SAND 2010-XXXX
MAR Determination Using Composite Package Methodology

Lessons Learned from the Nuclear Material Storage Facility on how a bounding Material at Risk can be determined for processes that involve a wide array of radiological packages that can be moved and stored in many different combinations

Composite Package Methodology

- Groups package types into similar groupings and determining the MAR for each grouping.
-
  - The worst case grouping is used as the basis for the bounding consequence analysis.
  - Allows multiple permutations of packages to be moved simultaneously without putting in place overly restrictive operational controls which provided for maximum operational flexibility.

Nuclear Material Storage Facility

- Hazard Category 2
  - Now deactivated
- Multiple storage cells which contained a broad array of containers with sensitive radiological legacy material.
- Activity scope included storage, movement between storage cells, and finally removal of these packages from the facility.

Nuclear Material Storage Facility

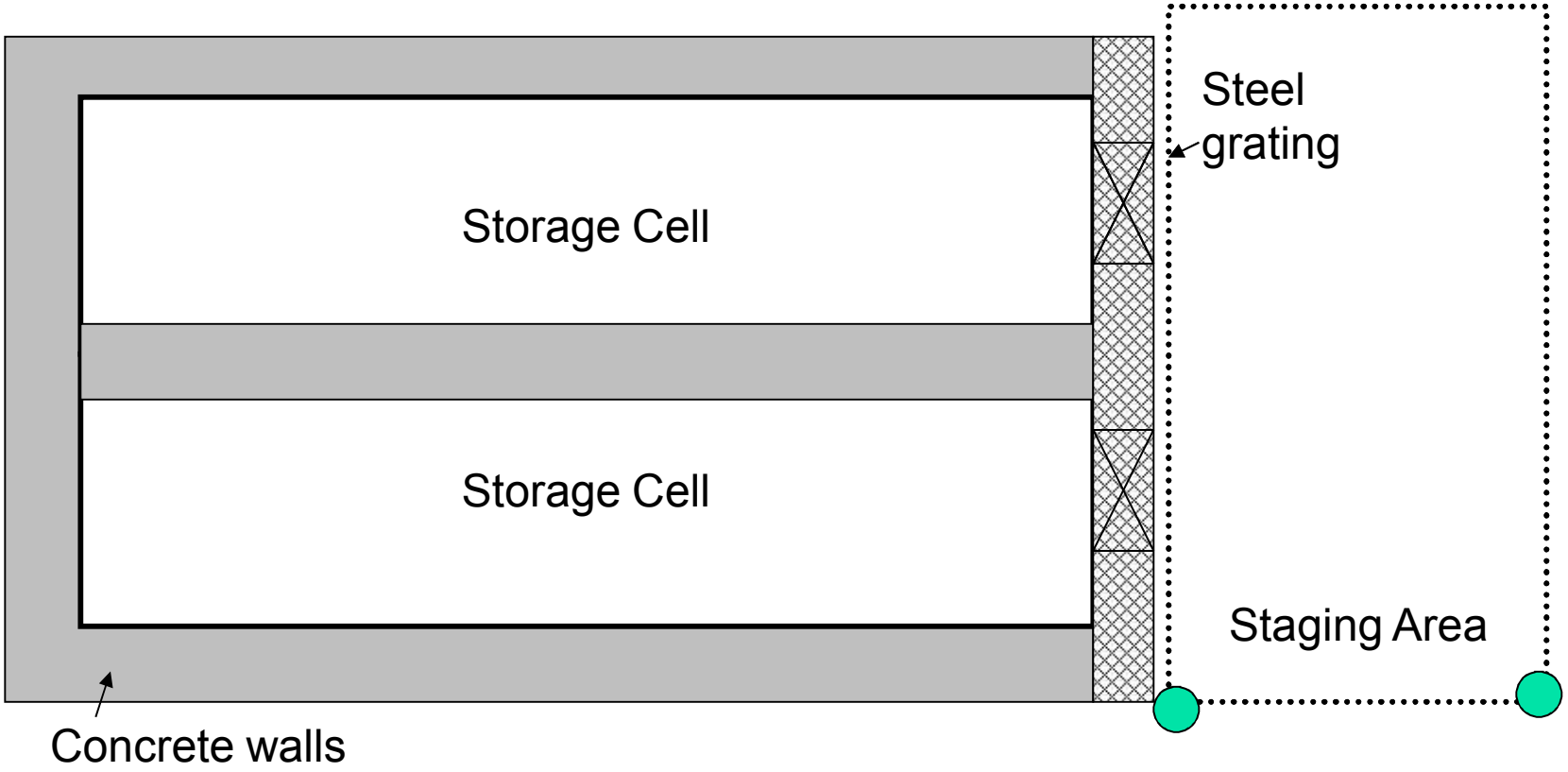
- Multiple storage cells which stored a broad array of containers with sensitive radiological legacy material.

