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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: WASTE CONTAINER THERMAL ANALYSES

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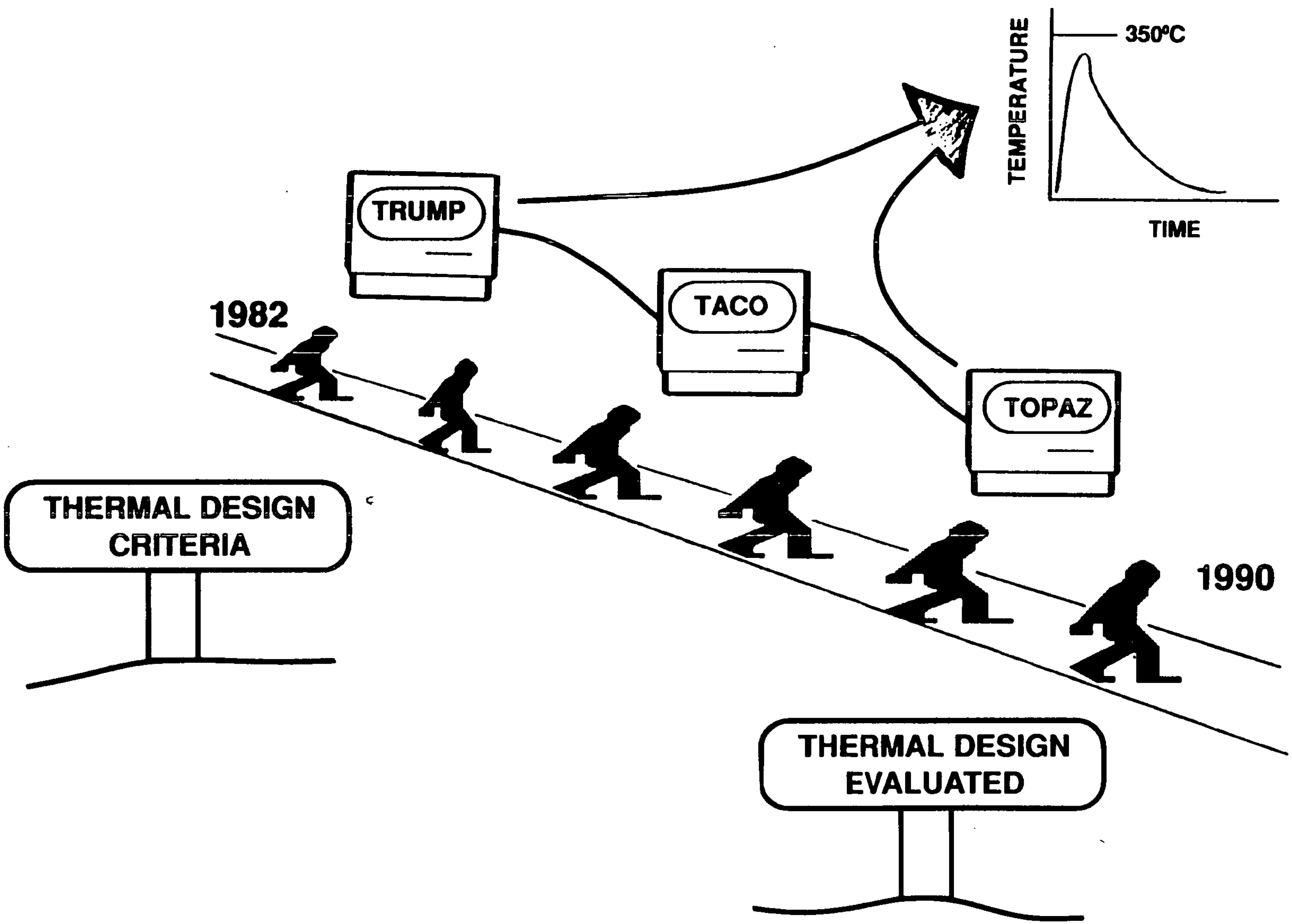
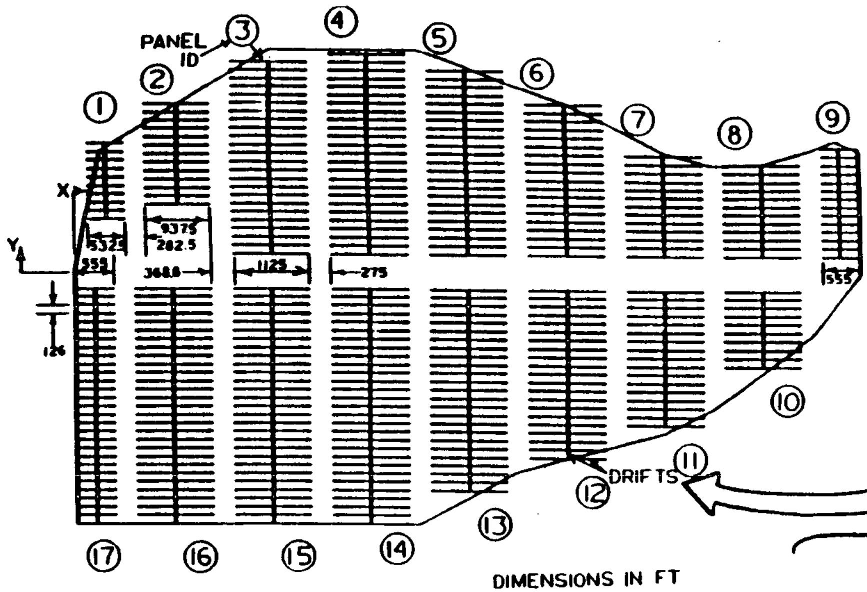
OBJECTIVE

USE EXISTING THERMAL MODELING TOOLS AND TECHNIQUES TO EVALUATE THE THERMAL PERFORMANCE OF VARIOUS WASTE CONTAINER CONFIGURATIONS AND SPACINGS

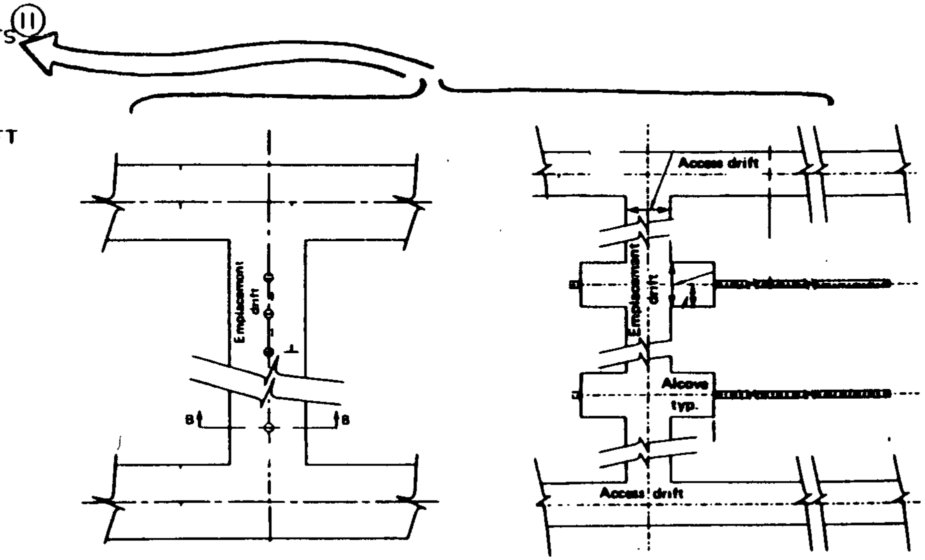
THERMAL PERFORMANCE EVALUATION OF YUCCA MOUNTAIN PROJECT CONTAINER CONFIGURATIONS HAS CONTINUED SUCCESSFULLY SINCE 1982



