



State of Nevada  
Agency for  
Nuclear Projects



**REVIEW AND CRITIQUE OF DRIP SHIELD CONCEPT  
AND RETRIEVAL CONCEPT PLANNED FOR THE  
YUCCA MOUNTAIN PROJECT, NEVADA**

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**U. S. Nuclear Waste Technical Review Board Meeting  
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**AGAPITO ASSOCIATES, INC.  
CONSULTING ENGINEERS**



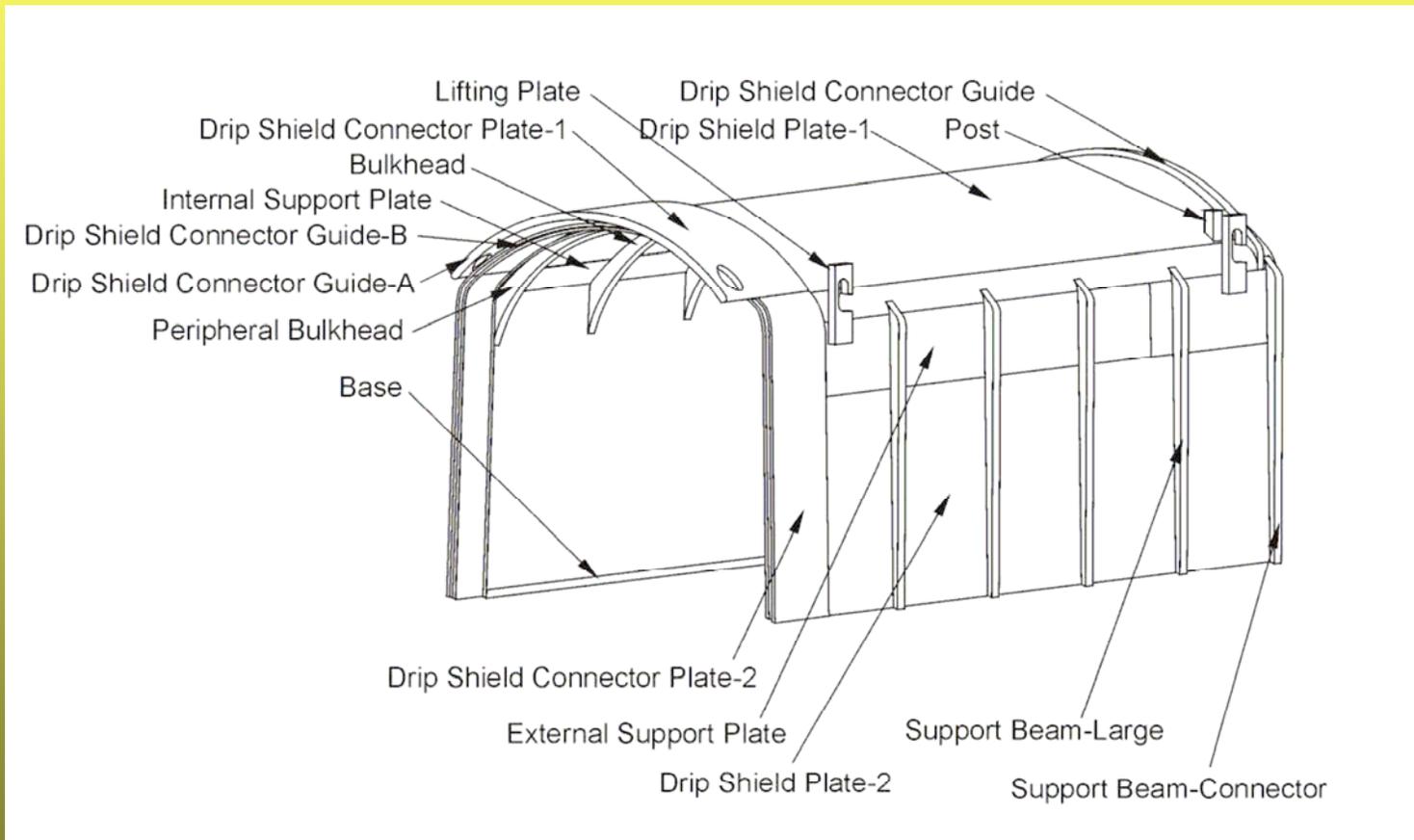
**NWTRB**

U.S. Nuclear Waste Technical Review Board

# Overview

- Review of Titanium Alloy Drip Shield Concept and Critique
- Review of Retrieval Concept and Critique
- Review of Features Common to Drip Shield and Retrieval Concepts
- Identification of Issues

# Interlocking Titanium Alloy Drip Shield



Perspective View

# Drip Shield Requirements

- Provide an additional corrosion-resistant engineered barrier over all waste packages
- Overlapping and interlocking so as to be a continuous shield for length of all waste packages in drift
- Each drip shield is made from Titanium Grade 7 and Titanium Grade 24
- Each drip shield weighs approximately 4 tonnes
- 12,500 drip shields will be needed
- Total weight of titanium alloy required is between 38,600 and 50,000 tonnes