- Process scope included storage, movement between storage cells, and finally removal of these containers from the facility.

Nuclear Material Storage Facility

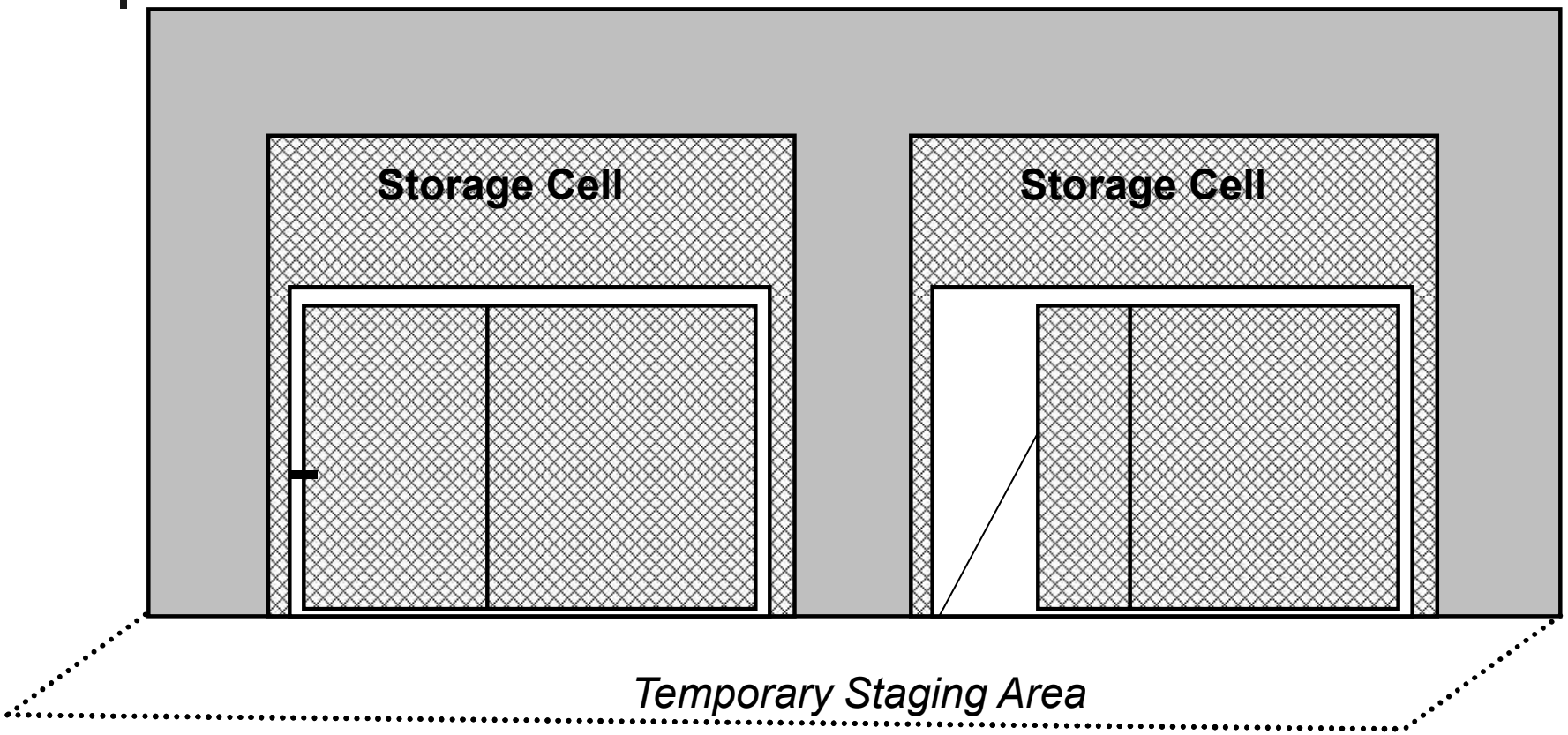
- The analysis considered potential accidents in the following zones:
  - Within one of a set of identical storage cells,
  - Within a transit area between these storage cells, and
  - On a loading dock and in the transportation vehicle.

