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WANL-TME-1551

Record

Westinghouse Astronuclear Laboratory

NR-1 SIZING PARAMETER STUDY (U)

SNPO-W PRESENTATION
December 2, 1966

1551

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Westinghouse Astronuclear Laboratory

WANL-TME-1551

NR-1 SIZING PARAMETER STUDY (U)

SNPO-W PRESENTATION
December 2, 1966

Classification cancelled for change to
by authority of DOC
by W.D.E. TIC, date SEP 10 1973

Prepared By:

F.D. Retallick

F.D. Retallick

SPECIAL REVIEW FINAL DETERMINATION	Revised	Class.	Date
	TR	U	5-10-82

GROUP - 1	
EXCLUDED FROM AUTOMATIC DOWNGRADING	
INFORMATION CATEGORY	
<u>C-100</u>	<u>J.M. Angley</u>
AUTHORIZED CLASSIFIER	DATE

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SUMMARY DESCRIPTION OF CANDIDATE REACTOR DESIGNS HIGH VOID FUEL

CASE	<u>5000 MW</u>			<u>4000 MW</u>		
	A	B	C	D	E	F
POWER (MW)		5000			4000	
W_c (LB/SEC)		285			228	
T_c ($^{\circ}$ R)		4500			4500	
CORE AVERAGE POWER DENSITY (MW/CU FT)		68			68	
FUEL VOID FRACTION		.37			.37	
FUELED DIAMETER		55.8			49.9	
BERYLLIUM I. D.		60.16			54.26	
BERYLLIUM THICKNESS		6.75			5.5	
REACTOR ASSEMBLY O. D.		6.75			5.5	
FUEL LENGTH		52			52	
CHAMBER PRESSURE(PSIA)	625	525	450	625	525	450
CORE PRESSURE DROP (PSI)	155	179	201	155	179	201
REACTOR WEIGHT (LB) ¹	18680	18690	18710	14770	14760	14780

¹ DOES NOT INCLUDE PRESSURE VESSEL AND NOZZLE

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SUMMARY DESCRIPTION OF CANDIDATE REACTOR DESIGNS LOW VOID FUEL

CASE	<u>5000 MW</u>			<u>4000 MW</u>		
	AA	BB	CC	DD	EE	FF
POWER (MW)		5000			4000	
W_c (LB/SEC)		285			228	
T_c ($^{\circ}$ R)		4500			4500	
CORE AVERAGE POWER DENSITY (MW/CU FT)		68			68	
FUEL VOID FRACTION		.29			.29	
FUELED DIAMETER		55.8			49.9	
BERYLLIUM I. D.		60.16			54.26	
BERYLLIUM THICKNESS		6.75			5.5	
REACTOR ASSEMBLY O. D.		73.91			65.51	
FUEL LENGTH		52			52	
CHAMBER PRESSURE (PSIA)	625	525	450	625	525	450
CORE ΔP (PSI)	258	294	327	258	294	327
REACTOR WEIGHT (LB) ¹	18380	18400	18420	14570	14710	14720

¹ DOES NOT INCLUDE PRESSURE VESSEL AND NOZZLE

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SUMMARY DESCRIPTION OF CANDIDATE REACTOR DESIGNS SUPPLEMENTARY REACTOR DESIGNS

NRX TECHNOLOGY		
CASE	G	H
POWER (MW)	5000	2850
W_c (LB/SEC)	308	174
T_c ($^{\circ}$ R)	4250	4250
P_c (PSIA)	625	371
CORE ΔP (PSI)	101	156
CORE AVERAGE POWER DENSITY (MW/CU FT)	39	39
FUEL VOID FRACTION	.29	.29
FUELED DIAMETER	74.2	55.8
BERYLLIUM I. D.	78.56	60.16
BERYLLIUM THICKNESS	12	6.75
REACTOR ASSEMBLY O. D.	102.81	73.91
FUEL LENGTH	52	52
REACTOR WEIGHT (LB) ¹	33910	18060

¹ DOES NOT INCLUDE PRESSURE VESSEL AND NOZZLE

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EFFECT OF REACTOR PARAMETERS ON CORE PRESSURE DROP DESIGN CHAMBER PRESSURE 625 Psia

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RESTRAINT ON DESIGN FLEXIBILITY OF CHAMBER PRESSURE

SELECTED CHAMBER PRESSURE - PSIA	625	525	450
1. Core Pressure Drop with 0.107 Channel Diameter - (PSID)	155	179	201
2. Minimum Fuel Diameter Capability with Design Power and Not Exceeding 200 Core ΔP - (Inches)	0.1015	0.1045	0.107
3. Power Which Can Be Achieved in Reactor with Channel Diameter of 0.095 and Not Exceeding Core ΔP of 200- (MW)	3120	2780	2500
4. Minimum Channel Diameter Capability While Maintaining 3700* MW and Not Exceeding A Core ΔP of 200 - (Inches)	0.099	0.1018	0.1045
5. Operating Time of Reactor for Powers in (3.), A 4 Million Pound Vehicle, and with Two Stages Into Mars - (Minutes)	35.5	39.9	44.4
6. Design Power Required to Provide 3700* MW At Conditions of (3.) - (MW)	4740	5320	5920 (New Core Diameter)
7. Required Design Power to Provide 3700 MW With 0.107 Channel Diameter and 50 % Achievement of NRX to NR-1 Power	4700	4700	4700
8. Required Design Power to Provide 3700 MW With 0.095 Channel Diameter and 50 % Achievement of NRX to NR-1 Power Density (Phoebus-1B Cond.) - MW	4900**	5540**	6160**

* Required Power for 4,000,000 Pound Vehicle With Two Stages Into Mars and Not Exceeding 30 Minutes Operating Time.