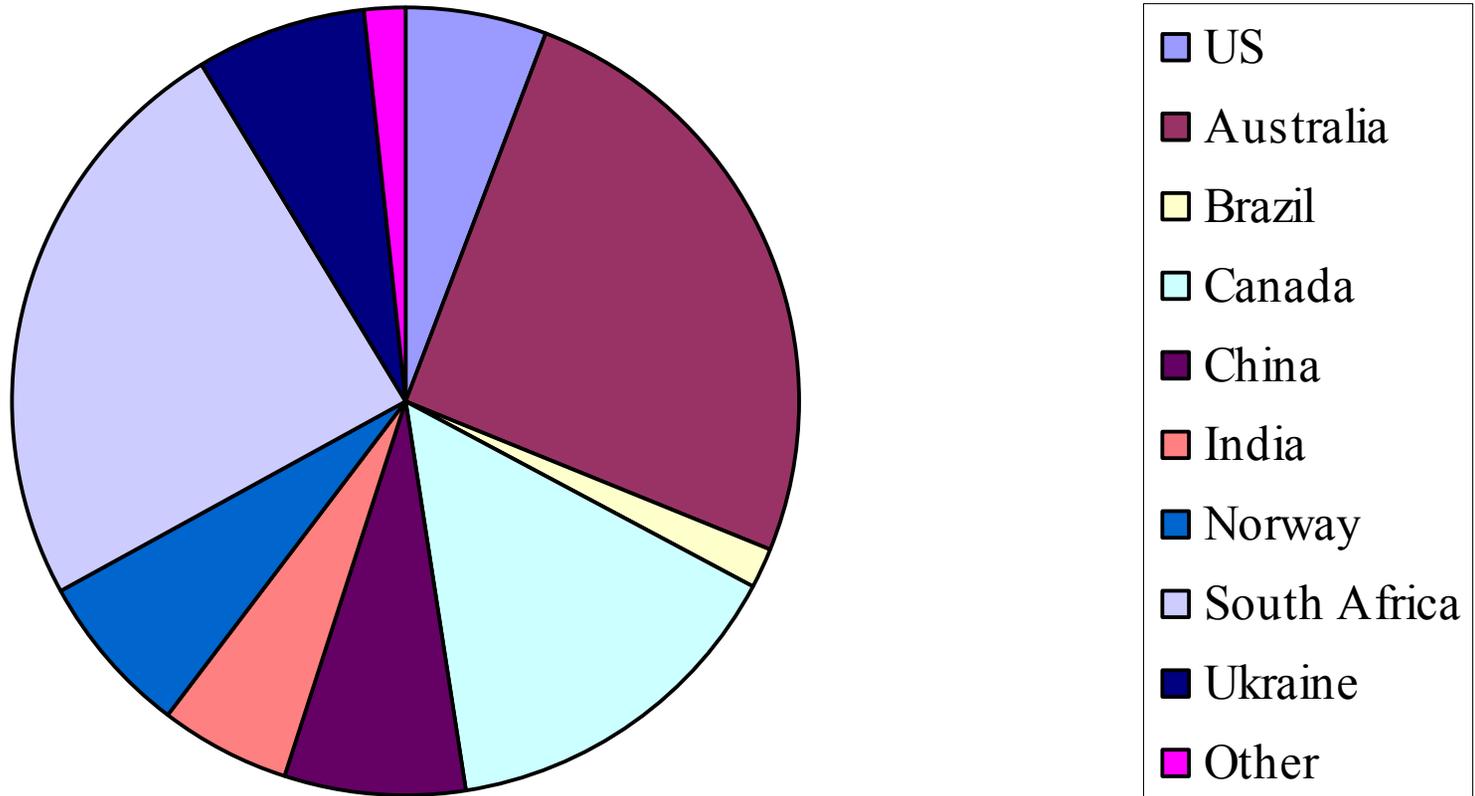
# Titanium Requirements for Drip Shields

## US Titanium Metal Statistics in Tonnes

| <b>Salient Statistics -- US</b>     | <b>2000</b>   | <b>2001</b>   | <b>2002</b>   | <b>2003</b>   | <b>2004</b>   | <b>Mean</b>   |
|-------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Consumption, Reported</b>        | <b>18,200</b> | <b>26,000</b> | <b>17,300</b> | <b>16,800</b> | <b>22,400</b> | <b>20,140</b> |
| <b>Domestic Apparent Production</b> | <b>13,000</b> | <b>13,570</b> | <b>15,710</b> | <b>13,570</b> | <b>11,540</b> | <b>13,478</b> |

- Total weight of titanium alloy required is between 38,600 and 50,000 tonnes
- Over approximately 10 years
- Total is approximately 2½ years annual domestic consumption
- Total is approximately 3 ½ years annual domestic apparent production

# Sources of Titanium Ores - 2004



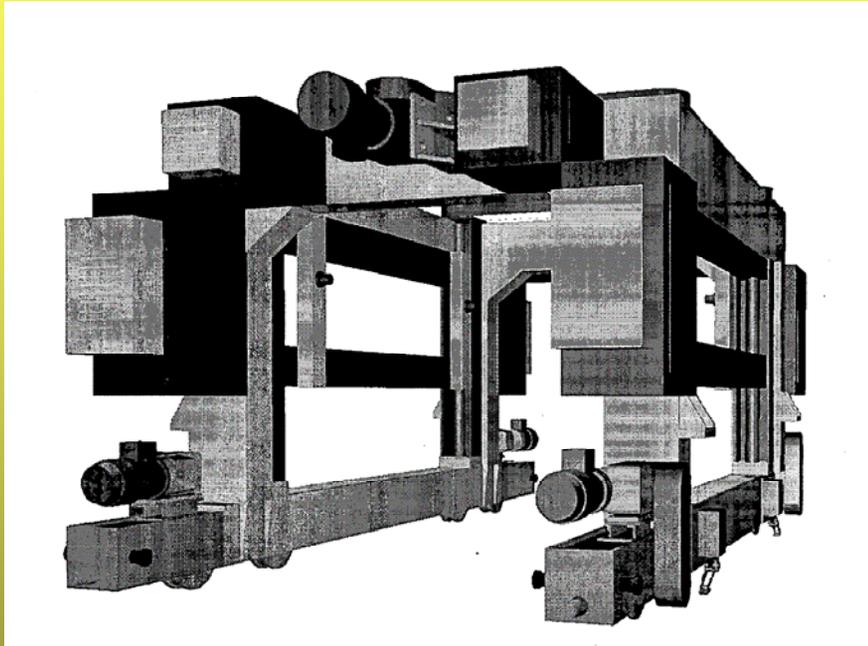
## **Timing of Drip Shield Installation**

- Installed just prior to closure and before retrieval (if any)
- Minimum 50 years after first HLW placement
- Possibility of a 100-year to 300-year preclosure period

