONAL

Dose Rate Calculations (continued)

- Operational procedures extremely similar to above ground HI-STORM system.
  - MPC loaded in HI-TRAC
  - MPC sealed in HI-TRAC
  - MPC transferred from HI-TRAC to HI-STORM
- Since procedures are similar, the occupational dose will be similar and therefore Chapter 10 does not explicitly calculate the occupational dose for a HI-STORM 100U.

HOLTEC INTERNATIONAL

MPC-32 Dose Rate Results
35 GWd/MtU – 3 Year Cooling

Location	HI-STORM 100U (mrem/hr)	HI-STORM 100S Version B (mrem/hr)
Inlet vent	56.3	68.9
Top	25.0	14.7
Outlet vent	38.8	26.4
Side of overpack	N/A	99.4

Conclusions

- Results clearly indicate that exposed surfaces of HI-STORM 100U have similar or better dose rates than HI-STORM 100S.
- Area of highest dose rate on HI-STORM 100S eliminated in HI-STORM 100U.
- Off-site dose rates for the HI-STORM 100U are 1 to 2 orders of magnitude lower than the above ground HI-STORM overpacks.

HOLTEC INTERNATIONAL

Structural Qualification of HI-STORM 100U System

by

Charles Bullard II

Holtec International
555 Lincoln Drive West
Marlton, NJ 08053

February 16, 2005

HOLTEC
INTERNATIONAL

Background

- HI-STORM 100U System consists of the MPC, the Vertical Ventilated Module (VVM), and the HI-TRAC transfer cask.
- HI-STORM 100U VVM functions with currently licensed MPCs and HI-TRAC transfer casks.
- Structural evaluation focuses primarily on HI-STORM 100U VVM.

HOLTEC INTERNATIONAL

Governing Codes

- ASME Section III, Subsection NF and Appendix F (1995 Edition w/ Addenda through 1997) for load bearing steel components.
- ACI 318.1-89 for unreinforced concrete monolith.
- ACI 349-85 for reinforced concrete base mat.
- ANSI N14.6-1993 for lid lifting lugs.

HOLTEC INTERNATIONAL

Individual Loads

- Normal Condition: Dead Weight, Handling, Pressure from Subgrade, Live Load, Ambient Temperature, Wind, and Snow
- Off-Normal Condition: Elevated Ambient Temperature, Partial Blockage of Air Inlets, and Elevated Wind Speed
- Accident Condition: Handling Accidents, Fire, Tornado, Flood, Earthquake, Explosion, Lightning, Burial Under Debris, 100% Blockage of Air Inlets, and Extreme Environmental Temperatures

Individual Loads (cont.)

- Bounding lateral subgrade pressure of 100 psi is applied on VVM under all conditions.
- Design basis maximum accelerations at top of grade adjacent to VVM are 2-g net horizontal and 1.5-g vertical.
- Tipover or sliding of the VVM are not credible because of subterranean design.

HOLTEC INTERNATIONAL

Load Combinations for HI-STORM 100U VVM

Load Case I.D.	Loading	Notes
01	D, T, P_o	Satisfy Level A limits for the steel components of the lid. Satisfy applicable factored load limits for reinforced concrete base mat. Demonstrate that the concrete monolith can support the loaded HI-TRAC transfer cask during the VVM loading operation.
02	M (penetrant missiles)	Demonstrate that no thru-wall breach of the VVM lid occurs, that primary stress levels are not exceeded away from the local area of impact, and that bearing stresses in the monolith remain below specified limits.

HOLTEC INTERNATIONAL

Load Combinations for HI-STORM 100U VVM (cont.)

Load Case I.D.	Loading	Notes
03	P_o*	Explosion: VVM lid must remain in-place.
04	D, T, P_o, E	Satisfy Level D limits for the steel components of the lid. Satisfy applicable load limits for reinforced concrete base mat under seismic loads. Demonstrate that Level D Stress Levels in the MPC Canister are not exceeded.
05	D, H	Demonstrate that lid lifting lugs meet ANSI N14.6 limits and that Level A stress limits are met away from the immediate vicinity of the lugs.