NMSF Storage Cells



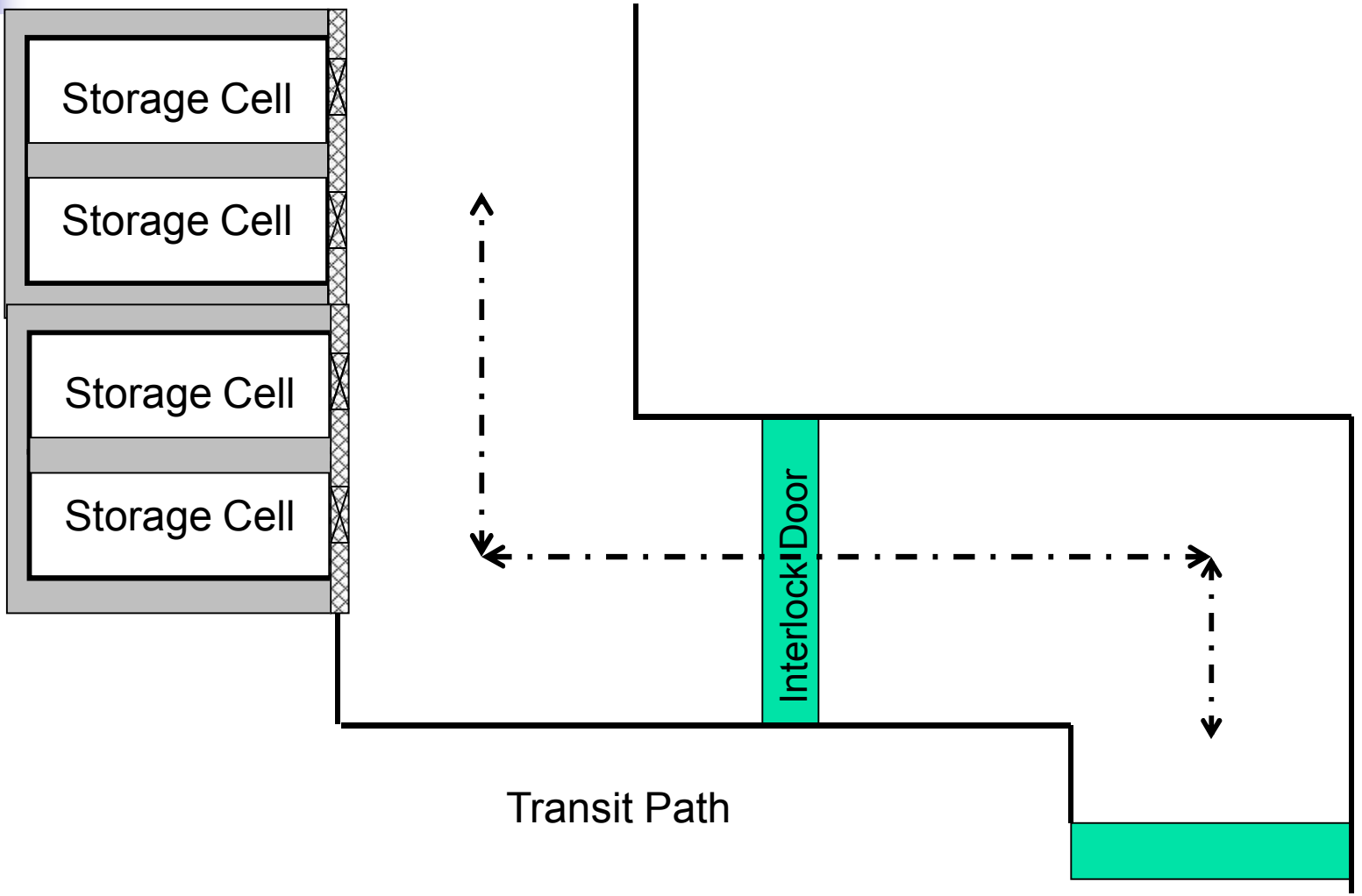
Typical Storage Cells

NMSF Storage Cells

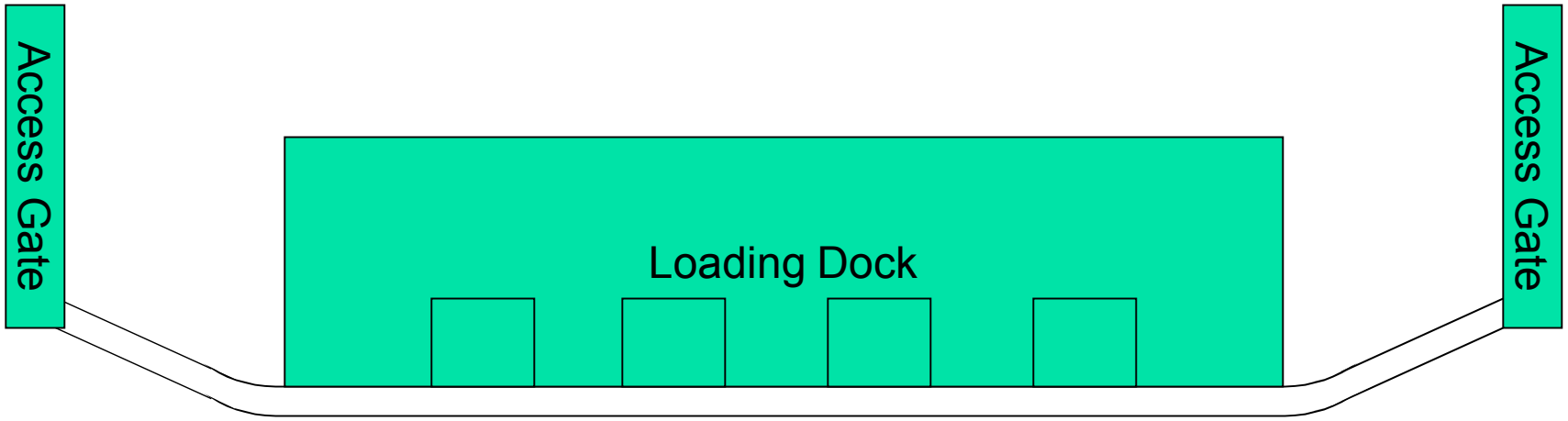


Front View Typical Storage Cells

NMSF Transit Area



NMSF Loading Dock



Determining Material at Risk (MAR)

- NMSF stored approximately 40 containers
  - No significant quantities of hazardous chemicals
  - No explosives
  - No criticality potential within any individual container.

Record Reviews

- In order to characterize the material type, quantity, and form in each containers, up to four decades of inventory records were reviewed.
  - For the majority of containers, the material contents were well defined and documented.
  - However, there were several issues relating to material content that had to be resolved.

Inventory Discrepancies

- Conflicts were identified within the inventory records
- For older packages, material inventory did not always include items that were less than a certain quantity of material. For large number of these items, the material inventory discrepancy within a container could be a significant.
  - Any discrepancy had to be researched and resolved.
  - In cases where this could not be resolved, the worst case value was taken.

Historic Mischaracterizations

- Some identified material did not match the contents of the containers.
  - i.e. if we looked at the material content of the item that was listed, it may not have matched the material listed.
  - For example, several items were listed as a metal when the analysis team recognized that they should be in oxide form.
  - In at least one case, an item was listed as a metal that should have been a sintered powder.

Incomplete Characterization Records

- Multiple containers existed with material from inhalation experiments that were not fully characterized as to particle size.
  - The analysts had to research the experimental process used several decades ago to determine what stage of the test the material was derived from.
  - Analysts were able to contact some of the original scientists that packaged the material at the time and access their notes from the packaging era.