## **Environment of Drip Shield Installation**

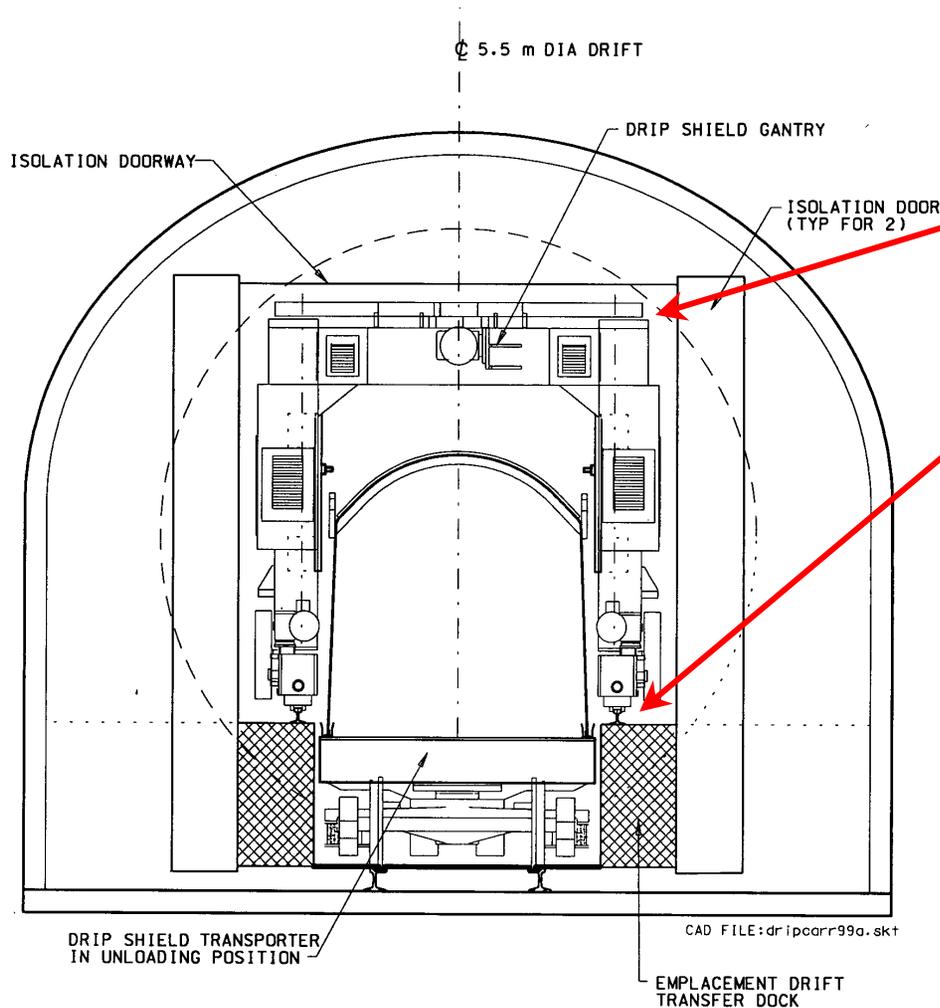
- 50°C (122°F) temperature environment
- Radioactive environment
- Ventilated at overall 15m<sup>3</sup>/second airflow
- Likely very dusty environment

# Drip Shield Transport Gantry



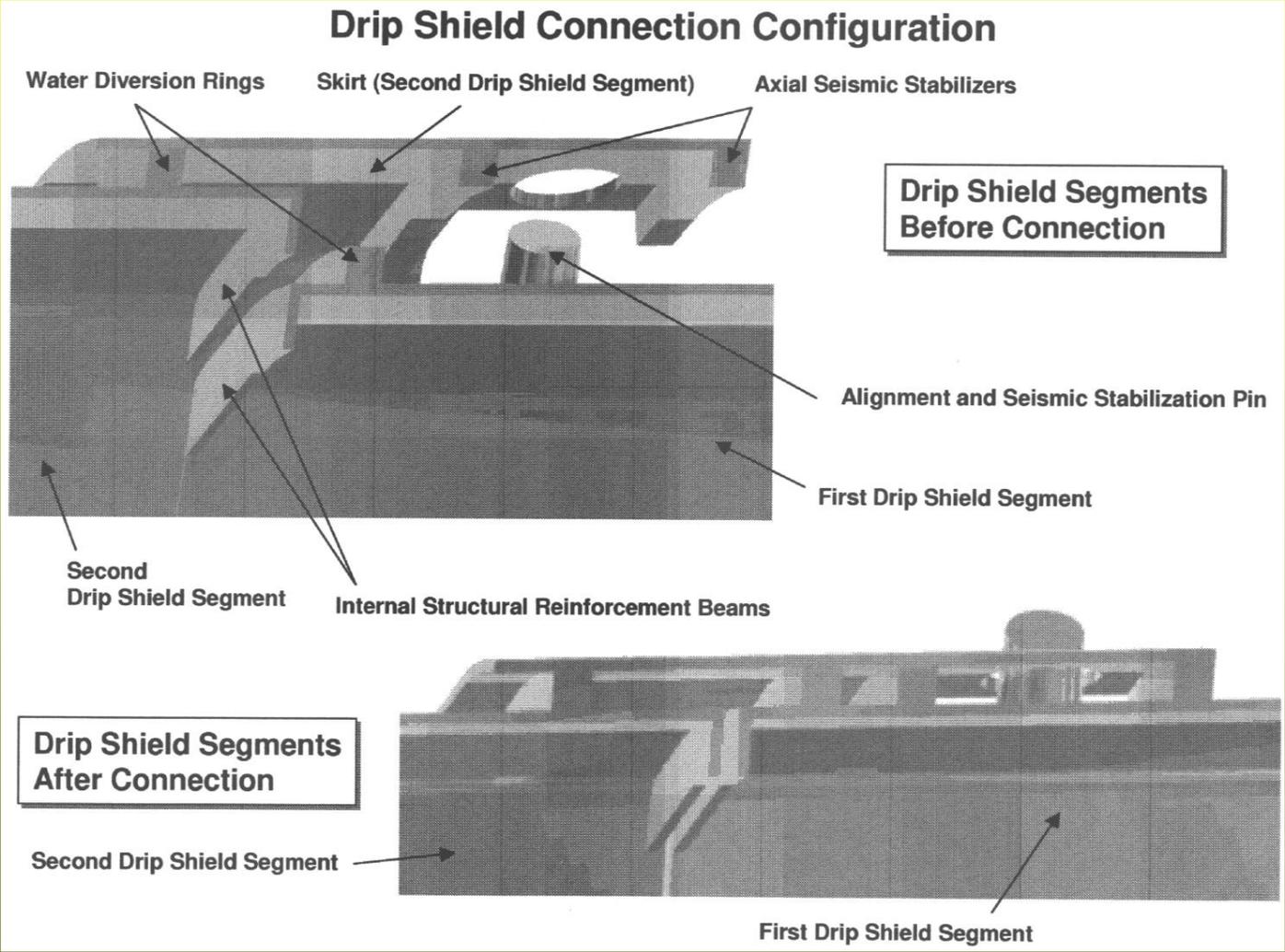
- Operates in a radioactive environment
- Operates in a 60°C (122°F) temperature
- Remotely controlled
- Self-propelled by 750-V DC electric motor from third rail
- Moves on steel rails
- 45 tonnes (49.6 tons)
- Difficult to recover if inoperable in drift

# Drip Shield Transport Gantry



- Tight clearances in emplacement drift
- Possibly corroded steel rails and third rail
- Dusty environment hinders optics for video

