APPENDIX A
NON-PROPRIETARY

REACTOR COOLANT SYSTEM ASYMMETRIC LOADS EVALUATION PROGRAM

FINAL REPORT

CALVERT CLIFFS 1&2
FORT CALHOUN
MILLSTONE 2

APPENDIX B
PALISADES FUEL
is also included herein

POWER SYSTEMS
COMBUSTION ENGINEERING, INC.

8007020593

APPENDIX A
NON PROPRIETARY

REACTOR COOLANT SYSTEM

ASYMMETRIC LOADS

FINAL REPORT

NUMERICAL RESULTS - EVALUATION OF CE FUEL

Prepared by

COMBUSTION ENGINEERING, INC.

for

CALVERT CLIFFS 1 & 2
FORT CALHOUN
MILLSTONE 2

June 30, 1980

APPENDIX A

NUMERICAL RESULTS

EVALUATION OF COMBUSTION ENGINEERING FUEL

TABLE A-1

14X14 SPACER GRID STRENGTHS AT ROOM TEMPERATURE

ONE SIDED	[
THROUGH GRID	]

TABLE A-2

FUEL ASSEMBLY COMPONENT STRESSES
GENERIC PLANT (CALVERT CLIFFS I AND 2, MILLSTONE 2)

	Maximum Stress (ksi)		
Component	Base Case	Revised Model	Ratio
End Fitting Castings	[		]
End Fitting Posts			
Guide Tubes			
Fuel Rods			

Allowable Stress (ksi)

Castings	-	[ ]
Posts	-	
Fuel Rods	-	

Guide Tube Properties

Yield Strength - Figure A-10

Strain Capability - Figure A-14

TABLE A-3

SPACER GRID IMPACT LOADS
GENERIC PLANT (CALVERT CLIFFS 1 AND 2, MILLSTONE 2)

	Maximum Impact Loads (lb)*			
	Peripheral Assemblies		Interior Assemblies	
Case	Max One-Sided	Max Thru-Grid	Max One-Sided	Max Thru-Grid
FP1B (1)	[			]
FP1B (2)	[			]

* Listed as Revised Model (Base Case)

(1) Full Power Inlet Break - Core Direction Perpendicular to Hot Legs

(2) Full Power Inlet Break - Core Direction Parallel to Hot Legs

Spacer Grid Impact Strength (lb)

One Sided - [ ]

Thru-Grid - [ ]

Impact Load Ratios (Revised Model/Base Case)

Peripheral Assemblies

One Sided - [ ]

Thru-Grid - [ ]

Interior Assemblies

One Sided - [ ]

Thru-Grid - [ ]

TABLE A-4

FUEL ASSEMBLY COMPONENT STRESSES
FT. CALHOUN PLANT

Component	Maximum Stress (ksi) Base Case	Maximum Stress (ksi) Revised Model
End Fitting Castings		
End Fitting Posts		
Guide Tubes		
Fuel Rods		

Allowable Stress (ksi)

Castings -	
Posts -	
Fuel Rods -	

Guide Tube Properties

Yield Strength - Figure A-10

Strain Capability - Figure A-14

TABLE A-5

SPACER GRID IMPACT LOADS
FT. CALHOUN PLANT

	Maximum Impact Loads (lb)*			
	Peripheral Assemblies		Interior Assemblies	
Case	Max One-Sided	Max Thru-Grid	Max One-Sided	Max Thru-Grid
FP1B (1)	[			]
FP1B (2)	[			]

* Listed as Revised Model (Base Case)

(1) Full Power Inlet Brea.: - Core Direction Perpendicular to Hot Legs

(2) Full Power Inlet Break - Core Direction Parallel to Hot Legs

Spacer Grid Impact Strength (Lb.)

One-Sided	-	[ ]
Thru-Grid	-	[ ]

FIGURE A-1

FUEL ASSEMBLY LATERAL LOAD DEFLECTION CURVE

FIGURE A-2

FUEL ASSEMBLY LATERAL IMPACT LOAD

VS.

INITIAL LATERAL DISPLACEMENT

FIGURE A-3

FUEL ASSEMBLY FUNDAMENTAL FREQUENCY VS. AMPLITUDE

FIGURE A-4

FUEL ASSEMBLY DAMPING RATIO VS. AMPLITUDE

FIGURE A-5

SPACER GRID APPROACH VELOCITY

VS.

