U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: WASTE PACKAGE AND
ENGINEERED BARRIER
SYSTEM ALTERNATIVE
DESIGN APPROACH

PRESENTER: DR. LESLIE JARDINE

PRESENTER'S TITLE
AND ORGANIZATION: TECHNICAL PROJECT OFFICER
                      LAWRENCE LIVERMORE NATIONAL LABORATORY
                      LIVERMORE, CALIFORNIA

PRESENTER'S
TELEPHONE NUMBER: (415) 423-5032

AUGUST 28-29, 1990
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OUTLINE

APPROACH FOR ESTABLISHING ALTERNATIVE WASTE PACKAGE AND EBS DESIGNS

- SYSTEMS ENGINEERING BASED METHODOLOGY
- ILLUSTRATIVE (ONLY) EXAMPLES OF METHODOLOGY
- SUMMARY
A CLASSIC SYSTEMS ENGINEERING APPROACH WILL BE USED

DEFINE WP DESIGN REQUIREMENTS

DEVELOP DESIGN OPTIONS

EVALUATE OPTIONS

SELECT PREFERRED DESIGN

DEVELOP & ENGINEER THE SELECTED DESIGN

VERIFY DESIGN REQUIREMENTS ARE SATISFIED

ACQUIRE LICENSE

10/92 6/96 10/01
FLOW DIAGRAM OF WASTE PACKAGE PROGRAM

<table>
<thead>
<tr>
<th>Pre-ACD</th>
<th>ACD</th>
<th>LAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Define waste package requirements</td>
<td>4. Develop design concepts</td>
<td>8. Conduct engineering evaluations</td>
</tr>
<tr>
<td>10. Issue updated environmental characteristics</td>
<td>11. Issue updated waste form characteristics</td>
<td>19. Input to license application</td>
</tr>
<tr>
<td>2. Prepare preliminary environmental characteristics</td>
<td>17. Continue long-term material testing</td>
<td>20. Verify waste Package requirements satisfied</td>
</tr>
<tr>
<td>3. Prepare preliminary waste form characteristics</td>
<td>18. Publish final WPDR</td>
<td></td>
</tr>
</tbody>
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THE SYSTEMS ENGINEERING PROCESS

A INPUT REQUIREMENTS
- MISSION OBJECTIVES
- MISSION ENVIRONMENTS
- MISSION CONSTRAINTS
- MEASURE OF EFFECTIVENESS

B TECHNOLOGY SELECTION FACTORS
- HARDWARE
- SOFTWARE
- RELIABILITY
- MAINTAINABILITY
- PERSONNEL/HUMAN FACTORS
- SURVIVABILITY
- SECURITY
- SAFETY
- STANDARDIZATION
- INTEGRATED LOGISTIC SUPPORT
- EMC
- SYSTEM MASS PROPERTIES
- PRODUCIBILITY
- TRANSPORTABILITY
- ELECTRONIC WARFARE
- COMPUTER RESOURCES

FUNCTIONAL ANALYSIS

SYNTHESIS

WILL ALTERNATIVES WORK?

EVALUATION AND DECISION (TRADE-OFF)

ACCEPTABLE SOLUTION?

DESCRIPTION OF SYSTEM ELEMENTS
- EQUIPMENT
- PERSONNEL
- FACILITIES
- COMPUTER SOFTWARE
- TECHNICAL DATA

REFERENCE:
1. SYSTEMS ENGINEERING FIELD MANUAL FM-770-78 (APRIL 1979)
2. DEFENSE SYSTEMS MANAGEMENT COLLEGE SYSTEMS ENGINEERING MANAGEMENT GUIDE SECOND EDITION, DECEMBER 1986
SYSTEMS ENGINEERING APPROACH:
DEFINE REQUIREMENTS OF WASTE PACKAGE

Develop input mission requirements
- mission objectives
- mission environment
- constraints
- performance measures

Define design selection factors & criteria

Requirements analysis
Perform functional analysis
Conduct synthesis
Identify trade studies

Are any designs feasible?
Yes
Document feasible designs
Select and rank preferred design solutions
Write specific design requirements (WPDR)

No
None acceptable

Next design phase
FLOWDOWN OF WASTE PACKAGE DESIGN REQUIREMENTS

NWPA

MISSION PLAN

WMSR VOL. I

WMSR VOL. IV

SR

WASTE PACKAGE MISSION REQUIREMENTS

FUNCTIONAL ANALYSIS

SYNTHESIS

TRADE STUDIES

SELECTION FACTORS

DOCUMENT DESIGN

SELECT & RANK PREFERRED SOLUTIONS

SPECIFIC DESIGN REQUIREMENTS (WPDR)

CONCEPT #1

SPECIFIC DESIGN REQUIREMENTS (WPDR)

CONCEPT #2

SPECIFIC DESIGN REQUIREMENTS (WPDR)

CONCEPT #3
REMARKS ON REQUIREMENTS ANALYSIS (STEP C)

- REQUIREMENTS CAN BE VIEWED AS A HIERARCHY

- REQUIREMENTS CAN BE CLASSIFIED AS TWO TYPES:
  - PROGRAMMATIC/POLICY
  - TECHNICAL

- SELECTIONS OF ALTERNATIVE REQUIREMENTS MUST BE MADE TO DEVELOP DESIGNS

- DOCUMENTATION AND FLOW-DOWN TRACEABILITY IS A MUST
REQUIREMENTS HIERARCHY
UPPER TIER

WASTE PACKAGE MISSION REQUIREMENTS

REPOSITORY MISSION REQUIREMENTS

INPUT REQUIREMENTS

SERVICE ENVIRONMENT

THERMAL CONDITIONS

CONTAINMENT PERIOD

10,000 YR

300 TO 1,000 YR

10,000 YR

300 TO 1,000 YR

10,000 YR

300 TO 1,000 YR

I I I I

DRAIN

300 TO 1,000 PERIOD, Y, v, Y.

~10,000 YR

---.- POTENTIAL COMBINATIONS OF REQUIREMENTS
TYPICAL INTERFACES AND LOWER TIER DESIGNER REQUIREMENTS LEAD TO DIFFERENT ACCEPTABLE DESIGN SOLUTIONS

Borehole

Vertical

No packing

No filler

System studies
Thermal
Criticality
Radiation
Material compatibility
etc.

