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WANL-TME-1532
Addendum

Westinghouse Astronuclear Laboratory

JOINT WANL / LASL / Y-12
FUEL AND REACTOR DEVELOPMENT REVIEW

Title Unclassified

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SPECIAL REVIEW FINAL DETERMINATION Class: <u>U</u>	Reviewer	Class.	Date
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Prepared By:
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INTRODUCTION

This addendum is published to supplement WANL-TME-1532. Information contained herein was not available for publication at the time of the October 11-12, 1966 meeting.

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NRX-A5 FUEL ELEMENT BORE

WEIGHT LOSS AND HYDROGEN CORROSION TEST SIMULATION RESULTS

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CORE AFT FACE NRX/EST

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NRX/EST SIDE OF CORE

SEAL SEGMENT
CONTACT AREA

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ELEMENT HOT ENDS NRX-A4 VS NRX-A5

NRX-A5

NRX-A4

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BREAK STATIONS FOR ELEMENTS IN NRX-A4
(Single Breaks)

BREAK STATIONS FOR ELEMENTS IN NRX-A5
(Single Breaks)

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Comparison of Break Stations in NRX-A4 and NRX-A5 Fuel Elements

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- MORE THAN ONE BREAK
- ONE BREAK
- INTACT
- HOT BUFFER

Distribution of Broken Elements in NRX-A5

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KEY
//// NbC - C

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TaC-C AND NbC-C COMPOSITES

VOLUME % VS. WEIGHT %

ASSUMED DENSITIES:

TaC	14.48 G/CC
NbC	7.80
CARBON	2.26

<u>VOLUME % CARBIDE</u>	<u>W/O NbC</u>	<u>W/O TaC</u>
10	28	41
20	46	61
30	59	73
40	70	81
50	77	87
60	84	91
70	89	94
80	93	96
90	96	99

85 W/O NbC-C HAS DENSITY OF ~ 5.7 G/CC

70 W/O NbC-C HAS DENSITY OF ~ 4.5 G/CC

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DEFORMATION DATA

HOT PRESSED BODIES:

TaC-C AND NbC-C DEFORMATION RELATIVELY
INSENSITIVE TO W/O FROM 70 TO 90 W/O.

DEFORMATION CAN BE LESS THAN 2% FOR TaC AND NbC-C
FOR 30 MINUTES AT 2700°C AND 2000 PSI.

ZrC-C COMPOSITES HAVE VERY HIGH DEFORMATIONS AT
2700°C AND 2000 PSI.

ATJ HAS ABOUT 1% DEFORMATION AT 2700°C AND 2000 PSI.

EXTRUDED BODIES:

DEFORMATION OF NbC-C EXTRUDED BODIES IS HIGHER THAN
HOT PRESSED BODIES. AT 2700°C AND 30 MINUTES

$$\frac{\Delta L}{L} = 2 \times 10^{-7} (\text{stress})^2$$

1% at 700 PSI

10% at 2000 PSI

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FLEXURE STRENGTH

ROOM TEMPERATURE:

80 W/O NbC	10,000 PSI
90 W/O NbC	30,000 PSI

2700°C

95 W/O NbC FLEXURE SPECIMEN FAILED
BY EXTENSIVE DEFORMATION AT 13,000 PSI.

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COEFFICIENT OF THERMAL EXPANSION

CTE OF 70 - 90 W/O COMPOSITES IS APPROXIMATELY THAT OF
PURE CARBIDE $\sim 7 \times 10^{-6}$ in/in/°C

NOT SENSITIVE TO COMPOSITION

NO DIFFERENCE BETWEEN GRAPHITE POWDER AND VARCUM FLOUR.

COEFFICIENT TO THERMAL DIFFUSIVITY

<u>SAMPLE</u>	<u>CM²/SEC</u>		
	1000°C	1500°C	2000°C
ATJ	0.125	0.103	0.088
85 W/O NbC	0.132	0.126	0.107
90 W/O TaC	0.142	0.131	0.120

ROOM TEMPERATURE - YOUNG'S MODULUS

(STRAIN GAGE DATA)

80 W/O NbC	10×10^6 (FLEXURE)
95 W/O NbC	50×10^6 (FLEXURE)
100 W/O NbC	70×10^6 (COMPRESSION)
100 W/O TaC	85×10^6 (COMPRESSION)
100 W/O ZrC	55×10^6 (COMPRESSION)

STRESS-STRAIN DIAGRAMS SHOW MATERIALS ARE ELASTIC AT ROOM TEMPERATURE.

POISSON'S NUMBER ~ 0.2 FOR THESE MATERIALS.

ANISOTROPY WAS ~ 1.5 WITH HIGHER VALUES IN THE TRANSVERSE DIRECTION TO PRESSING.

MACHINING

UP TO 90 W/O CARBIDE DRILLS AND DIAMOND DRILLS CAN BE USED.