** ΔP Limited

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CLUSTER SUPPORT - GRAPHITE

611520-3J

CLUSTER SUPPORT-COMPOSITE

611407-30C A

REACTOR SUPPORT SYSTEM SAFETY FACTORS

Void Fraction	.37	.29	.29
Core Pressure Drop (psi)	155.	258.	327.
<u>Composite Hot End Support</u>			
Pedestal	1.5*	1.29	0.86
Central Element	1.5*	1.13	0.94
Fuel Tip	1.5*	1.29	0.86
Threaded Washer	1.5*	1.20	0.90
Tie Tube	2.0	1.7	1.6
Support Plate	3.3	2.0	1.6
Support Ring	2.0	1.2**	1.1**
<u>Reference Design (WANL-TME-1485)</u>			
Skirtless Block	1.5	1.4	1.1
Tie Tube	2.0	1.7	1.6
Support Plate	3.3	2.0	1.6
Support Ring	2.0	1.2**	1.1**

* Assumed as reasonable goals.

** Easily redesigned to provide adequate strength at some cost in weight

CONCLUSIONS ON FUEL LIFETIME

1. PRIMARY THERMAL/FLUID FLOW EFFECTS ON CORROSION ARE:
 - MASS VELOCITY
 - TEMPERATURE
 - PRESSURE
 - VOID FRACTION
 2. MATERIAL LOSS IS DUE TO :
 - MIDBAND EFFECTS
 - HOT END EFFECTS
 3. MIDBAND LOSS IS PRIMARILY RELATED TO MASS VELOCITY
(FOR GIVEN GEOMETRY AND PRESSURE LEVEL)
 4. HOT END LOSS IS PRIMARILY RELATED TO EXIT TEMPERATURE
(FOR GIVEN GEOMETRY AND PRESSURE LEVEL)
 5. MATERIAL LOSS TENDS TO DECREASE WITH PRESSURE, IF OTHER PARAMETERS CONSTANT.
IN CORROSION TESTS, MASS VELOCITY, PRESSURE DROP, ETC. OFFSET EFFECT OF
ABSOLUTE PRESSURE VARIATION.
 6. VOID FRACTION EFFECTS
 - SURFACE AREA
 - MASS VELOCITY
 - PRESSURE
- PRESENT TEST DATA INCONCLUSIVE
7. MOLY COATED FUEL CORROSION TESTS INDICATE :
 - HOT END TEMPERATURE EFFECTS PREDOMINATE
 - SUPRESSED MIDBAND LOSS

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LASL ELECTRICAL TEST DATA PHOEBUS 1B ELEMENTS (MOLY COAT)

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CHANNEL DIA. = .095"

LASL
WANL

COATING BATCH
BCL 84 ; 20 MIN.
Y-12, 7609 ; 25.5 MIN.
Y-12, 8998 (-45 PSI) AT STA 20: 32 MIN.
Y-12, 8998 (-45 PSI) AT STA 20: 19.3 MIN.

HELD CONSTANT:

	LASL	WANL
FLOW LB/HR	205	159
POWER MW	1.01	0.7
EXIT H ₂ TEMP-°R	4500	
STATION 48.6		
MTL. TEMP. - °R		4600

RANGE OF CANDIDATE REACTORS

TOTAL WEIGHT LOSS - GMS

CHANNEL EXIT PRESSURE - PSIG

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WANL ELECTRICAL TEST DATA NRX-A3 GRADE FUEL

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GROUND RULES FOR SELECTION OF CANDIDATE NUCLEAR SUBSYSTEM

POWER LEVELS	4000, 5000 MW
CHAMBER TEMPERATURE	4500°R
CHAMBER PRESSURE	625, 525, 450 PSIA
RUN TIME	60 MINUTES
FUEL ELEMENT LENGTH	52 INCHES
NUMBER OF CHANNELS PER ELEMENT	19
SINGLE MODULE TANK HEATING DESIGN LEVEL SHIELD CRITERIA	200 KW
MECHANICAL REACTIVITY CONTROL	\$9
DEVELOPMENT SCHEDULE	PFRT IN 1974
AVERAGE CORE POWER DENSITY	68 MW/FT ³

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ESTIMATED FUEL LIFETIME NR REACTOR/ENGINE SIZING STUDY

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A CHAMBER PRESSURE OF 625 PSIA IS RECOMMENDED FOR THE FOLLOWING REASONS:

1. YIELDS ACCEPTABLE 155 PSID AT REFERENCE 37 % VOID FRACTION, THUS PROVIDING REQUIRED MARGIN FOR CORE SUPPORT SYSTEM DEVELOPMENT.
2. MAINTAINING 625 PSIA CHAMBER PRESSURE PROVIDES DESIGN FLEXIBILITY TO USE LOWER VOID FRACTION FUELS, IF FOUND NECESSARY DURING THE NR-1 FUELS DEVELOPMENT PROGRAM.
3. MAINTAINING 625 PSIA CHAMBER PRESSURE PROVIDES MAXIMUM FLEXIBILITY TO UTILIZE NRX OR PHOEBUS-1B TECHNOLOGY FUEL AND STILL ACCOMPLISH MISSION.
4. CORROSION TESTS OF FUEL ELEMENTS AT 625 PSIA DO NOT INDICATE A SIGNIFICANT INCREASE IN WEIGHT LOSS OVER THOSE LISTED AT 450 PSIA.

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LIMITING POWER FOR 200 PSI CORE PRESSURE DROP VS VOID FRACTION

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