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APPENDIX; PRODUCTION TEST IP-353-A, RAPID DEPRESSURIZATION OF A KER LOOP

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APPENDIX:

PRODUCTION TEST IP-353-A,
RAPID DEPRESSURIZATION OF A KER LOOP

by

K. W. Norwood
R. V. Dulin
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APPENDIX:

PRODUCTION TEST IP-353-A⁽¹⁾
RAPID DEPRESSURIZATION OF A KER LOOP

FUEL ELEMENT LOADING AND OPERATING CONDITIONS

The proposed fuel element loading and operating conditions for this test are given in Tables I and II. The loading is designed to provide high tube power and near-maximum-allowable coolant outlet temperature, accompanied by low fuel surface heat fluxes.

One of the major concerns involved in designing this test is to insure that no hazard to the test loop or the parent reactor can result from the test. With regard to determining the fuel loading and operating conditions, it is apparent that a major source of hazard is the possibility that a portion of the fuel might be melted during the depressurization transient. Internal damage to the elements or an ordinary element rupture, though not desirable, will pose no significant hazard problem since: a) the tube effluent can be cribbed, and b) the fuel will be removed from the reactor following completion of the test. In order to determine the potential for fuel meltdown which may be inherent in the proposed test, the conditions which would exist during the proposed test have been compared with those which existed during a rapid depressurization incident which occurred in KER-2 on January 31, 1960.⁽²⁾ This comparison is presented in Tables III and IV. No known damage to either the loop or the fuel occurred during or as a result of the referenced incident. Study of the data in Tables III and IV indicates that the proposed test provides a greater margin of safety with regard to fuel meltdown, either from film boiling or vapor-binding of flow channels, than did the test which was involved in the incident. Therefore, it is concluded that the proposed fuel loading and operating conditions are acceptable for the rapid depressurization test.

1. HW-66673, Production Test IP-353-A, Rapid Depressurization of a KER Loop,
K. W. Norwood, R. V. Dulin, W. A. Burns and F. E. Dearing,
September 1, 1960 (Unclassified).
2. HW-64443, KER Loop #2 Rapid Depressurization Incident of January 31, 1960,
K. W. Norwood, March 15, 1960 ().

K. W. Norwood
Special Studies
Process and Reactor Development

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Special Studies
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TABLE I

~~TABLE I~~ FUEL ELEMENT LOADING AND OPERATING CONDITIONS *

Variable	Value	Units
Type of element	Natural uranium, tube-in-tube	--
Number of elements	8 10	--
Element Dimensions:		
Inner Tube		
OD	1.050	Inches
ID	0.500	"
Outer Tube		
OD	1.820	"
ID	1.450	"
Length		
Total	20.2 14.0	"
Uranium	19.9 13.5	"
Cladding		
Type	Coextruded Zr-2	--
Thickness	0.020	Inches
Type of End Closure	Normal welded	--
Loading	See Table II	
Operating Conditions:		
Type of coolant	Pressurized water with pH adjusted to 10.0±0.5 with LiOH	--
Flow		
Normal	60	gpm
Low trip	48	"
Pressure, Low Trip	1500	psig
Temperature		
Normal Outlet	271	°C
High Trip	(303)	°C
Boiling Point Suppression Trip	25	°C
Expected Boiling Point Suppression Trip	46	°C
Expected Tube Power	750-850 850-900	kW
Expected Coolant Δ T	45-50 50-55	°C

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* Charge instructions are authorized provided a revised set of loading and set of operating conditions are approved by Process & Reactor Development Operation and Process Testing Operation are provided prior to charging.

TABLE II

FUEL ELEMENT LOADING FROM THE DOWNSTREAM END OF THE PROCESS TUBE

<u>Position</u>	<u>Number of Pieces</u>	<u>Type and Material</u>
1	1	stainless steel triangular eight-inch perf
2-21	20	carbon steel cylindrical eight-inch spacers
22	1	eight-inch stainless steel triangular perf
23	1	tube-and-tube element
24	1	eight-inch stainless steel triangular perf
25	1	tube-and-tube element
26	1	eight-inch stainless steel triangular perf
27	1	tube-and-tube element
28	1	eight-inch stainless steel triangular perf
29	1	tube-and-tube element
30	1	eight-inch stainless steel triangular perf
31	1	tube-and-tube element
32	1	eight-inch stainless steel triangular perf
33	1	tube-and-tube element
34	1	eight-inch stainless steel triangular perf
35	1	tube-and-tube element
36	1	eight-inch stainless steel triangular perf
37	1	tube-and-tube element
38	1	eight-inch stainless steel triangular perf
39	1	tube-and-tube element
40	1	eight-inch - - - - perf
41	1	tube - - - - element
42	1	eight- - - - - perf

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TABLE III
COMPARISON OF OPERATING CONDITIONS,
TEST VERSUS KER-2 INCIDENT OF JANUARY 31, 1960

Variable	Value		Units
	Test	KER-2, 1/31/60	
Tube Outlet Temperature	271	271	°C
Flow:			
Equilibrium	60	60	gpm
Low Trip	48	48	gpm
High Trip	68	68	gpm
Tube Power	750-850 850-900	750	kw
Tube ΔT	45-50 50-55	45	°C
Low-Pressure Trip	1500	1500	psig
Boiling Point Suppression:			
Equilibrium	46	46	°C
Low Trip Setting	25	25	°C

TABLE IV
COMPARISON OF MAXIMUM FUEL SURFACE HEAT FLUXES
AND ADJACENT COOLANT TEMPERATURES, TEST VERSUS KER-2 INCIDENT

- NOTES: 1. Elements are numbered from the upstream end.
2. Fluxes are in BTU/hr-ft² x 10⁻⁶, Temperatures are in °C.

KER-2

Element No.	Inner Tube				Outer Tube			
	OD		ID		OD		ID	
	Flux	Temp.	Flux	Temp.	Flux	Temp.	Flux	Temp.
1	.429	238	.516	237	.286	243	.319	238
2	.419	249	.502	246	.279	258	.310	249
3	.398	260	.479	255	.266	273	.296	260
4	.367	269	.442	263	.245	286	.273	269

PROPOSED TEST

Element No.*	Flux	Temp.	Flux	Temp.	Flux	Temp.	Flux	Temp.
8 6	.292	251	.305	250	.161	254	.189	251
8 10	.201	270	.210	270	.11	272	.130	270

Sixth
*Fifth element is highest power element, ~~eight~~ ^{tenth} is highest temperature element.

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