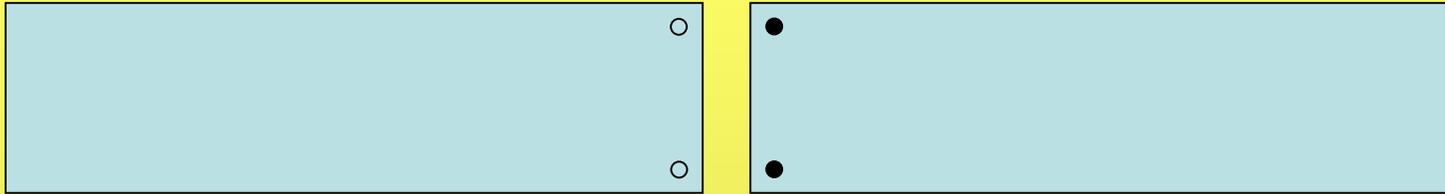
# Drip Shield Interlock Mechanism



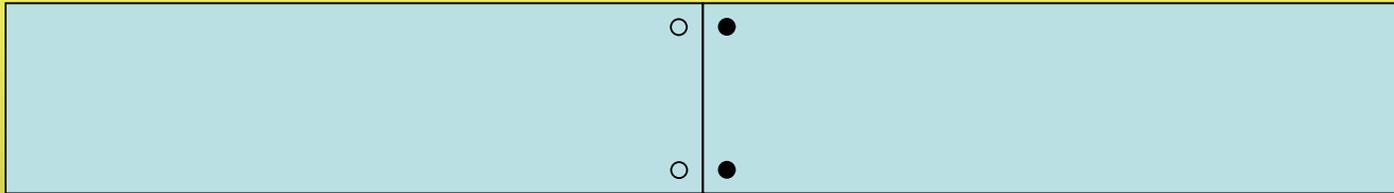
- The pinned connection is primarily intended to lock shields together mechanically to minimize separation during shaking from a seismic event
- The pinned connection has to be made by the Drip Shield Gantry by remote control, in a dusty environment, in a very tight clearance envelope
- No feedback mechanism or instrumentation for verifying that successful interlock has been achieved has been described

# Mating of Drip Shield Pins

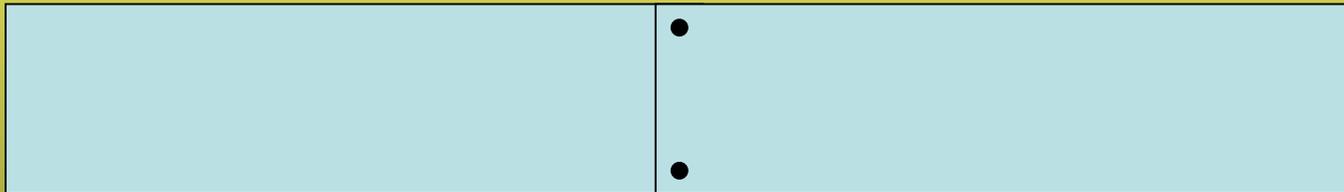
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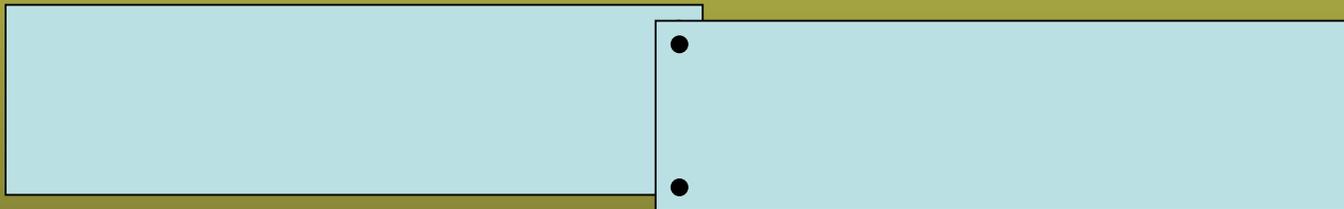
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**Successful Interlock**



**Unsuccessful Interlock**

# Drip Shield Interlocking Tolerance



**Less than  $1.2^\circ$  longitudinal angular tolerance**

# Dust

**Numerous studies in industrial, mining, and military environments have demonstrated the difficulty of operator visual recognition in degraded visibility environments such as dusty.**

**Dust gets in the way of sight, is lit up by lights, coats lenses, and penetrates equipment.**

# Degraded Visibility for Optics in Dusty Environment



Digital image I took in a stone mine recently

# Dust at Yucca Mountain Underground

## From Advisory Committee on Nuclear Waste Meeting of February 2001:

- CHAIRMAN WYMER: Most of the dust in our observations collects on the tops of things and not under them.
- AUDIENCE: Well, the drip shield doesn't replace until the water closure, and the waste package has been sitting there for quite some time, and that is an assumption in our model anyway. So I just wanted to clarify that.
- CHAIRMAN WYMER: **So you are saying there may be 300 years worth of dust?**
- AUDIENCE: **Yes, exactly.**
- CHAIRMAN WYMER: That's a good point.
- CHAIRMAN WYMER: **My original feeling about airborne dust was that it didn't amount to much, but the more I thought about it, the more I thought that, gee, it does.**
- AUDIENCE: Well, there is going to be ventilation going on, and I don't think the ventilation have got filters in it.
- DR. CAMPBELL: **One of the things that certainly I have noticed over the years in various tours through Yucca Mountain is that you pass by these placards and other things that when they are first put through the DSF were nice and clean, and over time those things have been heavily coated with dust.** And that is a process that is going to occur when they are drilling these drips and --
- DR. CAMPBELL: Wash it all out, right. **But over the operation period of the repository, you definitely are going to have a significant build up of stuff on the surfaces.**
- CHAIRMAN WYMER: Yes, I certainly after reflection arrived at that position, too.