CONTAINERS MAY BE EMPLACED VERTICALLY OR HORIZONTALLY ALONG ANY OF 300 DRIFTS



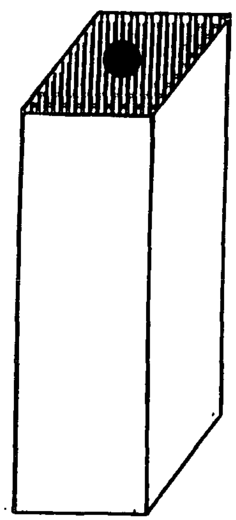
REPOSITORY DRIFT LAYOUT

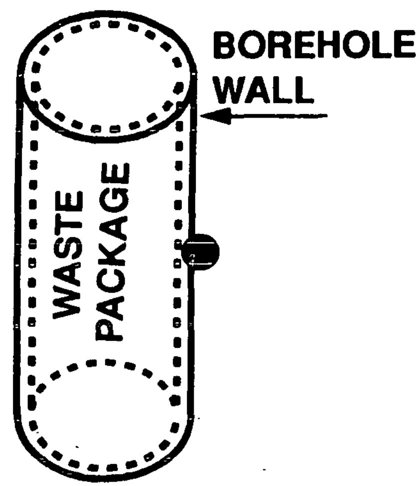


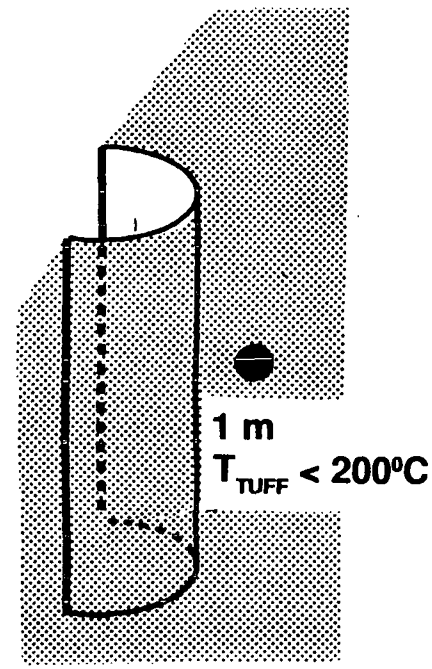
VERTICAL EMPLACEMENT

HORIZONTAL EMPLACEMENT

THE WASTE DISPOSAL CONTAINER AND ITS NEAR-FIELD ENVIRONMENT HAVE OPERATING TEMPERATURE CONSTRAINTS







● $T_{CLAD, MAX} < 350^0C$

● $T_{BHW, MIN} > 97^0C$

ADDED T INFO TO BE PASSED ON: $T_{INTERNAL\ CAN,\ O.D.}$, $T_{STRUCTURE}$, ETC.

ALTHOUGH VARIOUS THERMAL ANALYSIS TOOLS HAVE BEEN USED FOR CONTAINER ANALYSIS OVER THE PAST 7 YEARS, ALL HAVE BEEN BENCHMARKED AND VERIFIED

[TRUMP=TACO=TOPAZ] + [2-D + 3-D MODELS]

⬇

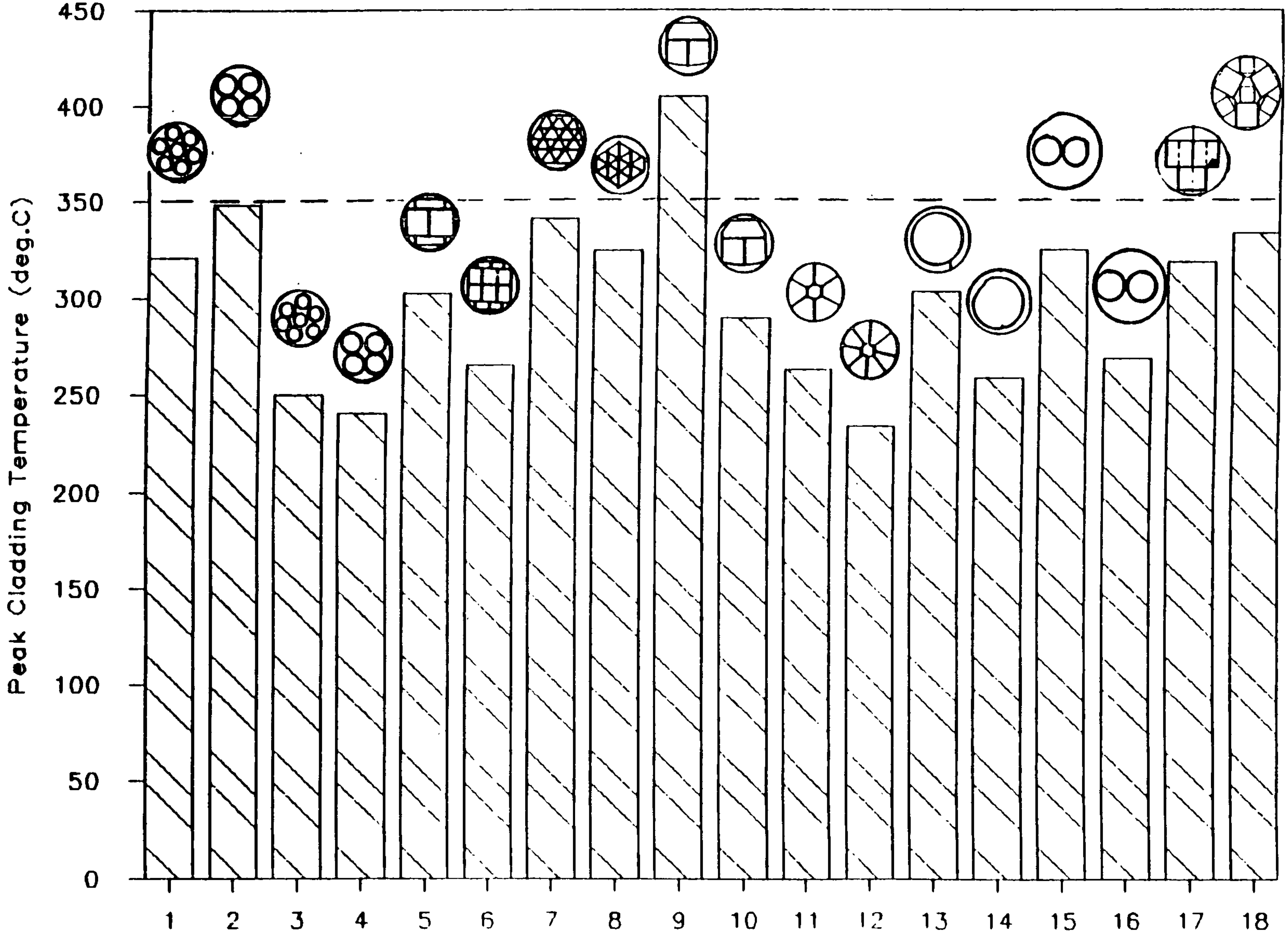
EVALUATIONS OF

- TOOLS AND MODELING TECHNIQUES
- MRS COMMON CANISTER CONFIGURATIONS
- PRELIMINARY CONFIGURATIONS FOR SCP-CDR CONTAINER DESIGN
- ALTERNATE CONFIGURATIONS (e.g., PWR/BWR HYBRID)