HOLTEC INTERNATIONAL

Minimum Subgrade Properties

Property	Value	Remarks
Minimum Effective Young's Modulus for Subgrade Underlying the Base Mat	16,000 psi	The equivalent Bousinesq stiffness of the subgrade is defined by the footprint of the base mat, the minimum specified Young's Modulus, and a Poisson's Ratio (assumed as 0.35).
Minimum Subgrade Bearing Capacity Under VVM Normal Load Conditions	25 psi	Average value over an area equal to L x W where L = base mat length and W = base mat width + 48".

HOLTEC INTERNATIONAL

Structural Calculations

- **Base Mat Strength Evaluation** - Analyzed using ANSYS as a one-way slab supported on an elastic foundation under dead load and vertical seismic load (1.5-g).
- **Concrete Monolith Strength Evaluation** - Developed 3-D ANSYS model (1/4 symmetric) to compute stresses in plain concrete and steel ducts due to surcharge pressure from loaded cask transporter.

HOLTEC INTERNATIONAL

Structural Calculations (cont.)

- **VVM Lid Strength Evaluation** - Developed 3-D ANSYS model (1/4 symmetric) to compute stresses in lid due to dead load and vertical seismic load.
- **Lid Lifting Calculation** - Used strength of materials formula to demonstrate compliance with ANSI N14.6 stress limits.

Structural Calculations (cont.)

- **Tornado Missile Analysis** - Examined missile penetration into VVM lid using Bechtel Topical Report TOP-9A. Performed dynamic impact analysis using VisualNASTRAN to determine stress in lid.
- **Explosion Analysis** – Used ANSYS and strength of materials formula to evaluate the effects of explosive pressure on the lid shear ring and bolts.

Structural Calculations (cont.)

- **MPC Baseplate Stress Analysis** - Developed 3-D ANSYS model (1/2 symmetric) to compute stresses in MPC baseplate due to dead load and vertical seismic load with support from MPC chairs.
- **MPC Shell Stress Analysis** – Considered MPC shell as pinned beam to compute stress in shell due to 2-g lateral acceleration. Stresses combined with MPC shell results for internal pressure plus temperature.

Minimum Safety Factors

Load Case I.D.	**Loading**	**Minimum Safety Factor**
01	D, T, P_o	1.08 (primary plus secondary bending stress intensity in MPC baseplate) 1.29 (subgrade pressure)
02	M (penetrant missiles)	2.22 (lid bending stress)
03	P_o*	24.6 (lid bolt tension)
04	D, T, P_o, E	1.76 (base mat bending moment)
05	D, H	2.66 (unreinforced concrete bearing stress)

HOLTEC INTERNATIONAL

Conclusions

- HI-STORM 100U System meets applicable ASME and ACI Code limits under all load conditions.
- VVM lid provides ample protection against tornado missiles.
- Resultant pressure on soil foundation is less than the minimum required bearing capacity of 25 psi.