DROP HEIGHT

[redacted] F[redacted]E A[redacted] [redacted]

MAXIMUM ONE-SIDED SPACER GRID IMPACT LOAD DISTRIBUTION

GENERIC PLANT - FULL POWER INLET BREAK

FIGURE A-7

MAXIMUM THRU-GRID IMPACT LOAD DISTRIBUTION

GENERIC PLANT - FULL POWER INLET BREAK

FIGURE A-8

MAXIMUM ONE-SIDED GRID IMPACT LOAD DISTRIBUTION

FT. CALHOUN PLANT - FULL POWER INLET BREAK

Note: No Scaling Factor Applied Unless Asterisked (*)

* Scaled

FIGURE A-9

YIELD STRENGTH VS. FLUENCE FOR ANNEALED ZIRCALOY-IRRADIATION TEMPERATURE 500 TO 650°F - ELEVATED TEMPERATURE TEST

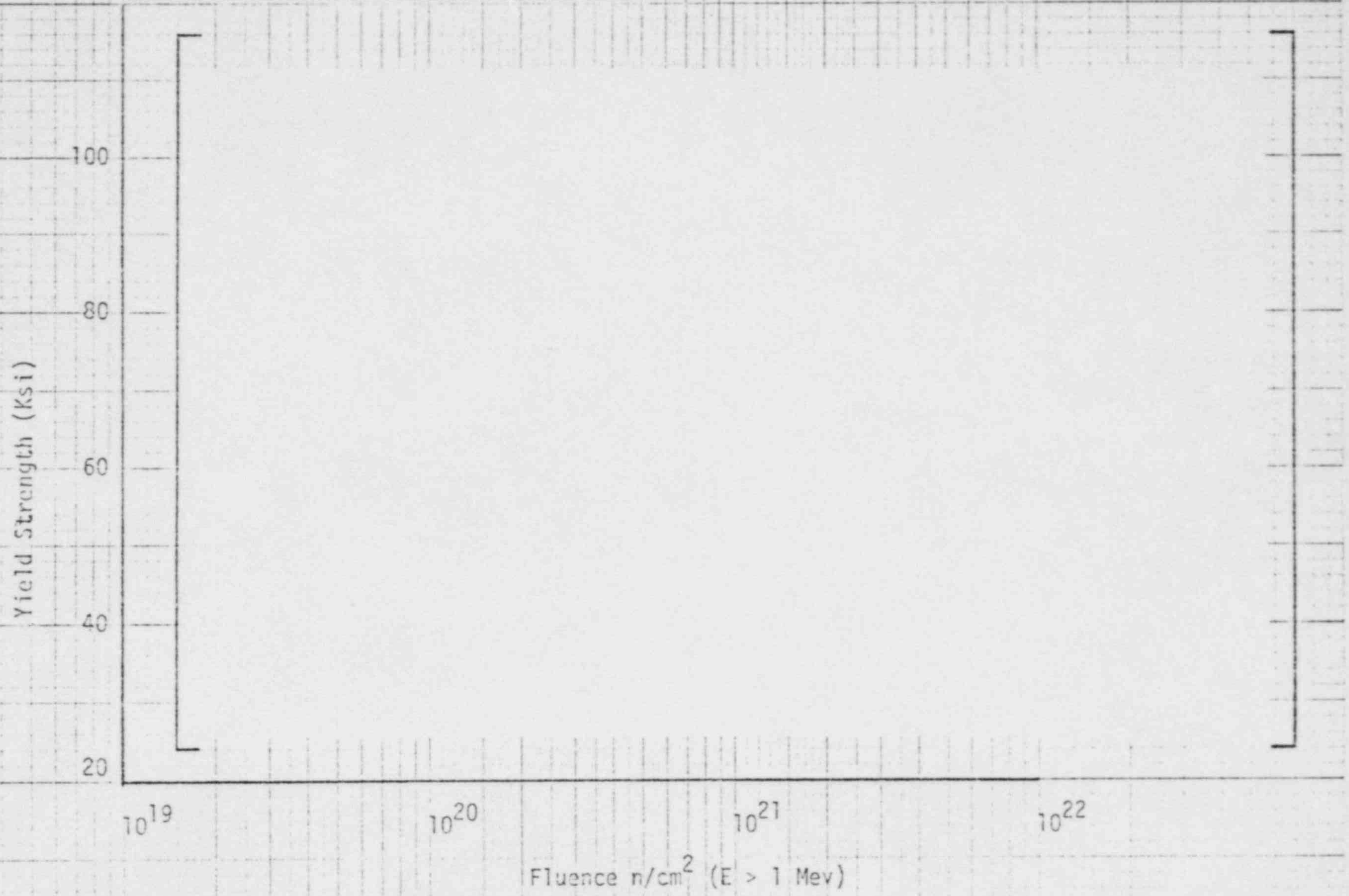
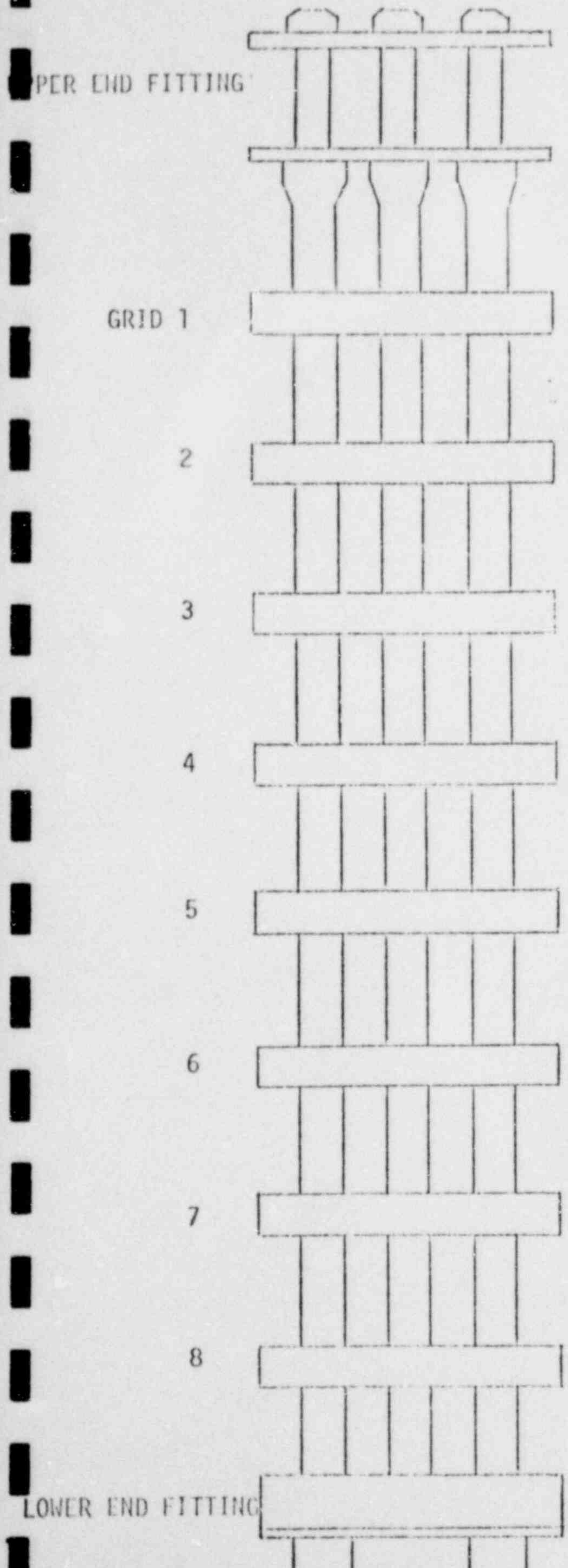