AT 85 W/O NbC CARBIDE DRILLS CAN BE USED FOR DRILLING
~1 LINEAR INCH.

AT 70 W/O NbC CARBIDE DRILL CAN BE USED FOR DRILLING
~20 LINEAR INCHES.

A PEDESTAL REQUIRES LESS MAN HOURS THAN A SUPPORT
BLOCK TO MACHINE.

FUEL ELEMENT END TIP MAY REQUIRE LARGER HOLES THAN
FUEL ELEMENT BECAUSE OF EXCESS REAMER WEAR IF END TIP
IS REAMED.

REACTOR DESCRIPTION

	<u>PHOEBUS-1C</u>	<u>PHOEBUS-2B</u>
CORE PRESSURE DROP	100 PSI	150 PSI
CLUSTER CROSS SECTION AREA	3.44 SQ. IN.	3.44 SQ. IN.
AVERAGE CLUSTER LOAD	344 LBS.	516 LBS.
EXPECTED LOAD DEVIATION	± 50%	± 50%
MAXIMUM CLUSTER LOAD	516 LBS.	744 LBS.
FUEL ELEMENT HOLE DIAMETER	0.100 IN.	0.110 IN.
PEDESTAL HOLE DIAMETER	0.110 IN.	0.115 IN.

INTERFACE DESCRIPTION

<u>CONTACT AREA</u>	<u>PHOEBUS-1C</u>	<u>PHOEBUS-2B</u>
FUEL ELEMENT - PEDESTAL	0.89 SQ. IN.	0.89 SQ. IN.
PEDESTAL - CUP	0.30 SQ. IN.	0.30 SQ. IN.
CUP - PYRO	0.33 SQ. IN.	0.33 SQ. IN.

<u>BEARING PRESSURE</u>		
FUEL ELEMENT - PEDESTAL	580 PSI	835 PSI
PEDESTAL - CUP	1720 PSI	2580 PSI
CUP - PYRO	1565 PSI	2345 PSI

HIGH TEMPERATURE LOAD TESTS OF
PEDESTAL AND CUP

STICKING OF COATED SURFACES AT 500 POUNDS OR GREATER LOAD
AND 4500°R.

LOADS OF 1000 POUNDS AT 2500°C FOR 30 MINUTES CAUSE SOME
SLIGHT DEFORMATION AT CUP - PEDESTAL INTERFACE.

REPEATED LOADS OF 1000 POUNDS AT 2500°C AFTER COOLDOWN
CAUSED NO OBVIOUS CRACKING.

85 W/O NbC CUP FAILED AT 1800 POUNDS LOAD (4500°R) UNIT LOAD
AT INTERFACE AT FAILURE WAS ~ 6000 PSI.

RELATIVE THERMAL STRESS OF PEDESTAL-CUP

ATJ SUPPORT BLOCK

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COMPONENT EVALUATION

70 W/O NbC PEDESTAL - CUP (COATED)

LOADED AT 500, 1000 POUNDS 30 MINUTES EACH TIME AT 2500°C. O.K.

1 RAMP AT 150°C/SEC. DOWN. O.K.

3 RAMPS AT 500°C/SEC. DOWN. O.K.

30 MINUTES AT 4800°R CORROSION TEST. LOST 3 GRAMS.

SANDED OFF COATED SURFACES THEN 30 MINUTE CORROSION TEST.
LOST 4 GRAMS. O.K.

LOADED 1000 POUNDS 30 MINUTES AT 2500°C. SMALL CRACKS IN
AREAS WHERE CARBON REMOVED.

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RELATIVE THERMAL STRESS OF TIPS

70 W/O NbC DID NOT CRACK

85 W/O NbC HAD SMALL CRACKS

3 SECOND COOLDOWN

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CORROSION TESTS OF UNCOATED COMPOSITE TIPS

140 LBS/HR., 4800°R, 550 PSIG H₂, 30 MINUTES

SHRINKAGE, INCHES

<u>SAMPLE</u>	<u>CARBON LOSS %</u>	<u>LENGTH</u>	<u>FLATS</u>
85 W/O NbC VARCUM	15%	-0.002/1.3	-0.002/0.75
85 W/O NbC GRAPHITE	16%	-0.002/1.4	-0.002/0.75
85 W/O NbC VARCUM	16%	-0.035/1.4	-0.002/0.75
75 W/O NbC VARCUM	25%	-0.004/1.4	-0.004/0.75
75 W/O NbC VARCUM	25%	+0.004/1.4	-0.005/0.75

LOAD PROPERTIES OF LEACHED MATERIAL:

1000 LBS. ON FUEL ELEMENT FACE AT 2700°C RESULTS IN LARGE DEFORMATION AND EVENTUAL CRUSHING. 85 W/O MORE RESISTANT THAN 70 W/O.

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