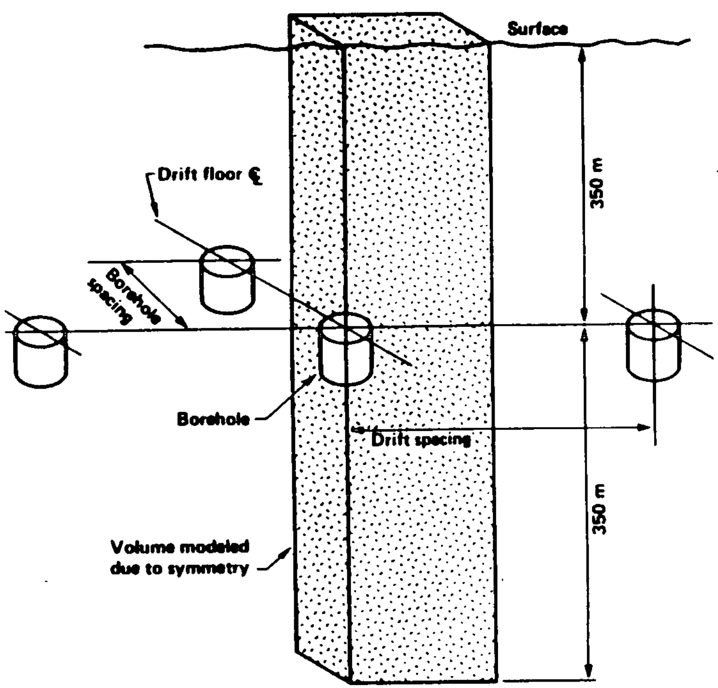
OTHER

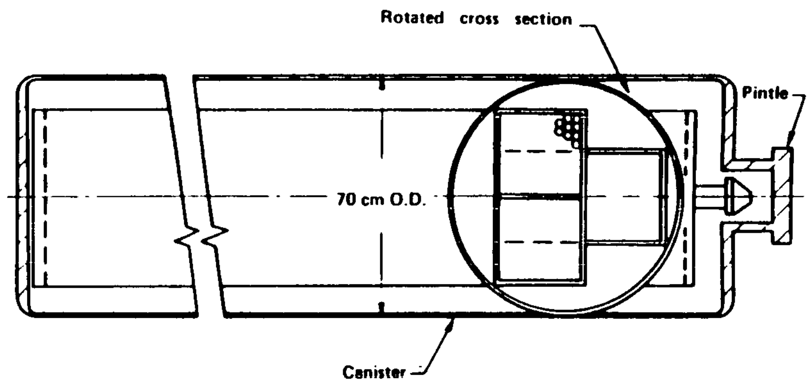
- MODEL PARAMETER VARIATIONS

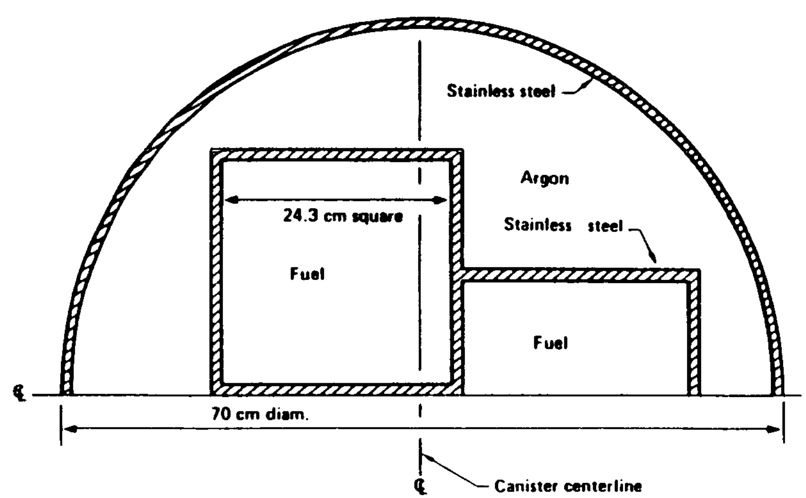
$T_{MAX,\ CLAD}$ HAS BEEN DETERMINED FOR A VARIETY OF CONTAINER DESIGNS, LOADS, AND INTERNAL LAYOUTS



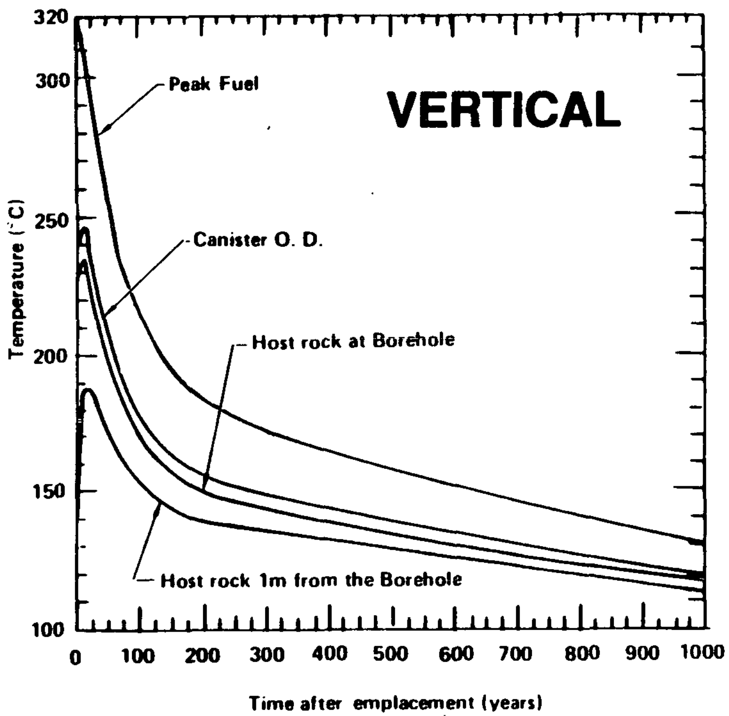
ONE EARLY PWR CONTAINER CONFIGURATION WAS USED FOR SEVERAL THERMAL MODEL STUDIES



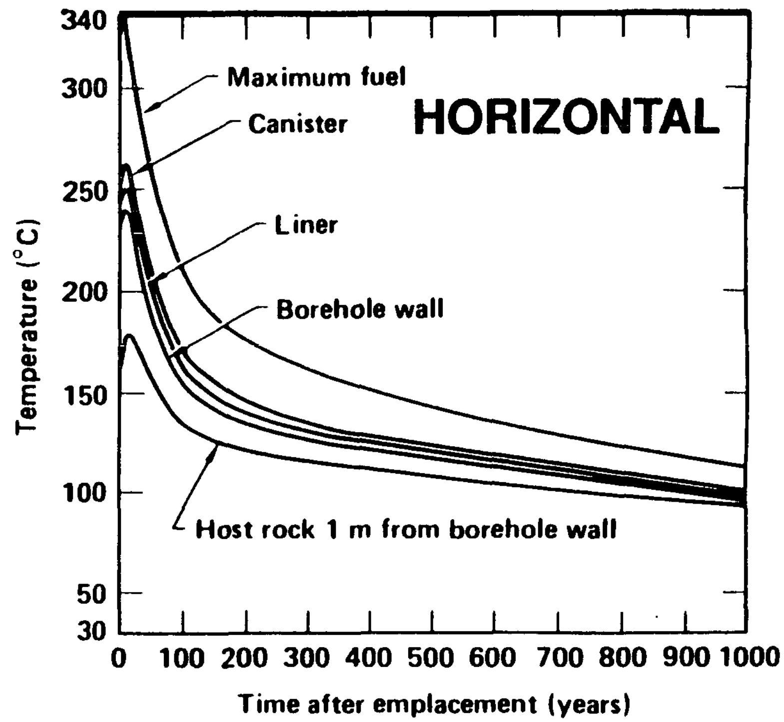




COMPARISON BETWEEN VERTICAL AND HORIZONTAL EMPLACEMENT SHOWED SIGNIFICANTLY DIFFERENT RESPONSE



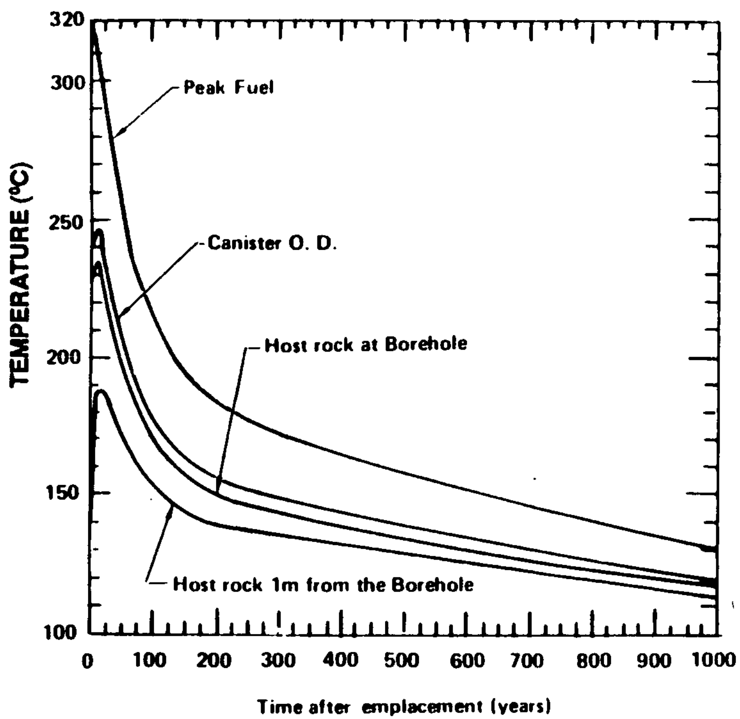
WF	PWR.SF
LPD	57.0
APD	48.4
10yr PWR-AVE	3.3KW
C_{Diam}	0.7m
P_{PKG}	5m
P_{DRIFT}	46.86m
Directory No.	P57V3.3A