FIGURE A-10

YIELD STRENGTH VS. FLUENCE FOR ANNEALED MATERIAL-EFFECT OF STRAIN RATE

FIGURE A-11

DISTRIBUTION OF MAXIMUM GUIDE TUBE STRESS
GENERIC PLANT - FULL POWER INLET BREAK



MAXIMUM GUIDE TUBE STRESS (KSI)

FIGURE A-12

DISTRIBUTION OF MAXIMUM GUIDE TUBE STRESS

FT. CALHOUN PLANT - FULL POWER INLET BREAK

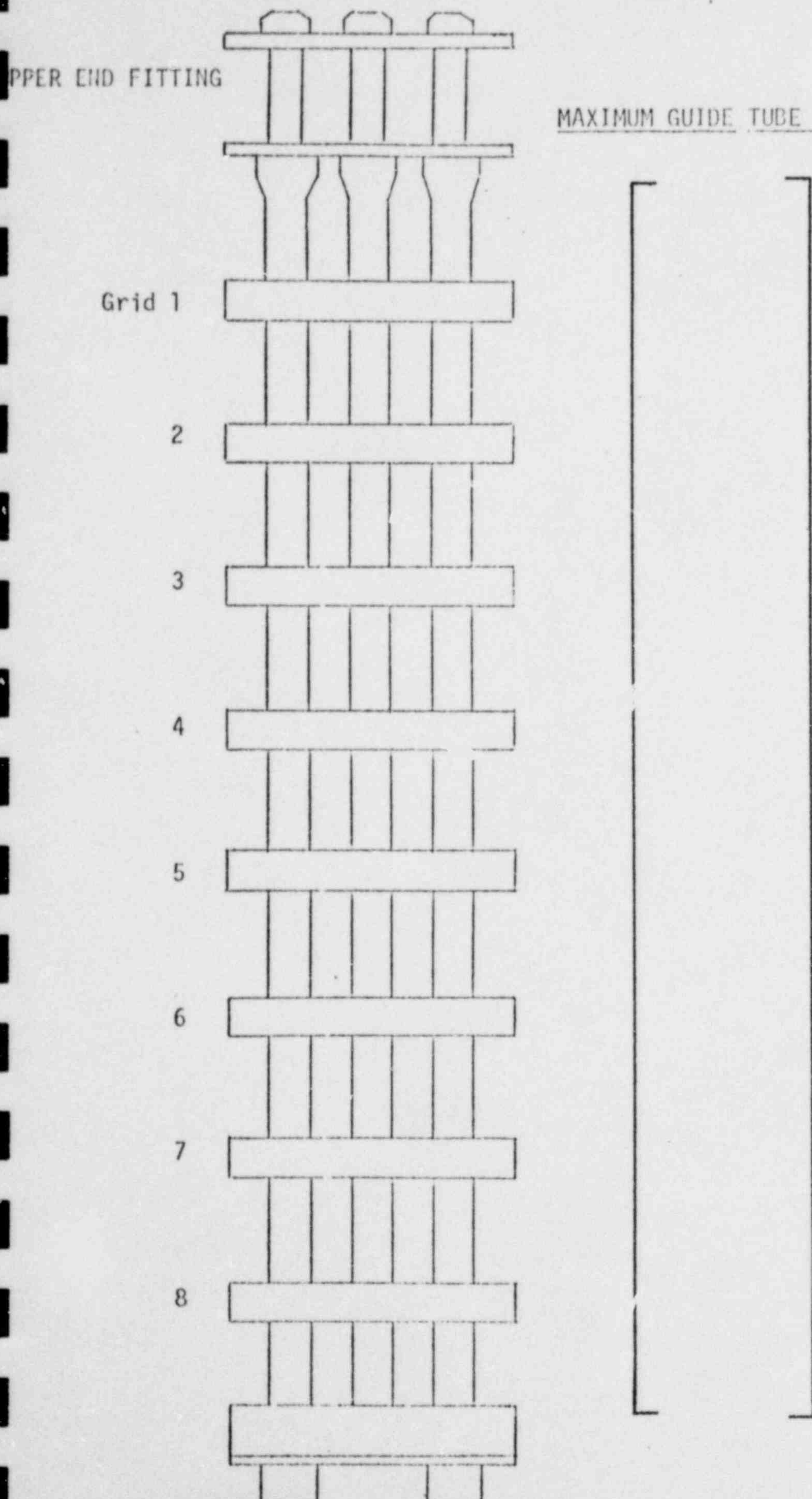


FIGURE A-13

TOTAL ELONGATION AS A FUNCTION OF FLUENCE FOR ANNEALED MATERIAL