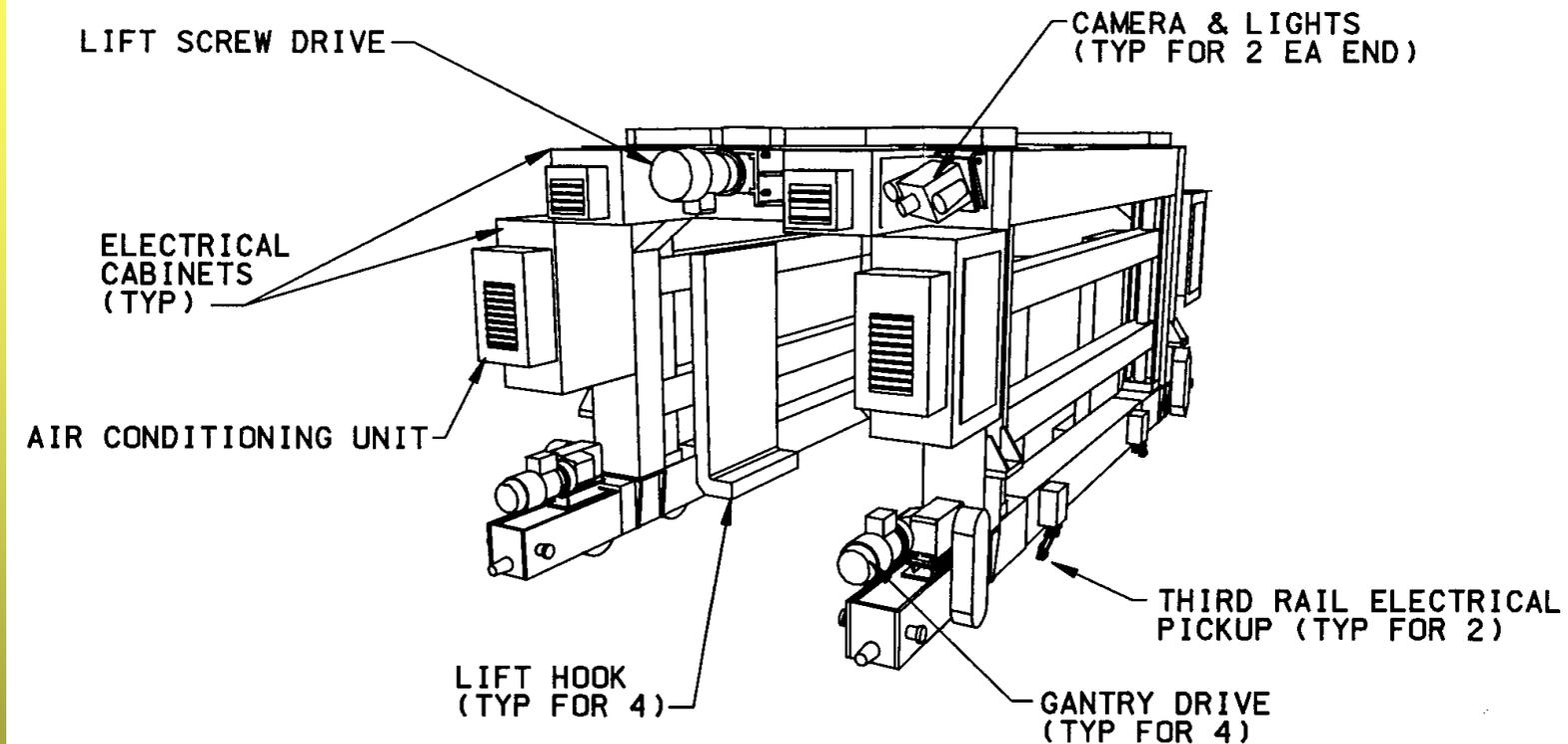
# Retrieval of HLW

*Requires innovation and  
equipment development  
for a very difficult  
underground  
environment...*

# Emplacement Drift Retrieval Environment

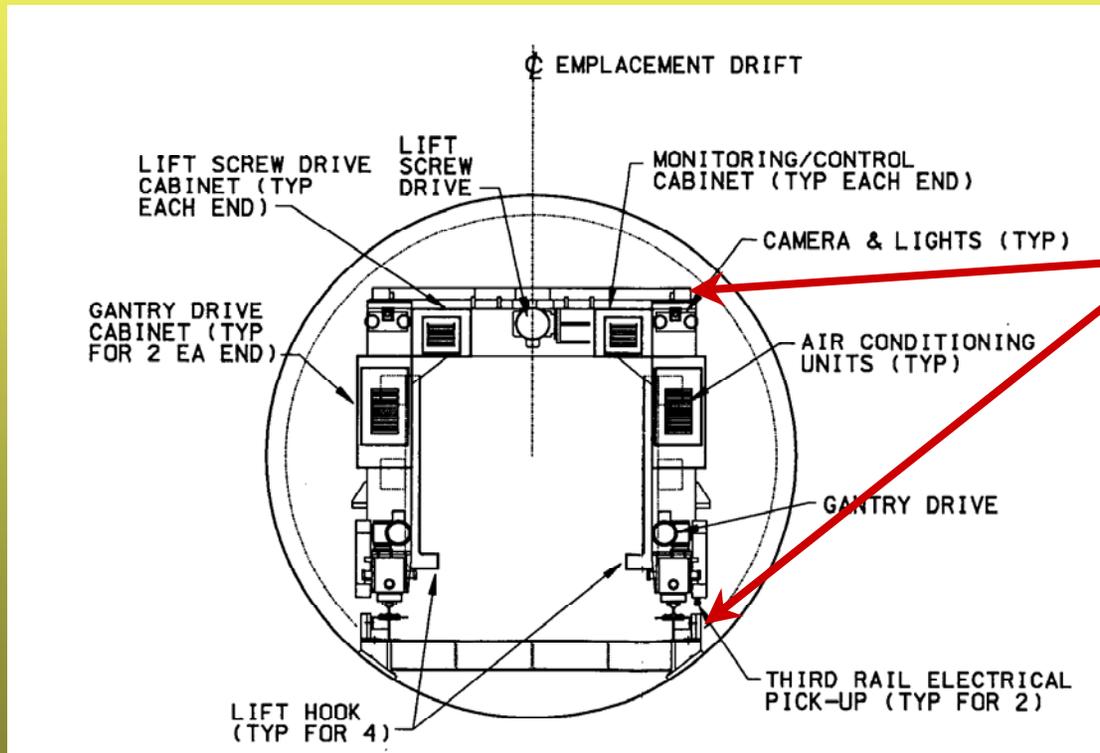
- Waiting from zero to as much as 300 years after emplacement
- 50°C (122°F) temperature environment
- Radioactive environment
- Ventilated at overall 15m<sup>3</sup>/second airflow which carries dust
- Likely very dusty environment
- Likely corroded steel or copper electric third rail
- Likely corroded mild steel railroad rails

# Waste Package and Pallet Emplacement and Retrieval Gantry



- Remotely controlled
- Operates in a radioactive environment
- Operates in a 60°C (122°F) temperature
- Self-propelled by 750-V DC electric motor drives on steel rails