Surface
Remote handling
Surge storage
Shielded transfer casks
Closure method
Fabrication tolerances
Inspection techniques
etc.

Subsurface
Shielded transfer casks
Emplacement methods
Construction tolerances
Shielding closures
Retrievability
etc.

Specific designer choices:
- Number of assemblies/container
- Shape of container
- Length of container for spent fuel: single or multiple
- Internal geometry
- Wall thickness
- Diameter or width
- Etc.

Interface considerations

Others

PWR
BWR
PWR & BWR
PWR & BWR

Example 1
Example 2
Example 3

etc.
WASTE PACKAGE DESIGN CONCEPTS GENERATED BY THE PROCESS

- REFERENCE IN SCP
- SELF-SHIELDED CONCEPTS
- PACKING CONCEPTS
- OTHERS
REFERENCE CONFIGURATION FOR VERTICAL EMPLACEMENT

- COVER
- NEAR FIELD ROCK
- 10'
- PARTIAL LINER
- SHIELD PLUG
- BOREHOLE IN TUFF
- AIR GAP
- WASTE CONTAINER
- SUPPORT PLATE
POSSIBLE EMLACEMENT CONFIGURATION
FOR SELF-SHIELDED WASTE PACKAGE
DESIGN CONCEPT

PREPLACED BACKFILL

TUNNEL BACKFILL
(SAND, BENTONITE,
ADDITIVES)

EMPLACED SELF-SHIELDED
PACKAGES

NEXT EMLACEMENT
POSITION

~ 3.0 m

30 TO 60 cm

1.3 m
POSSIBLE WASTE PACKAGE HORIZONTAL BOREHOLE DESIGN CONCEPTS

- Carbon steel container
- Pre-formed packing
- Shell
- Closure plate
- Consolidated spent fuel rods
- Shield packing
- Spent fuel waste forms
- Packing
- Shell
- Consolidated spent fuel rods
- Intact spent fuel assemblies
- Filler material
- Placement room
- Horizontal borehole
- Consolidated spent fuel rods assemblies
FLOWDOWN AND TRACEABILITY FOR SOURCE OF REQUIREMENTS FOR WASTE PACKAGE DESIGN ALTERNATIVES MUST BE DONE

WASTE PACKAGE MISSION REQUIREMENTS
- RETRIEVABLE
- GEOLOGIC DISPOSAL
- UNSATURATED SITE

ADDITIONAL REQUIREMENT ALTERNATIVES
- WET OR DRY
- COLD OR HOT
- 10,000 OR 300-1,000 YR
- + ..., OR + .... OR

SPECIFIC DESIGN REQUIREMENT ALTERNATIVES
- BOREHOLE CONCEPT
- NO PACKING
- NO FILLER
- HOT, DRY, 300-1,000 YR CONTAINMENT

DESIGN SPECIFIC FEATURES
- NO BOREHOLE LINER
- HIGH NI ALLOY CONTAINER
- STEEL SHIELDING PLUG
- 3 INTACT PWR/CAN

SPECIFIC DESIGN REQUIREMENT ALTERNATIVES
- NO BOREHOLE CONCEPT
- PACKING
- FILLER
- COLD, WET, 10,000 YR CONTAINMENT

DESIGN SPECIFIC FEATURES
- SIDE TO SIDE ON DRIFT FLOOR
- CARBON STEEL
- CRUSHED/SCREENED TUFF PACKING
- 50 MREM/HR SURFACE DOSE

EMPLACEMENT DRIFT
- BACKFILL (AFTER 50 YRS?)

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DESIGN REQUIREMENTS PROCESS

A MISSION REQUIREMENTS

1
2
3
4
5
6
7
8
....

B SELECTION FACTORS

WEIGHTING

C FUNCTIONAL ANALYSIS

TRADE STUDIES SYNTHESIS

D DRAWINGS

- SPECIFICATIONS
- PERFORMANCE

E ENGINEERING

ANALYSES

F PREFERRED PATH
SELECTED FOR NEXT PHASE OF DESIGN

G DEVELOP SPECIFIC DESIGN REQUIREMENTS

H HIERARCHY

DEVELOP

I SPECIFIC

J REQUIREMENTS

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SUMMARY

• IMPLEMENTATION OF PROCESS HAS BEEN INITIATED

• MISSION REQUIREMENTS AND SELECTION FACTORS ARE NOW BEING FORMULATED

• REQUIREMENTS ANALYSIS IS TO BE INITIATED

• SPECIAL ATTENTION WILL BE GIVEN TO DEVELOPMENT OF DOCUMENTATION FOR PROCESS TO ENSURE TRACEABILITY

• METHODOLOGY FOR SELECTION AND RANKING OF ACCEPTABLE DESIGN SOLUTIONS WILL BE DEVELOPED

• SPECIFIC DESIGN REQUIREMENTS WILL BE DEVELOPED FOR A FEW (2-4) PREFERRED DESIGNS. THOSE SELECTED WILL BE DEVELOPED FURTHER IN THE NEXT PHASE OF DESIGN (ACD)