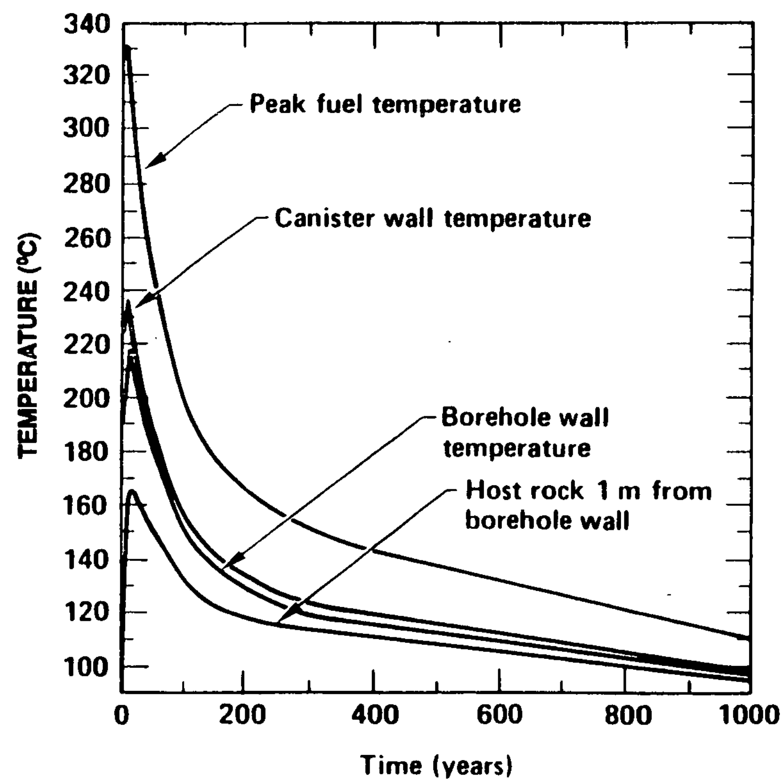
WF	PWRSF
LPD	50 kW/acre
APD	40.6 kW/acre
10 yr pwr – Ave	3.05 kW
10 yr pwr – Peak	3.3 kW
C_{diam}	0.68 m
P_{pkg}	4.5 m
P_{bh}	52 m
Directory No.	P50H3.3A

INCLUDING THE EFFECTS OF AXIALLY-VARYING HEAT OUTPUT AND ORTHOTROPIC MATERIAL PROPERTIES IN A 3-D MODEL SHOWED AN INCREASE OF 15°C IN $T_{MAX,\ CLAD}$ OVER 2-D MODEL

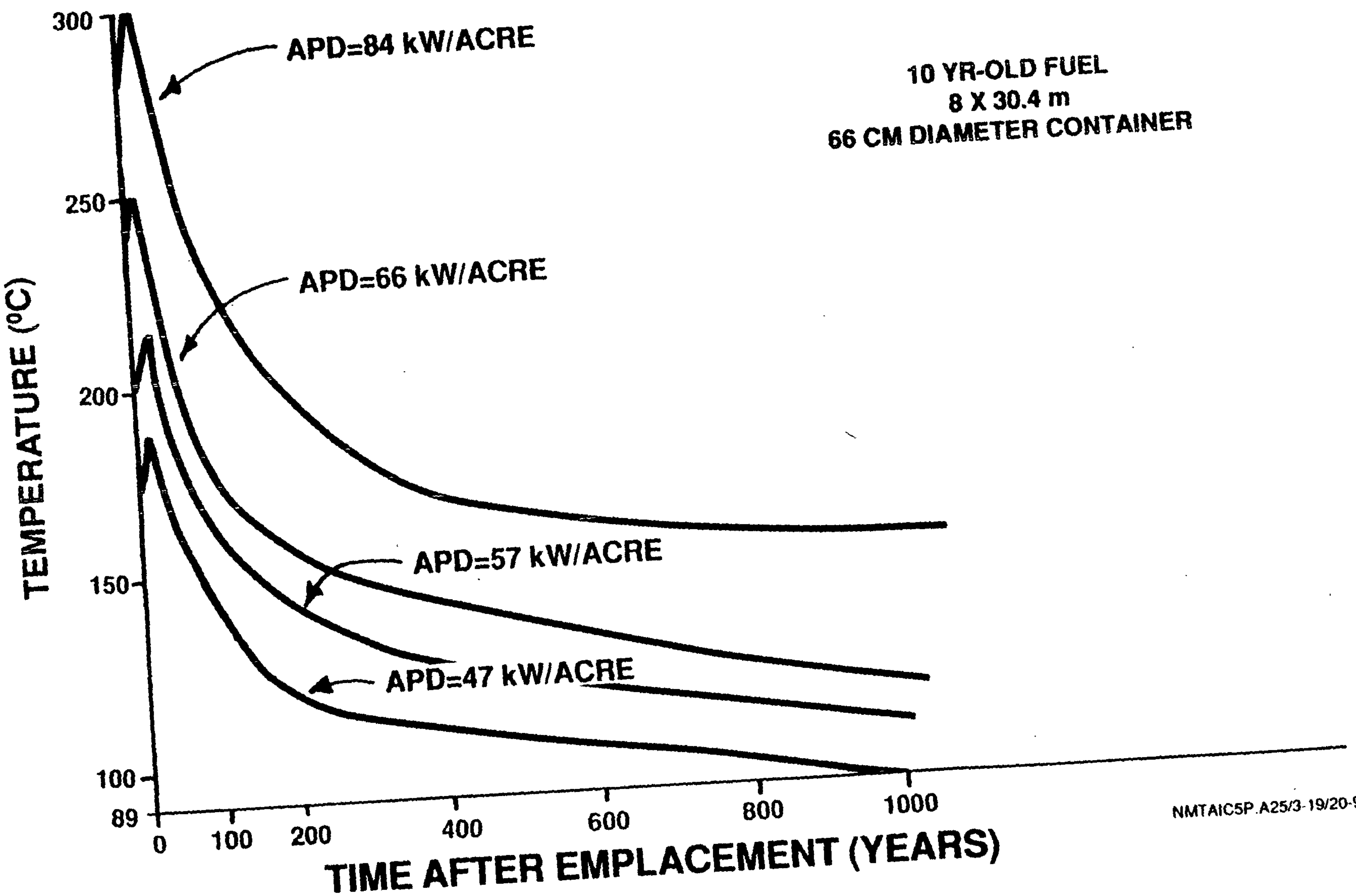
3-D ROCK/2-D CONTAINER ANALYSIS MODEL



3-D ROCK/CONTAINER MODEL WITH AXIALLY VARYING POWER OUTPUT AND ORTHOTROPIC MATERIAL PROPERTY



PARAMETERS, SUCH AS LOCAL POWER DENSITY (LPD), HAVE A VERY STRONG EFFECT ON THE CONTAINER WALL TEMPERATURE, THUS AFFECTING ITS PROPERTIES



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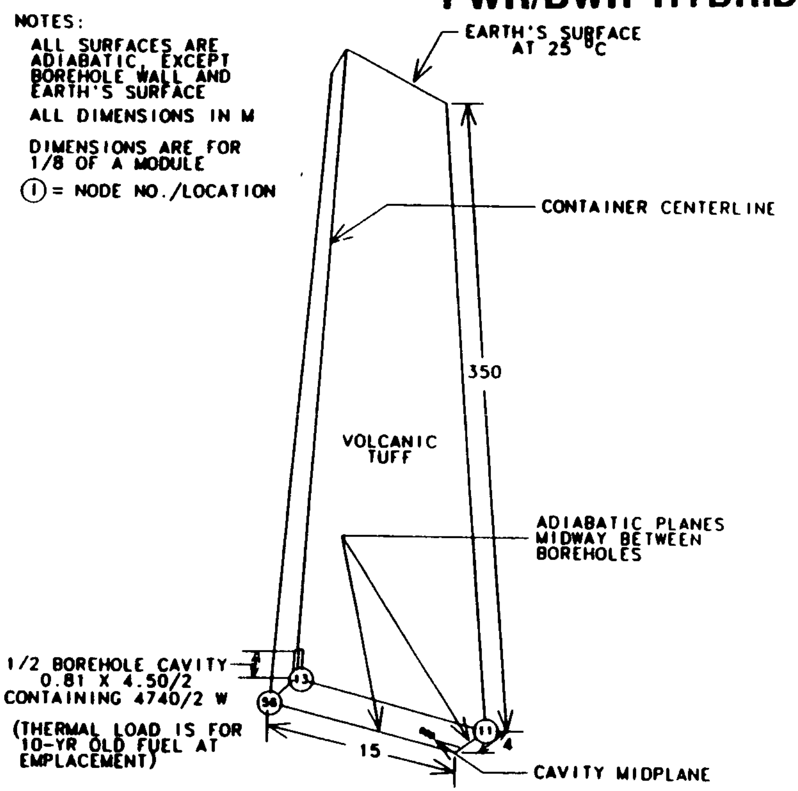
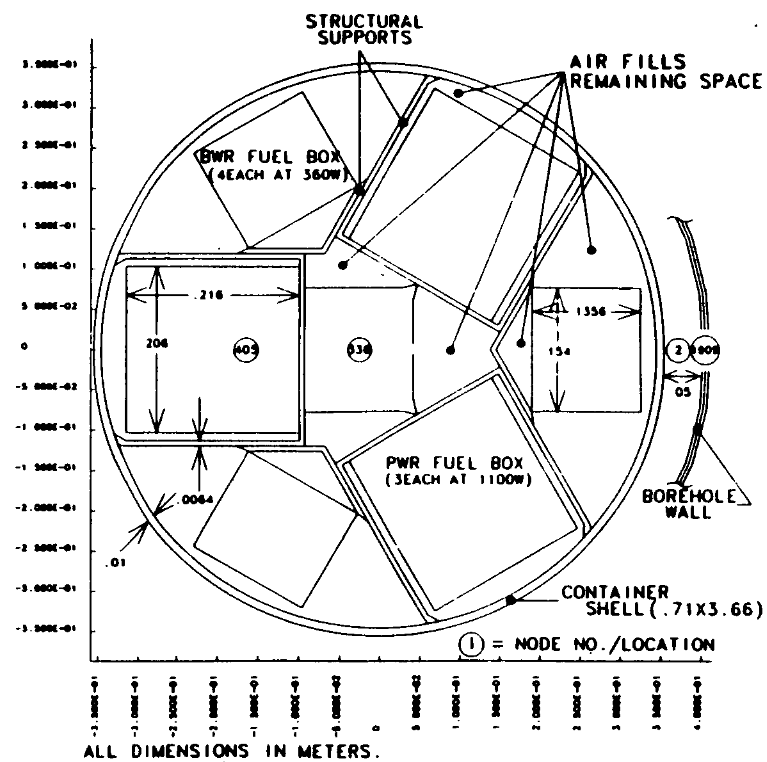
AN ALTERNATIVE DESIGN ON 8 x 30.4 m SPACINGS WAS USED FOR VARIOUS OTHER PARAMETER STUDIES

PWR/BWR HYBRID DESIGN DISPOSAL CONTAINER

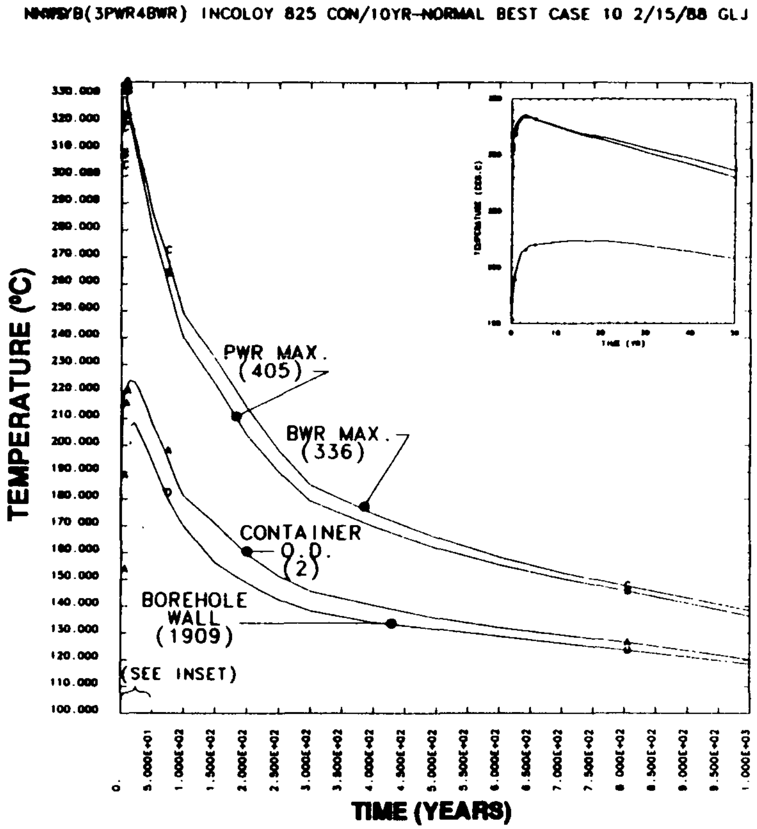


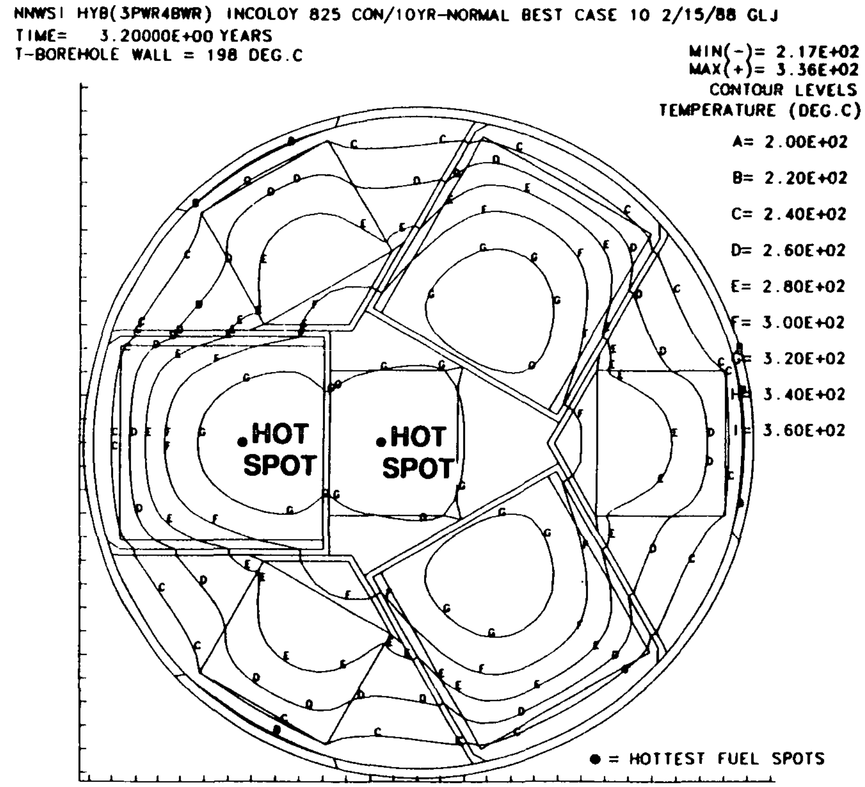


CHECKED EFFECTS OF

FUEL CONDUCTIVITY, MATERIAL EMISSIVITY, FUEL AGE, CONTAINER MATERIAL, BOREHOLE SPACING, ANNULUS PACKING, BOREHOLE GAS FILL vs. LEAD FILL

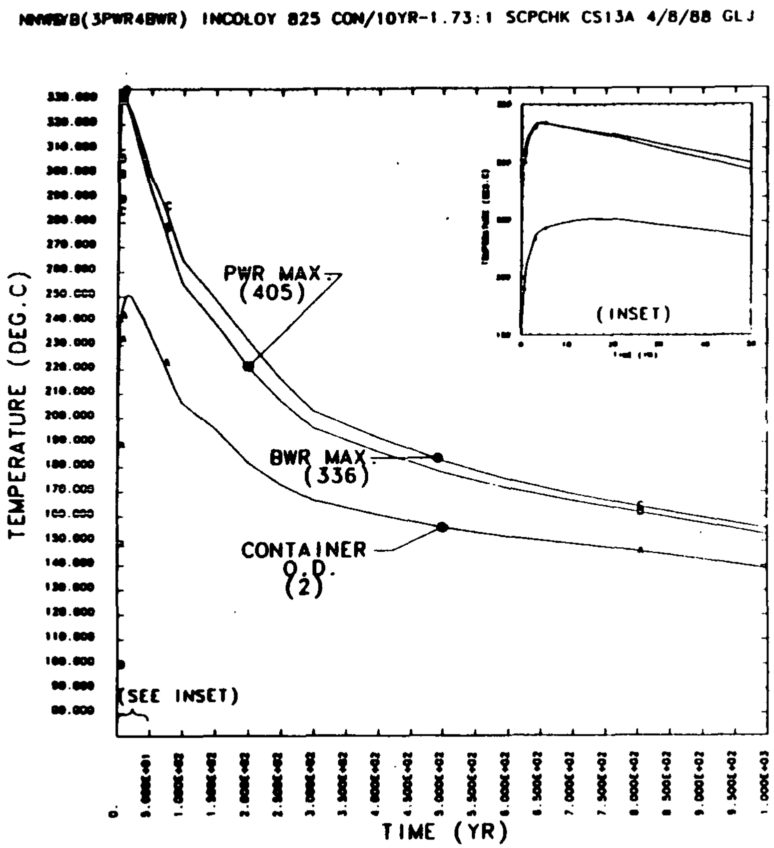
THE HYBRID DESIGN CLADDING REACHES A MAXIMUM TEMPERATURE OF 336°C AFTER 3.2 YEARS

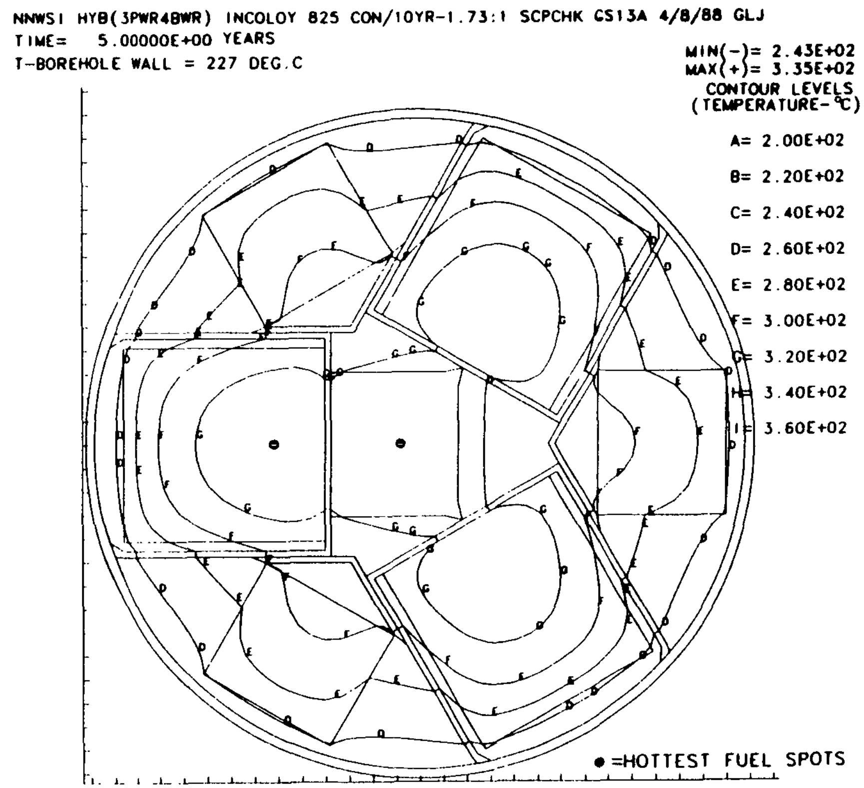




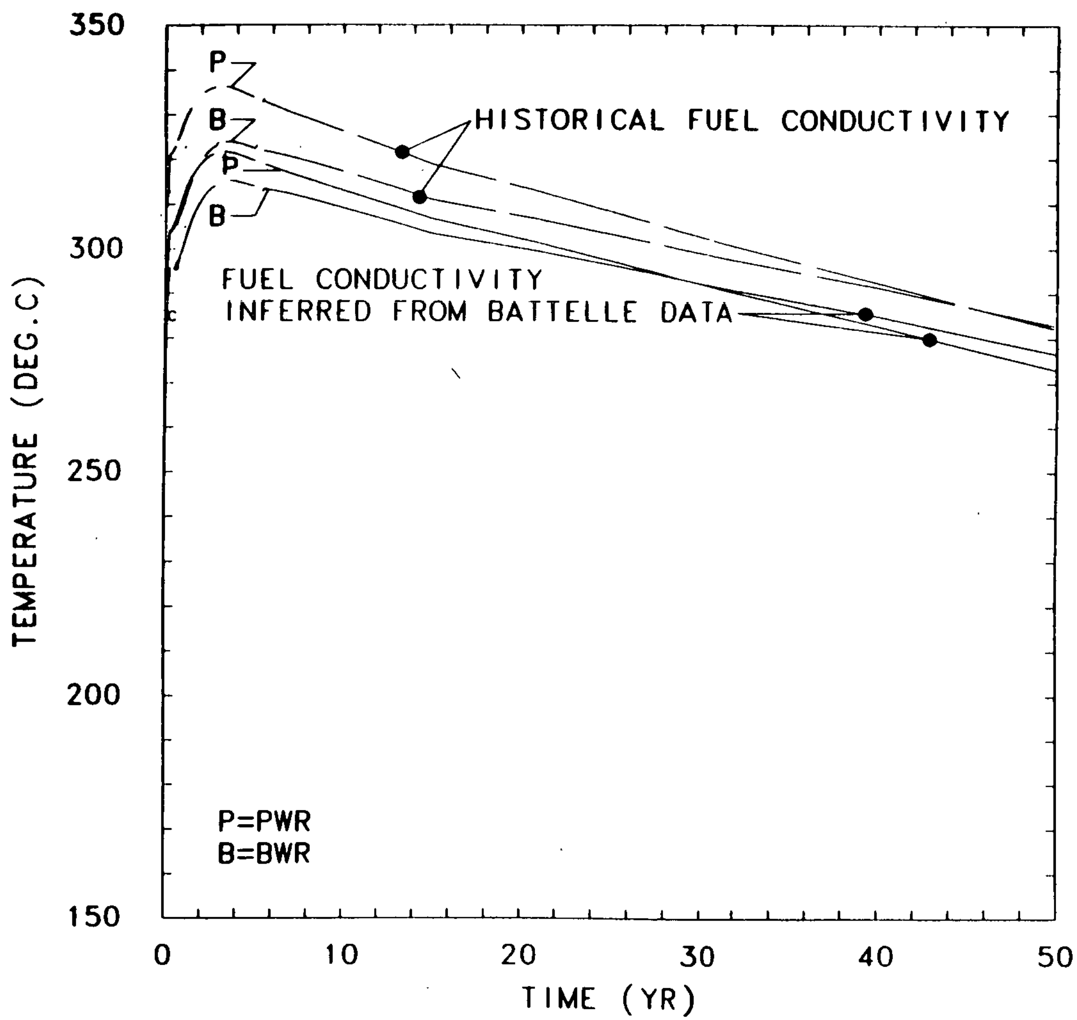
4.75 kW ON 8 X 30.4 m SPACING

IF SPACING IS REDUCED TO 15 x 126 ft (SCP CDR), THE LOAD MUST BE REDUCED TO 4.1 kW FOR A SIMILAR THERMAL RESPONSE

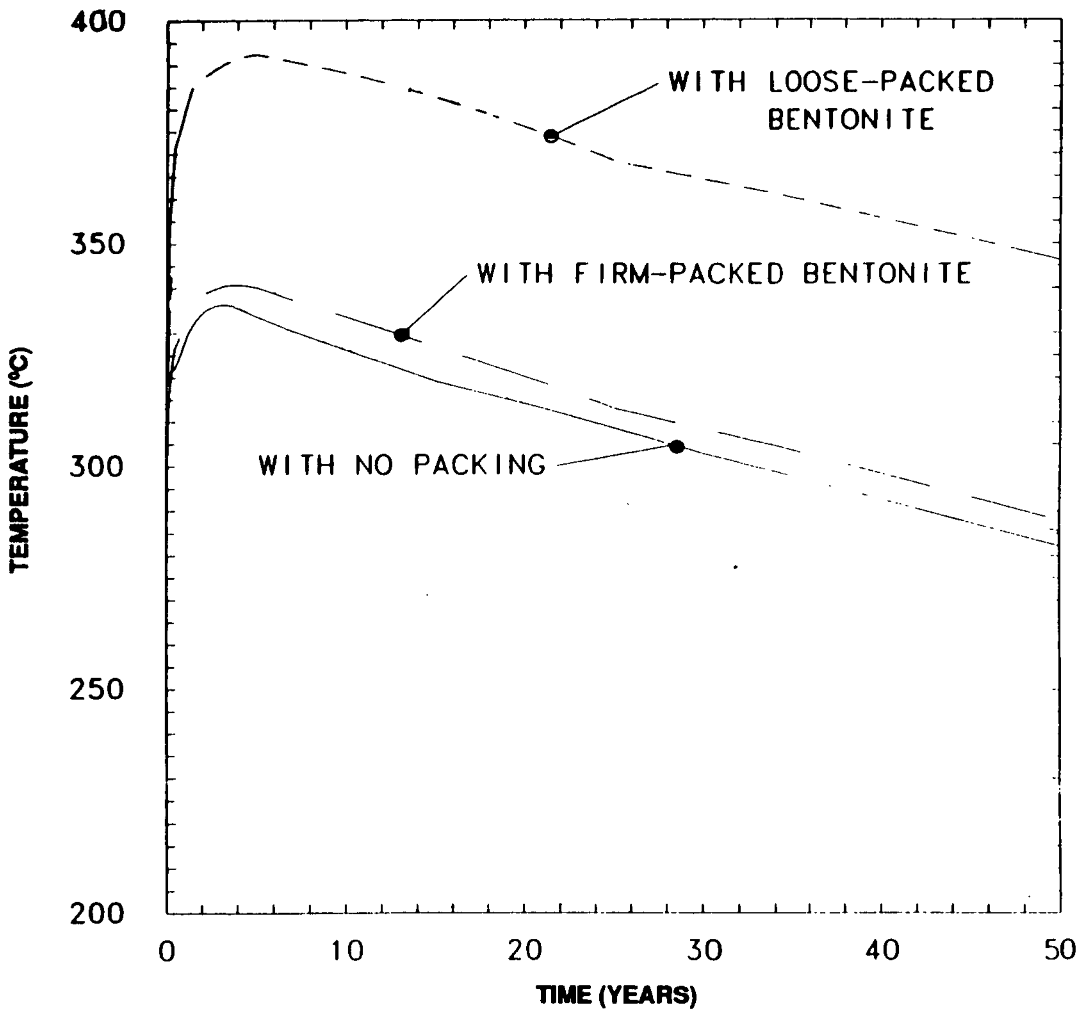




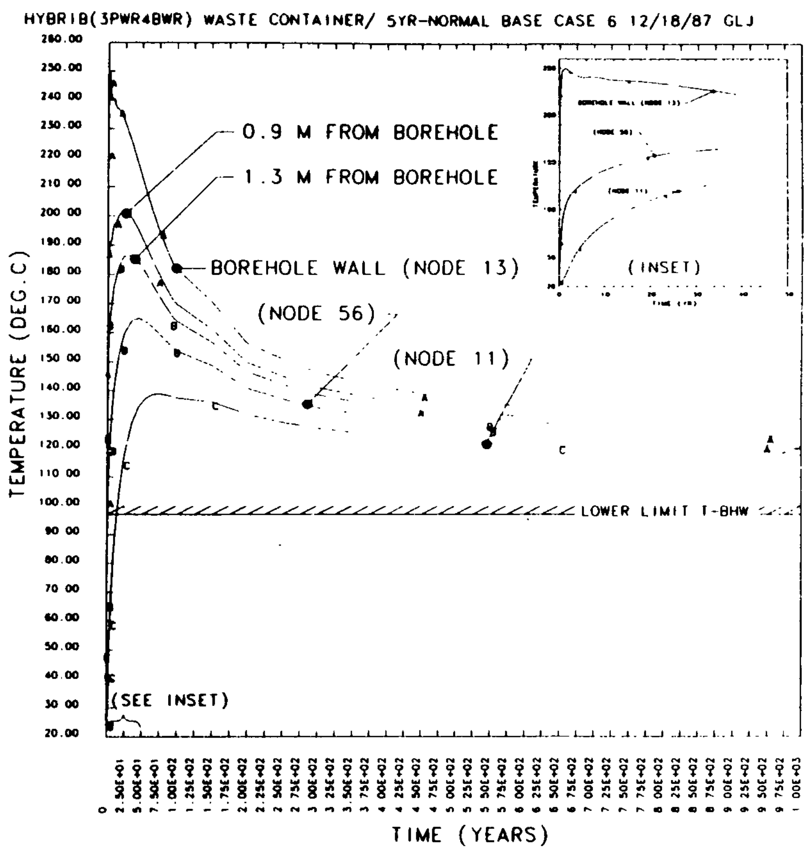
USING A REVISED VALUE FOR THE FUEL BUNDLE CONDUCTIVITY LOWERS THE PEAK CLADDING TEMPERATURE BY ABOUT 15°C



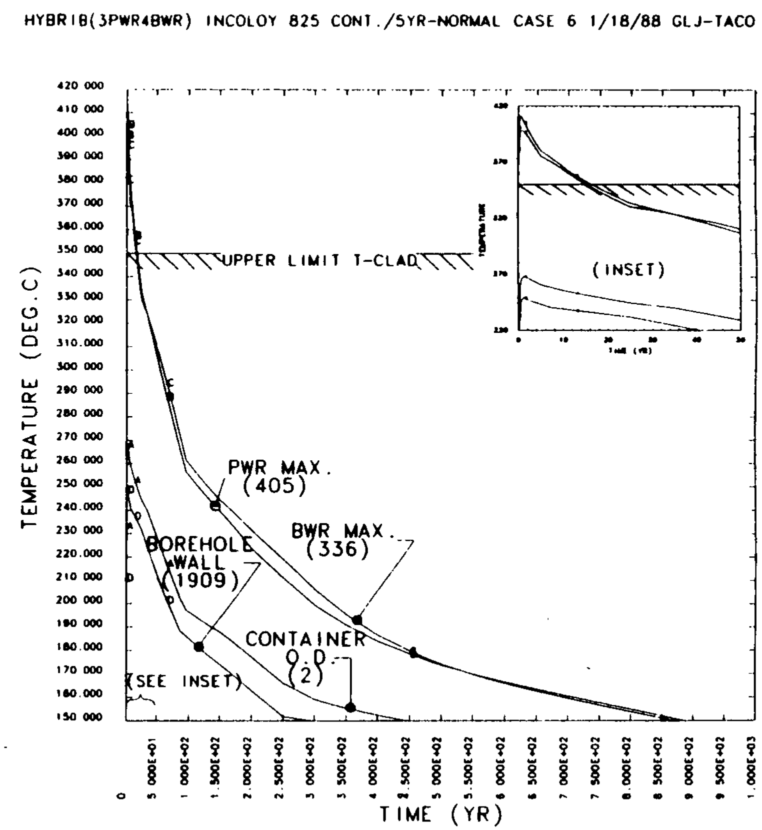
PEAK CLADDING TEMPERATURE IS ESPECIALLY SENSITIVE TO THE ASSUMED PROPERTIES OF A BOREHOLE PACKING