Other Challenges

- There were concerns that the content of one of the packages contained a much more hazardous component than shown by the record.
  - A PISA was declared and a DoD representative was brought in who confirmed that the original assumptions on material content were correct.
- Some of the exact values of the material content were classified and a bounding value had to be used.

Other Challenges

- Packages could not be opened so no confirmation could be performed
  - DOT required inspections could not be performed to keep containers in certification.

Explosive Potential

- There were no explosives identified in the container inventory.
- The potential for explosion due to radiolytic hydrogen generation inside the package was deemed incredible based on a container by container examination of contents based on the following facts.
  - Liquid radioactive waste material can generate hydrogen gases due to the radiolysis process of the liquid waste and metallic corrosion of the containers. There was no liquid radioactive waste material in the containers.
  - Alpha emitting radioisotopes were contained in double or triple metallic encapsulation or were otherwise separated from packing material which prevents any radiolysis of packaging material.

Explosive Potential

- After the DSA was approved, there was a concern that a dent in one of the drums was in fact a bulge calling into question the possibility that the conclusions reached relating to hydrogen generation potential.
  - Through the new information process, it was confirmed that the drum in question was dented and not bulging.

Final Set of Composite Packages

- The containers were grouped into eight sets:
  1. Reactor fuel elements stored in criticality safe containers,
  2. Radiological metallurgical samples encased in epoxy and are stored in a drum from reactor safety experiments performed for the Nuclear Regulatory Commission (NRC),
  3. A set of sensitive radiological components in formerly qualified Type B container,

Final Set of Composite Packages

- The containers were grouped into eight sets:
  4. Fission foils stored in steel drums,
  5. Sealed source stored in a pressure cooker type container,
  6. Oxide material from reactor safety experiments for NRC melted in a crucible coated with epoxy and stored in a steel drum.

Final Set of Composite Packages

- The containers were grouped into eight sets:
  7. Encased granular material from inhalation research experiments in a sealed container stored in a formerly qualified DOT Type B container.
  5. Encased granular material of a different type from inhalation research experiments in a sealed container stored in a formerly qualified DOT Type B container (different from group 7 due to isotopic content).

Application of Groupings

- The makeup of the composite package consisted of the entire inventory of the worst case package type.
  - One of the above groupings constituted about 95% of the total material inventory.
  - This was used as the composite package for most of the hazard scenarios.

Applicable Hazard Families

- Since there is no explosive potential, hazard scenario families of concern were
  - drops,
  - impacts,
  - spills, and
  - fires.

Application of Methodology – Drops and Spills

- For drops and spills, it was demonstrated that the consequences of an accident were acceptable with only minimal controls.

Application of Methodology - Fires

- For fires, the facility was divided into three zones:
  - In storage cells,
  - in transit, and
  - on the loading dock.

Application of Methodology - Fires

- Because of the level of flammable/combustible loading in the storage cell and along the transit route, it was demonstrated that using this highly conservative approach resulted in acceptable consequences with a small number of controls.

- For the loading dock fire (our most significant fire), controls had to be established based on groupings of packages, with the worst cast package requiring consideration for additional controls.

Demonstrated Strengths

- The strengths of utilizing a composite analysis are obtaining creditable results with the following benefits:
  - Time savings,
  - Defensibility of analysis, and
  - Provides maximum operational flexibility.

Demonstrated Strengths

- At NMSF this was demonstrated by the following :
  - Using the composite package methodology let us simplify the analysis process such that a Hazard Category 2 DSA was written and approved in approximately 6 months.
  - This methodology allowed multiple packages to be moved together and the operational personnel could select the combination of packages that could be moved together

Demonstrated Weaknesses

- Limitations of using this methodology include:
  - This methodology cannot be used without a strong understanding of package material content including potential for explosion, and
  - Results may be too conservative for some hazard scenario.

Demonstrated Weaknesses

- For NMSF
  - The methodology relies on having a strong and defensible understanding of container content. As was shown previously in this paper, substantial effort and challenges were presented to the accuracy of the material content. Without a strong base, these challenges could not be defended.
  - Results are very conservative which may not be desirable for a specific situation. For NMSF the worst case composite package constituted approximately 95% of the total inventory.