MECHANICAL DESIGN OF HI-STORM 100U

by
Dr. K.P. Singh
President and CEO
Holtec International
February 16, 2005

HI-STORM 100U PERFORMANCE OBJECTIVES

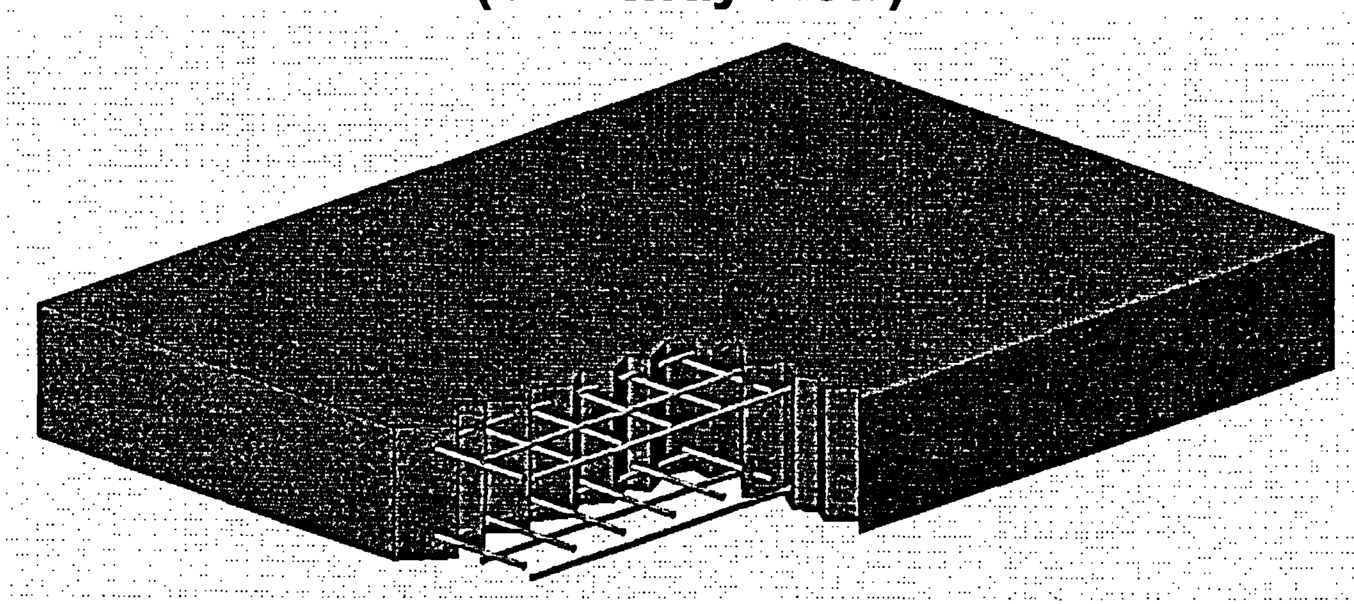
- Compared to HI-STORM 100 and "100S", HI-STORM 100U's performance objective is to have:
  - equal heat rejection capacity
  - lower dose emission rate
  - greater resistance to extreme environmental phenomena loads
  - greater resistance to accident events such as flood and fire
  - inconspicuous profile
  - safe and convenient loading operations
  - convenient MPC transfer to a transport package for off-site shipment

DESIGN FEATURES OF HI-STORM 100U

- Vertical Ventilated Module (VVM)
- VVM design completely compatible with existing MPC and transfer cask designs
- The VVM is a permanent part of the ISFSI
- Superior protection from impactive and impulsive loads
- Improved shielding effectiveness
- Unobtrusive profile
- Utilizes the same ancillaries (lift yoke, drying system, etc.), for loading operations

GENERAL INFORMATION

VVM Founded on a Basemat Made of Reinforced Concrete (Cut-Away View)



Thickness = 24 inches Minimum

Rebars = #9 @12 inches in both directions, top and bottom

Subgrade Modulus ≥ that of an elastic half space defined by

E = 16,000 psi @ ν = 0.35

ADDITIONAL DESIGN CONSIDERATIONS

- All sub-surface load bearing carbon steel components given 1/8″ corrosion allowance

- Effect of wind on heat rejection rate quantified
  - Wind (normal storage condition): up to 10 MPH
  - Wind (off-normal storage condition): up to 30 MPH

MPC LOADING AND UNLOADING OPERATIONS

- MPC transfer occurs in the vertical configuration, eliminating any concern of binding or galling due to friction, even after decades of storage.
- Load handling components, namely MPC cleats, lift yoke, and crawler are the same as those being used presently at all HI-STORM ISFSIs - no new ancillaries.

SHIELDING AND RADIATION PROTECTION

- Direct dose rate via sides negligible due to monolith and surrounding subgrade.
- Dose rate through ventilation passages specifically analyzed.
- Personnel dose during VVM operations bounded by other analyzed HI-STORM 100 Overpack cask loading scenarios evaluated in FSAR, therefore, no specific personnel dose estimate performed for use of 100U.
- Shielding analysis model prepared on MCNP and dose characteristics of HI-STORM 100U quantified in Chapter 5 of the LAR.

OPERATIONS

- MPC loaded and prepared for storage operations in the same manner as currently done
- All operations performed at ground level
- Crawler transports loaded HI-TRAC Transfer Cask with MPC to ISFSI
- Crawler Performs MPC Transfer
  - Same ancillaries used

FIRE

- Because of its subterranean configuration, the HI-STORM 100U is largely insulated from an ISFSI fire event. Licensing application seeks certification for the same fire event for which the above-ground HI-STORMs are presently certified.

CONCLUDING REMARKS

- HI-STORM 100U is a natural extension of HI-STORM 100S.
- The subterranean configuration of HI-STORM 100U renders it into an extremely efficient dose attenuator and protector of the MPC against impactive missiles.
- Extremely resistant to hazards such as fire and flood.
- Convenient and safe MPC loading and unloading
- Superb radiation protection characteristics.

Thermal-Hydraulic Evaluation of the HI-STORM 100U System

by

Debabrata Mitra-Majumdar, Ph.D.

Principal Engineer

Holtec International

555 Lincoln Drive West

Marlton, NJ 08053

February 16, 2005

HOLTEC INTERNATIONAL

Purpose of this Presentation

- Summarize the principal design features of the HI-STORM 100U System pertinent to its thermal-hydraulic performance.

- Present an overview of the models and parameters used for the thermal-hydraulic evaluation of the HI-STORM 100U System.

- Summarize the thermal-hydraulic evaluations and the results of these evaluations.

Principal Model Features

- The HI-STORM 100U Vertical Ventilated Module (VVM) is modeled as a 3-D steel/concrete monolith.
- The geometric features of the HI-STORM 100U VVM are modeled explicitly, with minimal simplifications.
- The vertical surfaces between adjacent modules are assumed insulated.
- The three-dimensional model of the VVM permits simulation of varying wind direction, to enable addressing the effect of wind on the thermal performance.

Principal Model Features

- The three-dimensional model of the VVM allows accurate portrayal of several flooding scenarios.
- An MPC-68 was assumed to be placed in the VVM. Results demonstrate that VVM has approximately the same thermal performance as the design-basis aboveground design, so only one MPC needed to be evaluated.
- The MPC and its internals are modeled in the same manner as in the design basis (2-D) aboveground HI-STORM thermal models.

List of Evaluations

- Long Term Normal Storage
- Elevated Ambient Air Temperatures
- Partial Blockage of Inlets
- 100% Inlets Blockage
- Flood Condition
- Non-Quiescent Ambient (Wind) Condition

Primary Evaluation Parameters

1. Design Basis Maximum MPC Heat Load of 35.5 kW.
2. Ambient temperature of 80°F, except for elevated ambient temperature conditions.
3. For elevated ambient temperature conditions, values of 100 °F and 125 °F are used.
4. Maximum solar insolation.
5. Quiescent air, except for wind conditions.
6. Wind speeds from 2.5 mph to 30 mph.
7. Steady state evaluations, except for the 100% inlets blockage scenario.

Long-Term Storage Condition

Component	Calculated Value in HI-STORM 100U	Allowable Limit
Fuel Cladding	687°F	752°F
Fuel Basket	661°F	725°F
MPC Shell	446°F	500°F
Overpack Inner Shell	332°F	400°F
Lid Bottom Plate	265°F	400°F
Monolith Concrete	221°F	300°F
Maximum MPC Internal Pressure	95.1 psig	100 psig

HOLTEC INTERNATIONAL

100% Inlets Blocked Evaluation (at 32 hours after blockage)

Component	Calculated Value in HI-STORM 100U	Allowable Limit
Fuel Cladding	1003°F	1058°F
Fuel Basket	985°F	1200°F
MPC Shell	670°F	1200°F
Overpack Inner Shell	622°F	800°F
Lid Bottom Plate	410°F	800°F
Monolith Concrete	281°F	350°F
Maximum MPC Internal Pressure	128.6 psig	200 psig

Flood Condition

- Partial or complete submergence of the volume between the MPC and the cavity shell.
- Partial blockage would reduce the air flow area.
- Full blockage would eliminate the direct air cooling path, but introduce a conduction heat dissipation path between MPC and the VVM.
- Material blocking the inlet duct is assumed to be sand/soil, which has lower conductivity than water and does not evaporate.

Flood Evaluation

Component	Calculated Value in HI-STORM 100U	Allowable Limit
Fuel Cladding	762°F	1058°F
Fuel Basket	736°F	1200°F
MPC Shell	512°F	1200°F
Overpack Inner Shell	417°F	800°F
Lid Bottom Plate	328°F	800°F
Monolith Concrete	251°F	350°F
Maximum MPC Internal Pressure	102.9 psig	200 psig

Non-Quiescent Ambient Condition

- For all the wind conditions evaluated, the peak cladding temperature remains below the long-term normal limit.
- The effect of the wind is to either increase or decrease the peak cladding temperatures, depending on the wind direction and speed.

Conclusions

- The maximum fuel cladding temperatures are below the applicable limits.
- The maximum internal pressures of the cask remain below the design pressures.
- All cask and fuel materials are maintained at below their design basis temperatures limits.
- The fuel temperatures and MPC components temperatures in the HI-STORM 100U closely match those in the aboveground HI-STORM.