IF 5 YEAR-OLD FUEL IS EMPLACED INSTEAD OF 10 YEAR-OLD FUEL, $T_{PEAK, CLAD}$ INCREASES TO 65°C ABOVE THE 350°C LIMIT

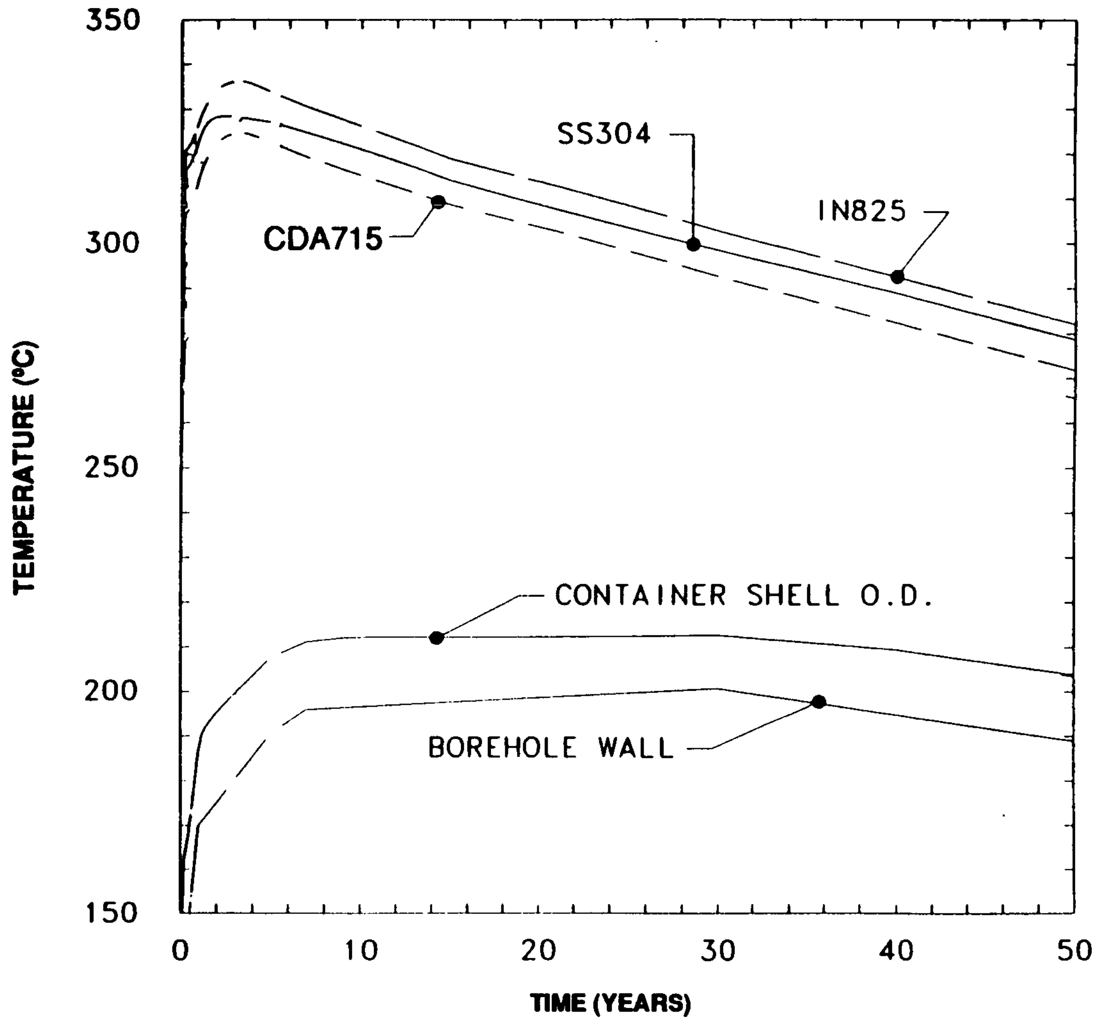


3-D TUFF MODEL

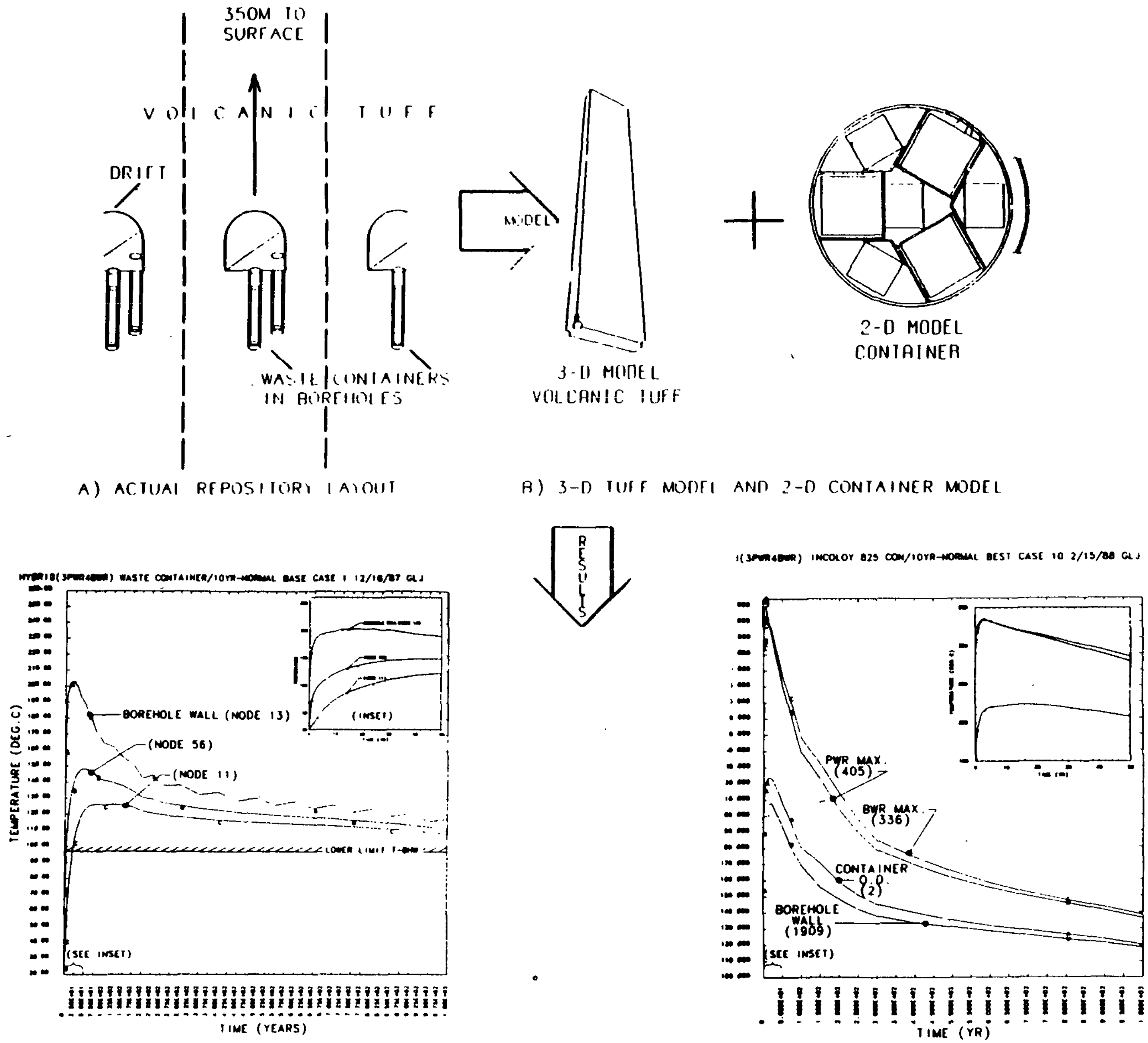


2-D CONTAINER MODEL

THE CHOICE OF STRUCTURAL MATERIAL FOR THE CONTAINER AND INTERNAL SUPPORTS HAS A SMALL EFFECT ON $T_{PEAK, CLAD}$



IN REVIEW, A 3-D TUFF MODEL WITH A 2-D CONTAINER MODEL OF A 4.75 kW LOADED HYBRID DESIGN, PREDICTS FUEL TEMPERATURES <350°C



REVIEW OF
WORK-EVALUATIONS COMPLETED

- REVIEW OF MODEL TYPES AND TOOLS
- MRS COMMON CANISTER STUDY - INTERNAL DESIGN, ORIENTATION, SPACING
- PRELIMINARY EVALUATION OF PWR CONTAINER AND BWR CONTAINER FOR SCP-CDR CONFIGURATION
- PWR/BWR HYBRID CONFIGURATION - PARAMETRIC ANALYSES

SUMMARY OF RESULTS FROM THERMAL ANALYSES

- RADIATION = DOMINANT HEAT TRANSFER MODE AMONG COMPONENTS (~80%)
- $T_{PEAK, CLAD}$, FOR VAST PROPORTION OF CONTAINER/SPACING DESIGNS <350° C (ALSO MOST CASES HAVE TUFF AT 1 m <200°C AND T_{BHW} > 95°C)
- $T_{PEAK, CLAD}$, OCCURS 3 TO 10 YEARS AFTER EMPLACEMENT
- MAXIMUM LOAD MUST DECREASE BY 15% WHEN REPOSITORY AREA PER PACKAGE REDUCED BY 30% TO GIVE SAME RESPONSE
- 3-D MODEL WITH REALISTIC AXIAL POWER DISTRIBUTION AND ORTHOTROPIC MATERIAL PROPERTIES HAS $T_{PEAK, CLAD}$, 15°C > 2-D MODEL
- EXPECTED VARIATIONS IN FUEL "EFFECTIVE" CONDUCTIVITY, ORIENTATION, AND SURFACE EMISSIVITY EACH RESULT IN 15oC $T_{PEAK, CLAD,}$ CHANGES
- EFFECT OF PACKING ON $T_{PEAK, CLAD}$ HIGHLY DEPENDENT OF EXPECTED DENSITY AND THEMAL CONDUCTIVITY OF PACKING

WHERE THIS WORK FITS IN

- $T_{PEAK,\ CLAD}$, $T_{MIN,\ BHW}$, AND $T_{1m,\ TUFF}$ FROM CONDUCTION-ONLY MODEL IS HIGHLY DEPENDENT ON K_{TUFF} AS WELL AS SOUCE INVENTORY AND LAYOUT (DRIFT/PANEL)

- ADDING IN EFFECTS OF WATER/STEAM REFLUX IN TUFF ADDS NO CHANGE AT EARLY TIMES AND 5-10°C CENTURIES AFTER EMPLACEMENT

- CONTAINER ANALYSIS, BASED ON INFINITE ARRAY CONDUCTION-ONLY-IN-TUFF MODEL, IS O.K. FOR $T_{PEAK,\ CLAD}$ EVALUATION (EARLY TIMES)

- CONTAINER TEMPERATURES AVAILABLE FOR:
  - HANDLING EVALUATION
  - CLADDING CREEP CALCULATIONS
  - WASTE FORM DEGRADATION CALCULATIONS
  - CORROSION CALCULATIONS
  - THERMAL-STRESS CALCULATIONS