# Waste Package and Pallet Emplacement Gantry in Emplacement Drift with Cross-Section and Clearance Envelope



**Note tight clearances of just inches**

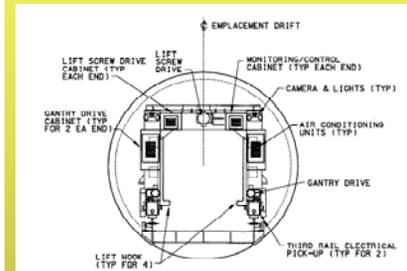
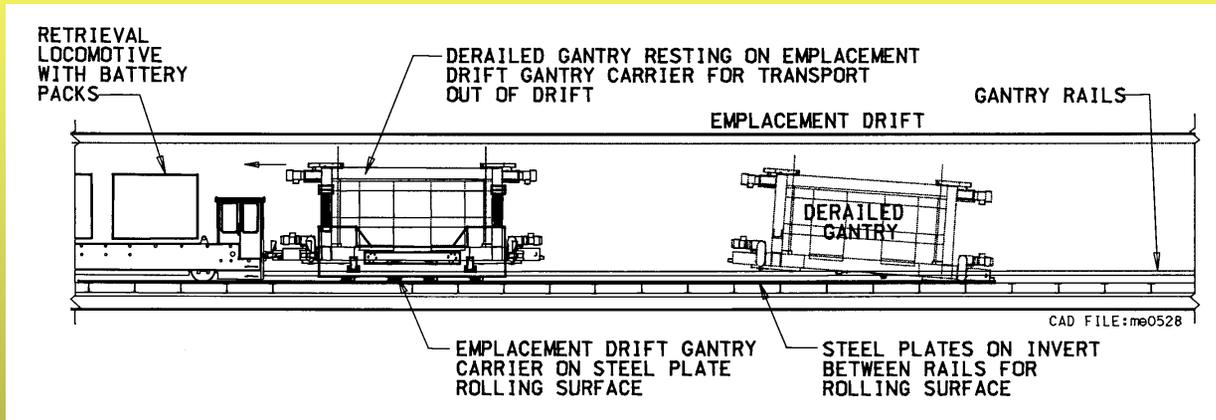
**Retrieval takes at least 23 distinct steps from drift inspection to equipment movement to remotely controlled operations to transport out of the drift to the surface.**

# **The Project has Identified Abnormal Retrieval Scenarios:**

- Derailment of an emplacement gantry in an emplacement drift.
- Rockfall or emplacement drift ground failure.

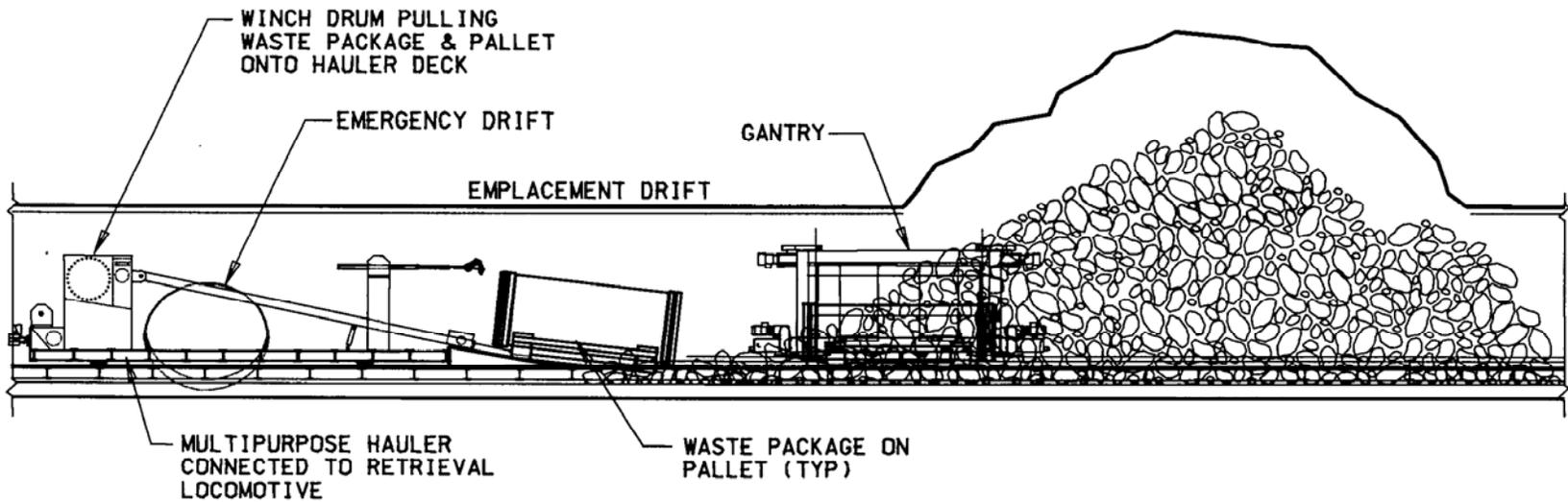
## **Remember, such scenarios have to be dealt with and successfully accomplished in an environment of:**

- From zero to as much as 300 years after emplacement
- 50°C (122°F) or higher temperature environment
- Radioactive environment
- Ventilated at overall 15m<sup>3</sup>/second airflow which will carry dust
- Tight clearances
- Very dusty environment
- Likely corroded steel or copper electric third rail
- Likely corroded mild steel railroad rails