IRRADIATION TEMPERATURE 500 TO 650°F - ELEVATED TEMPERATURE TEST

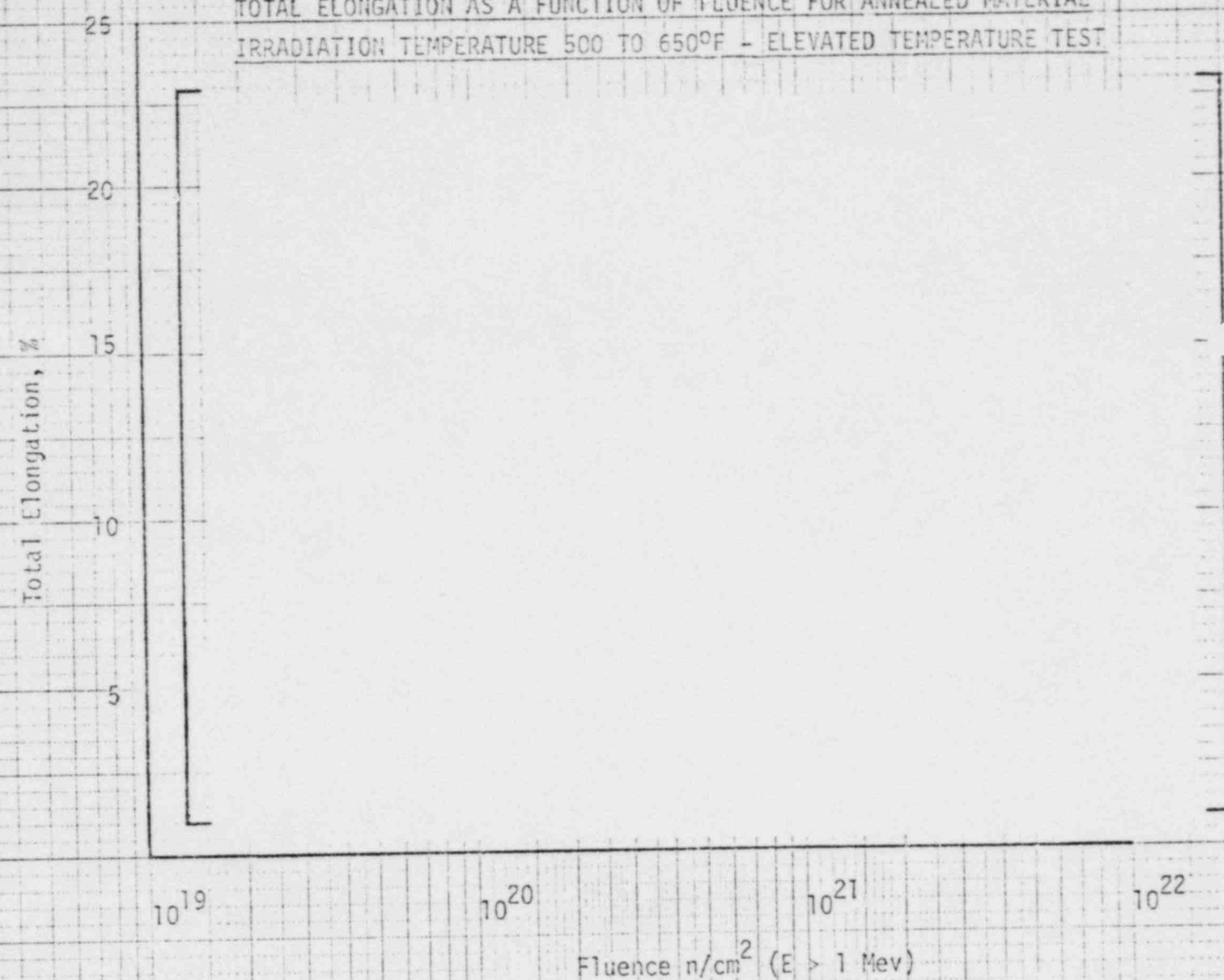


FIGURE A-14

STRAIN CAPABILITY (ELASTIC AND PLASTIC) AS A FUNCTION OF FLUENCE FOR ANNEALED MATERIAL 600°F

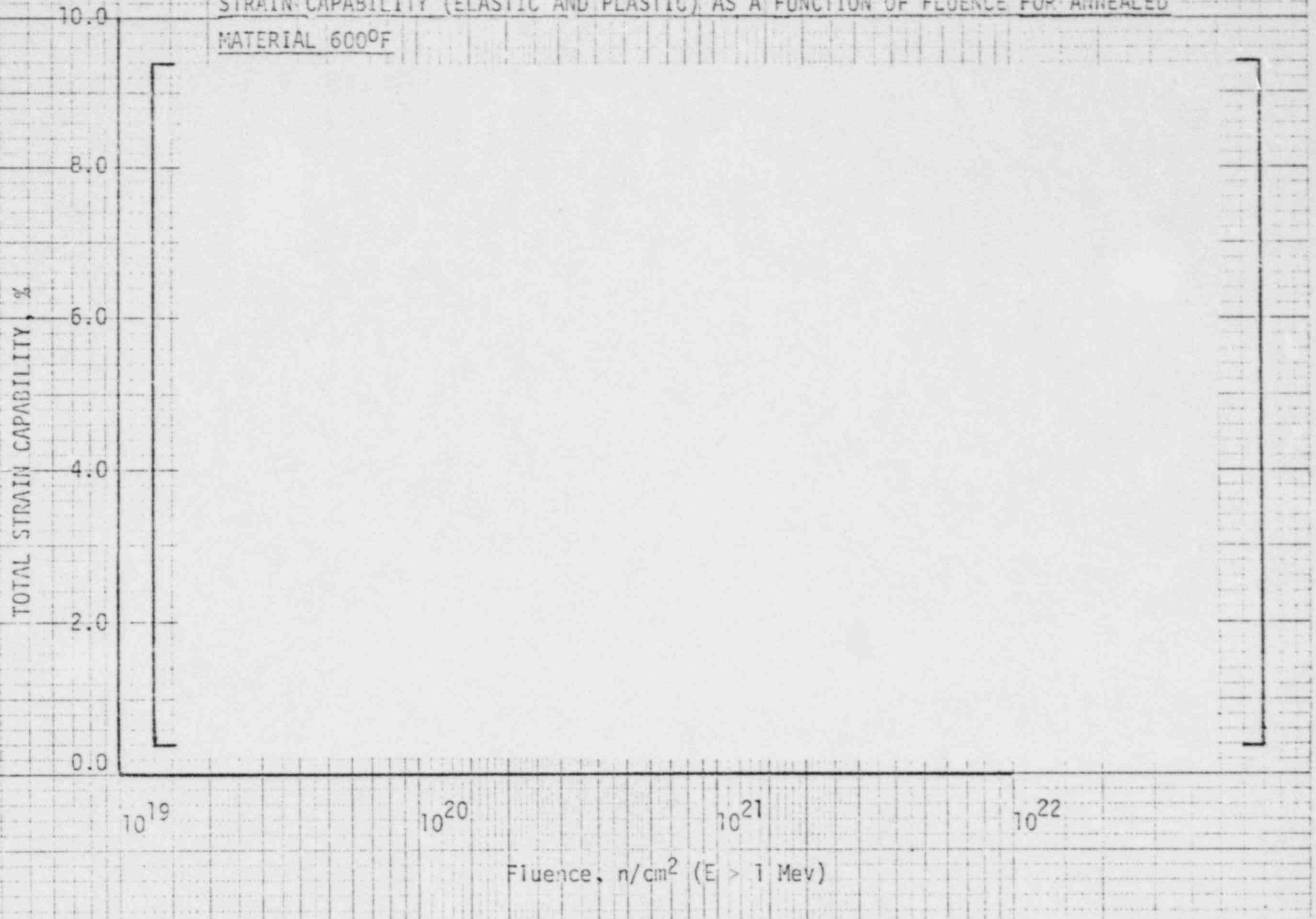


FIGURE A-15

DISTRIBUTION OF MAXIMUM GUIDE TUBE STRAIN
GENERIC PLANT - FULL POWER INLET BREAK

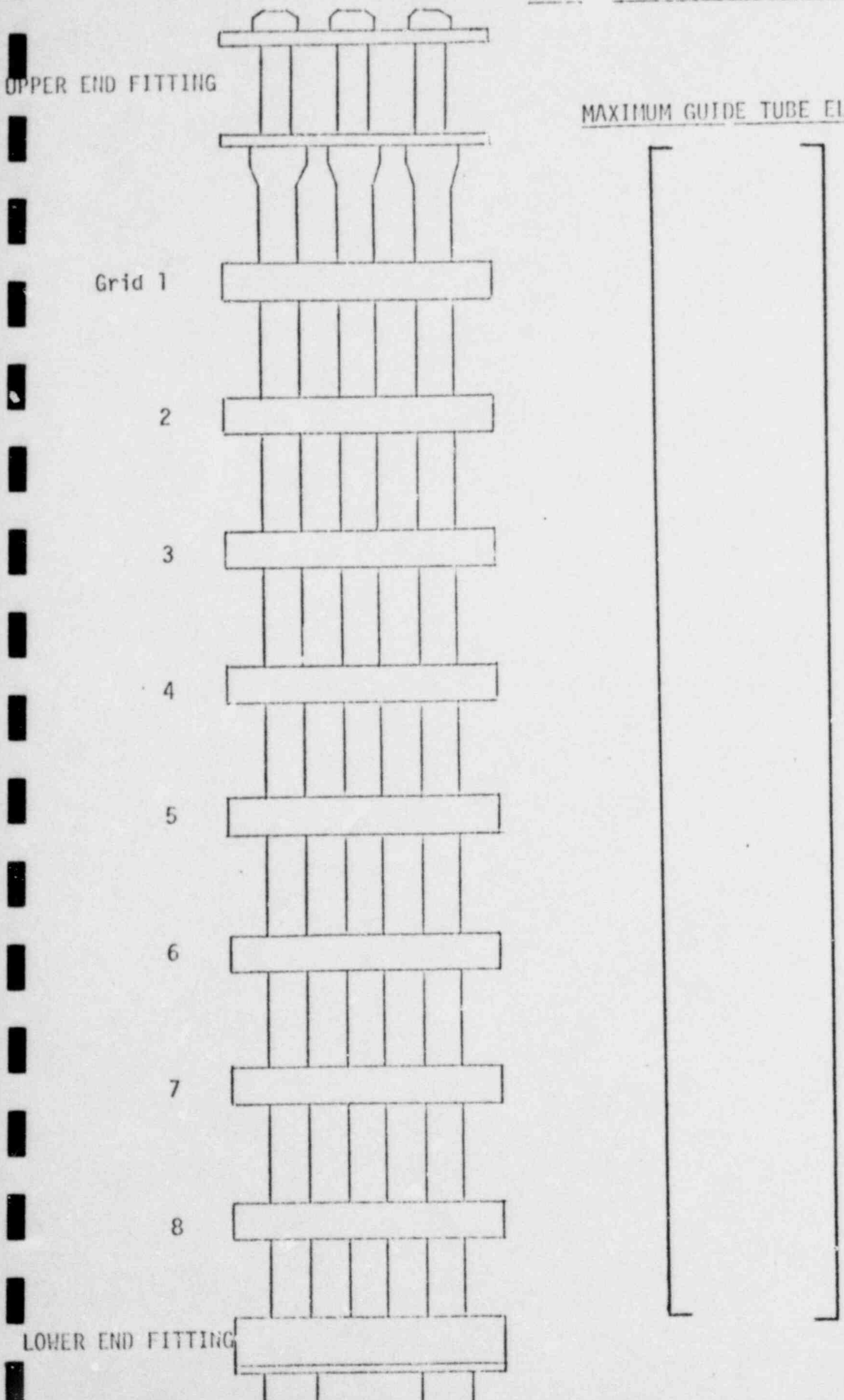
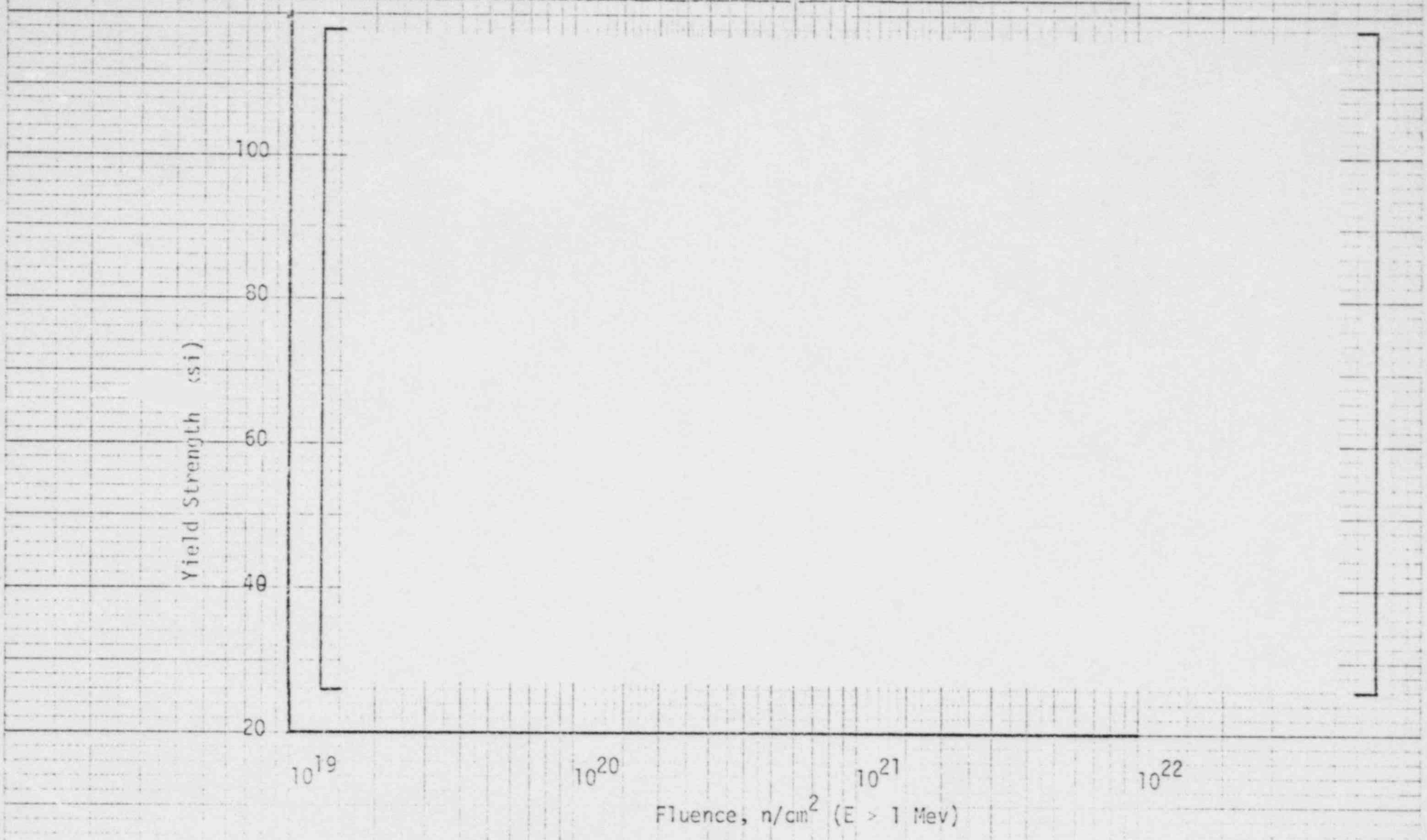