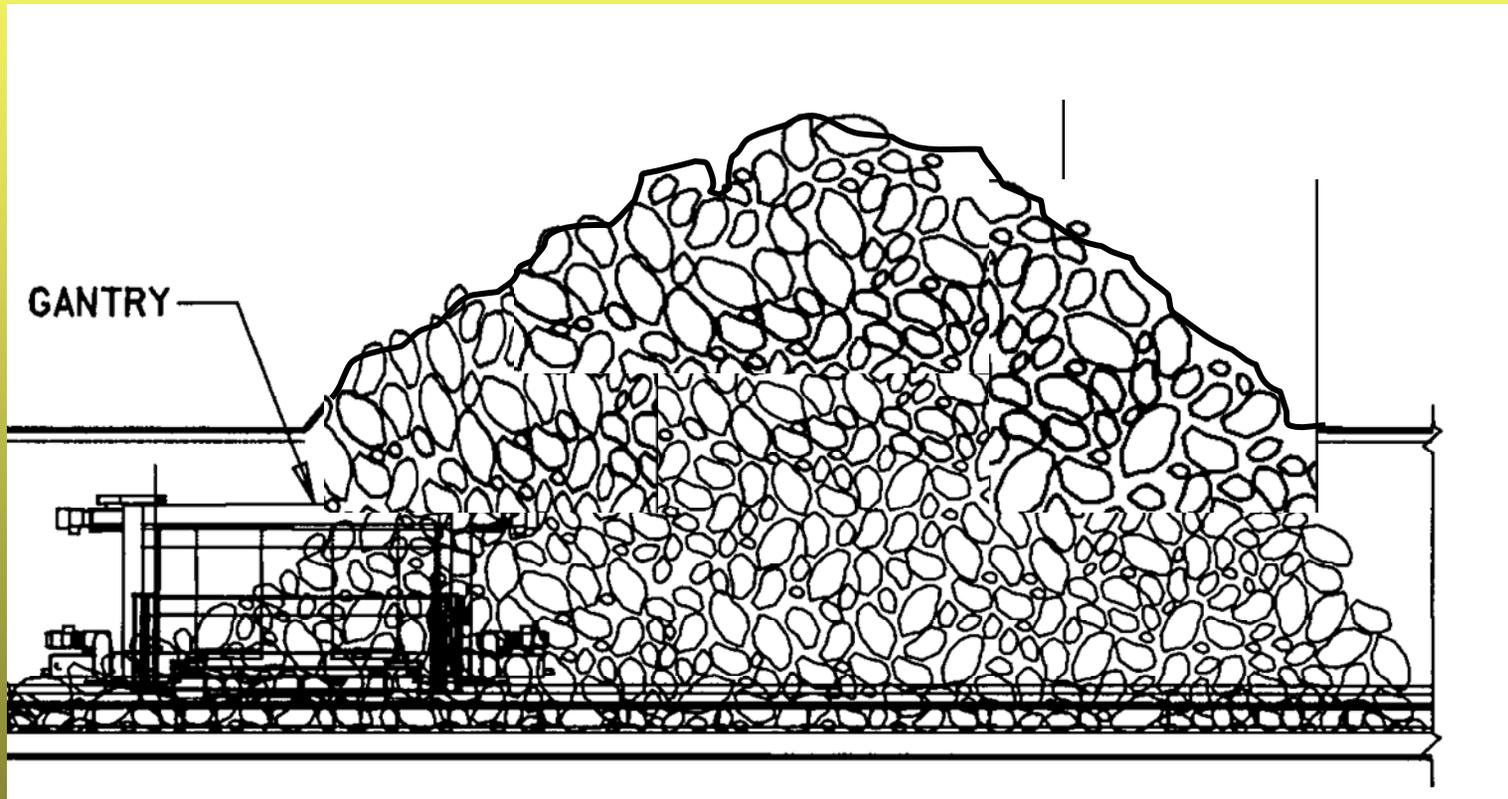
If emplacement gantry derails, it will damage and dig-into side walls of drift, severely complicating recovery

# Large Ground Collapse in Emplacement Drift with Ventilation Airflow Unaffected



Usually-depicted major ground failure situation in tuff

# Large Ground Collapse in Emplacement Drift with Ventilation Airflow Blocked

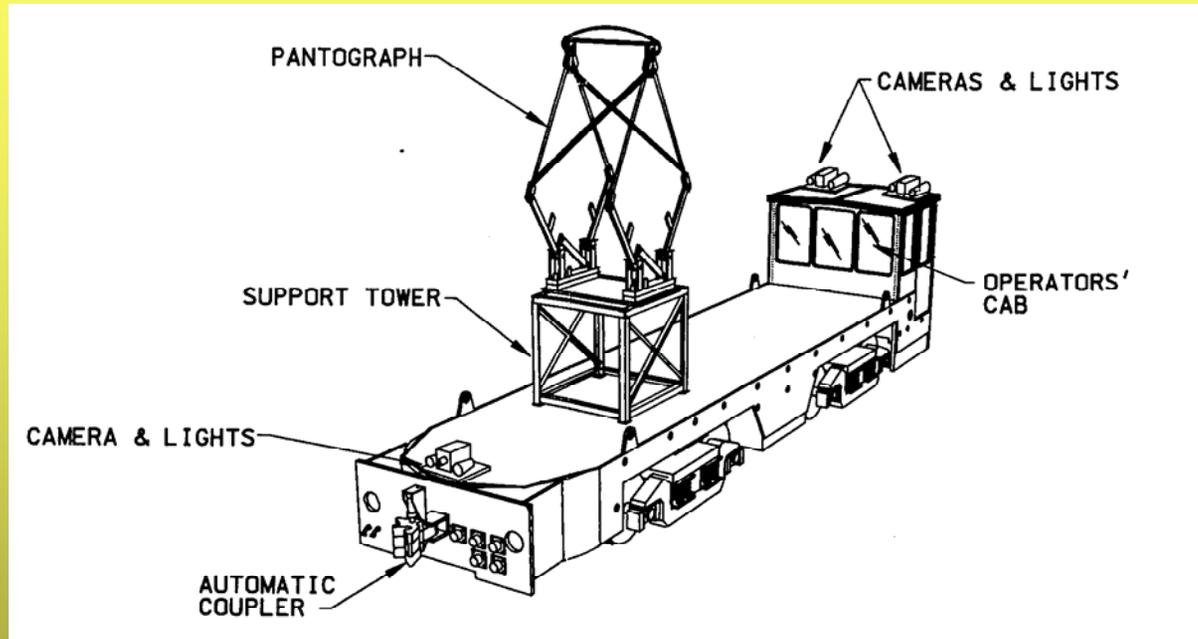


**Most likely major ground failure situation in tuff**

# **Large Ground Collapse in Emplacement Drift with Ventilation Airflow Blocked**

- Buried waste packages
- Blocked airflow
- Heat not dissipating
- Dangerous radioactive environment
- Rising temperatures
- Tunneling in from adjacent drift or raise boring up from ventilation level will be slow and difficult

# Common Problems

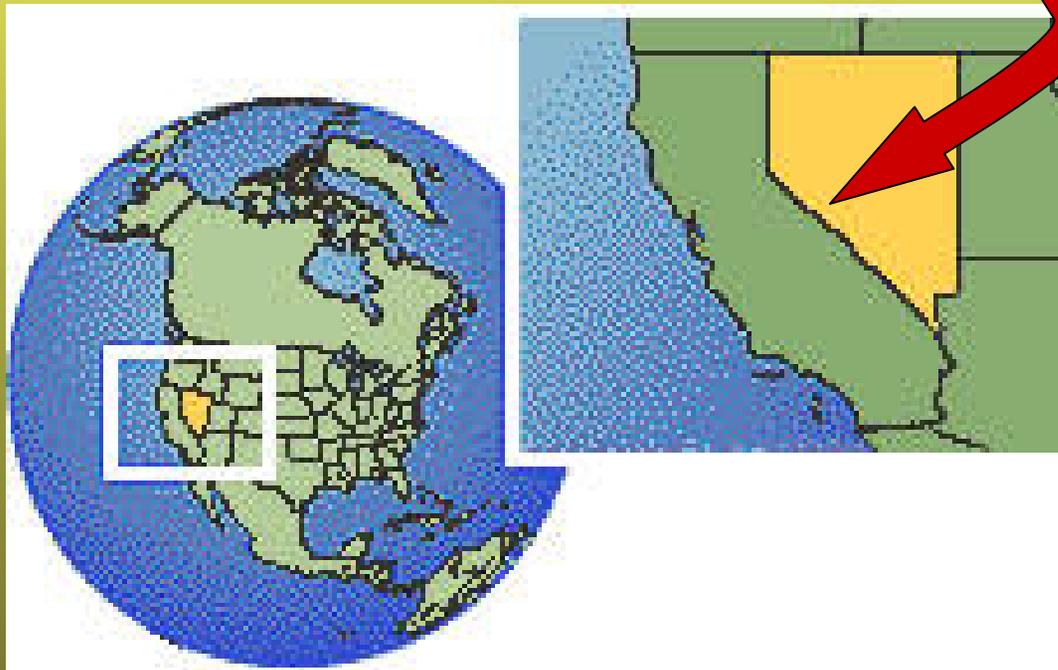


## Repository Locomotive

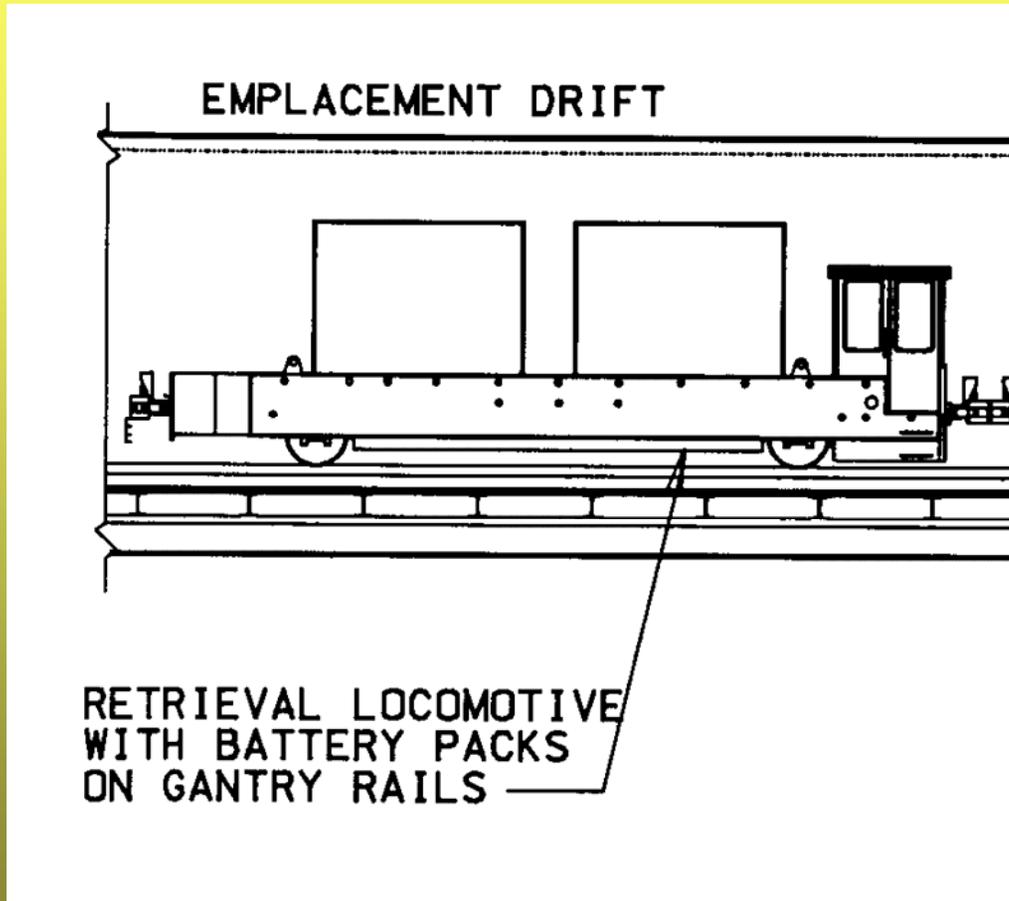
- 50-ton class electric no longer manufactured except in Sweden by special order
- No non-coal rail-haulage mines remaining in United States to our knowledge
- All operators switching to continuous belt haulage or trackless haulage

# Mining Locomotives

Yucca Mountain Project is quite likely the last remaining United States market for large electric mining locomotives



# Common Problems



- 750-V wet cell batteries do not exist
- Above ~300-V cell-to-cell arcing and creep occur
- 750-V locomotive will operate at 300-V but slower with less power
- Wet cell battery discharge increases rapidly above 60°C (140°F) due to  $\text{Pb} \rightarrow \text{PbO}_2$  reaction in acid

# **Drip Shield Issues**

- 1. Titanium supply**
- 2. Achieving drip shield interlock**

# **Retrieval Issues**

- 1. Retrieval under realistic expected environment**
- 2. Manipulating derailed gantries in tight clearances**
- 3. Recovering waste packages from ground failures in tight clearances**
- 4. Clearing ground failures remotely**
- 5. Blocked ventilation causing heat rise before recovery and retrieval**

# **Common Issues**

- 1. Availability of repository locomotives**
- 2. Availability and performance of locomotive and other batteries in the anticipated environment**
- 3. Steel rail corrosion**
- 4. Third rail corrosion**
- 5. Remote controlled optics and equipment operation in dusty environment**

# Issues

If these operations are integral to safety and licensing, there must be an up-front and credible plan and design (using currently available technologies) for how they are to be accomplished; and we do not see such plans and designs in the Project documents.