FIGURE A-16

YIELD STRENGTH VS. FLUENCE FOR ANNEALED ZIRCALOY-EFFECT OF STRAIN RATE



APPENDIX B

PALISADES FUEL ANALYSIS

A preliminary estimate has been obtained of the Palisades fuel assembly loads. These loads were obtained using plant specific Palisades fuel alignment plate, core support plate, and core shroud motions obtained from the internals response analysis. These motions were employed with a standard CE 14 x 14 fuel assembly model. The results do not include the load reduction of about ten percent due to realistic treatment of the friction between the core barrel flange and reactor vessel support ledge.

The preliminary results do not account for the differences between the CE 14 x 14 fuel assembly model and the Palisades fuel; which is supplied by Exxon. Most importantly:

* The Palisades fuel spacer grid stiffness is less than that of the CE 14 x 14 fuel. It is expected that this difference will decrease the magnitude of the spacer grid loads.

* The spacing between Palisades fuel assemblies is greater than the spacing between fuel assemblies in the standard CE model. The effect of this difference has not yet been defined.

* The crush properties of the Palisades fuel are different that those of the CE fuel. It is expected that the allowable spacer grid load will be less than for CE fuel, i.e., about 2000 pounds for Palisades. In addition, the reduced area properties of crushed Palisades grids have yet to be defined.

The specific steps which will be taken to finalize results for Palisades fuel are as follows:

* The standard CE 14 x 14 fuel assembly model will be revised to incorporate Palisades fuel assembly spacing. Spacer grid loads will be obtained for this model, based on the Palisades fuel alignment plate, core plate and core shroud motions. The loads obtained from this analysis should be conservatively high, because they do not account for the reduced stiffness of the Palisades fuel.

* Spacer grid impact tests will be performed to determine the allowable grid impact loads. These tests will also define the reduced area properties of crushed grids, i.e., the overall grid reduction in area and the maximum localized reduction in area.

It is expected that these results will demonstrate adequacy of the Palisades fuel spacer grids, i.e., show that:

APPENDIX B

PALISADES FUEL ANALYSIS

A preliminary estimate has been obtained of the Palisades fuel assembly loads. These loads were obtained using plant specific Palisades fuel alignment plate, core support plate, and core shroud motions obtained from the internals response analysis. These motions were employed with a standard CE 14 x 14 fuel assembly model. The results do not include the load reduction of about ten percent due to realistic treatment of the friction between the core barrel flange and reactor vessel support ledge.

The preliminary results do not account for the differences between the CE 14 x 14 fuel assembly model and the Palisades fuel; which is supplied by Exxon. Most importantly:

* The Palisades fuel spacer grid stiffness is less than that of the CE 14 x 14 fuel. It is expected that this difference will decrease the magnitude of the spacer grid loads.

* The spacing between Palisades fuel assemblies is greater than the spacing between fuel assemblies in the standard CE model. The effect of this difference has not yet been defined.

* The crush properties of the Palisades fuel are different that those of the CE fuel. It is expected that the allowable spacer grid load will be less than for CE fuel, i.e., about 2000 pounds for Palisades. In addition, the reduced area properties of crushed Palisades grids have yet to be defined.

The specific steps which will be taken to finalize results for Palisades fuel are as follows:

* The standard CE 14 x 14 fuel assembly model will be revised to incorporate Palisades fuel assembly spacing. Spacer grid loads will be obtained for this model, based on the Palisades fuel alignment plate, core plate and core shroud motions. The loads obtained from this analysis should be conservatively high, because they do not account for the reduced stiffness of the Palisades fuel.

* Spacer grid impact tests will be performed to determine the allowable grid impact loads. These tests will also define the reduced area properties of crushed grids, i.e., the overall grid reduction in area and the maximum localized reduction in area.

It is expected that these results will demonstrate adequacy of the Palisades fuel spacer grids, i.e., show that: