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PROJECT 41

REPORT ON WINDOW FAILURE

MK-IV LINEAR ELECTRON ACCELERATOR

M-108

by P. C. Edwards

AEC Contract AT(04-3)-21

(Project Agreement No. 1)

DESCRIPTION

A klystron window was punctured during MK-IV operations July 17, 20, 21, 1959. This window was part of an assembly consisting of a circular wave guide and an accelerator wave guide window. The inter-window, circular wave guide was evacuated with a titanium ion pump (vac-ion-type).

The appearance of the window damage was typical of many that have been observed. The ceramic face adjacent to the inter-window vacuum chamber was blackened, whereas the tube side was clean. Marks on this ceramic surface, which were the result of electrical discharge, were roughly parallel and aligned about an axis tilted 25° to the right of vertical as viewed facing the window and klystron. In addition, the ceramic was cracked along this axis. The ceramic plate had been punctured in several places but the resulting holes were small in size. Light could be observed through the crack but not the holes. The puncture holes occurred in an area roughly one-third the disc diameter, centered on the axis noted above, and adjacent to the bottom wall of the circular wave guide.

Evidence of arcing at the circular wave guide vacuum pump out was discovered at the same time that the klystron window damage was found. The inside surface of the brass circular wave guide was darkened. Arcing between bars in the pumpout throat had produced surface melting of the brass to an extent that indicated considerable power loss in this limited area. Melting was most noticeable on the first two bars nearest the klystron and little or none on the bars nearest the load.

DISCUSSION

The exact cause of the window failure is not determinable from the evidence given above. However, some thought on this matter speculates that the following events occurred. First, klystron tube spurious oscillations may produce resonant voltages in the cavity consisting of the 1-15/32" ID x 1-21/32" long pumpout nipple which is closed all but a 21/32" hole. Second, this produced spark over between bars of the pumpout throat. Third, this arcing increased the pressure in the inter-window section. Fourth, this allowed the surface of the window ceramic to spark and hence puncture.

The subject tube window failure is but one occurrence of this nature in the experience with the last four tubes that have been installed on MK-IV, and then have been removed for various reasons (two with end-of-life temperature limiting and one with punctured glass seal). The attached table summarizes this history and includes experience starting in August, 1957, the period in which MK-IV utilization increased from an average of 50 to 60 hours per month to an average of 70 to 80 hours per month accelerator operating time.

The hours per month accelerator operating time includes the total accelerator running time plus the time that the machine is ready to run in favor of a project. On the other hand, klystron operating time includes only the total time that the tube is receiving beam power as indicated by the average current flow to the tube cathode.

#### OPERATION AT TIME OF FAILURE

The klystron window of high power klystron unit No. 44 was punctured during a tube processing run on MK-IV station No. K-2. This run was made for the purpose of increasing the tube's beam operating voltage to 300 kv in order to permit the MK-IV accelerator's use up to a required 80 Mev.

The high beam voltage was necessary because the efficiency (25 per cent) of klystron tube unit No. K-39 operating in accelerator station K-1 called for 300 kv (165 amps pulse) peak beam pulse voltage in order to provide the 50 Mw peak beam power required for 12.5 Mw peak rf power input to the accelerator. The present arrangement in the MK-IV modulator using a common charging choke dictated that both klystrons were operated at the same charging voltage level. Thus, in order to produce an 80 Mev energy level, accelerator section No. 1 required klystron unit No. K-39 to operate at 300 kv beam pulse (50 Mw beam input) for 12.5 Mw rf output producing 38 Mev (12° accelerator), and accelerator section No. 2 supplied by klystron unit No. K-44 operated at 300 kv beam pulse (50 Mw beam input) for 15 Mw of rf output producing 42 Mev (10° accelerator).

The first evidence of window failure was the erratic wave shape of the signal of a crystal detector located at the accelerator section No. 2 rf input. Disassembly of the inter-window circular wave guide assembly revealed the window damage, which was confirmed by failure to hold vacuum in the klystron tube. The klystron heater power and the diffusion pump were previously turned off and the nitrogen trap was blown dry.

The particular inter-window circular wave guide section consists of a 3" ID brass tube with two standard 3-3/4" ID 90° ring groove flanges, 3-11/32" face to face. The pumpout nipple is a brass tube 1-15/32" ID x 1-21/32" long. The pump end of the nipple is closed all but a 21/32" hole. The vacuum pumpout throat at the wall of the 3" circular wave guide is made of (7) 1/8" wide slots parallel to the transverse "E" axis. The gaskets used are (2) 1/8" cord x 3-3/4" ID size 18 white "O" rings, compound KFE 5909, product

of Vinylloyd Co., Los Angeles, Calif.; and the pumpout seal is (1) 1/8" cord x 1-3/4" ID teflon. The inter-window space, titanium ion vacuum pump does not have a sensitive overpressure warning system and thus a complete history of pressure is not available. However, checks from time to time during the tube processing period did not indicate anything above  $10^{-5}$  mm hg.

Klystron unit K-44 was removed from service 7-21-59 for purposes of repair and reconditioning.

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KLYSTRON PERFORMANCE SUMMARY

MK-IV LINEAR ELECTRON ACCELERATOR

UNIT NO.	MK-IV ACCEL. STATION NO.	DATE INSTAL.	PERIOD IN STATION DAYS	BEAM PULSE TOTAL ON TIME, HOURS	REASON FOR REMOVAL	NOTES
K-16	K-1	9/10/57	393	700	Temperature limiting	+ 18 per cent beam pulse voltage reflection
K-51	K-1	11/13/58	166	279	" "	Processed in MK-IV accelerator, ready for use, 5/11/59.
K-39	K-1	4/28/59	120	208	Transfer to Sta. K-1 on account of low efficiency (25 per cent).	On loan from MK-III
K-49	K-1	8/27/59				Result of loss of focus current
K-39 (Sealed-off)	K-2	8/16/57	251	277	Punctured glass seal	
K-44	K-2	4/25/58	451	550	Punctured klystron window	
K-43	K-2	7/22/59	36	31	Removed on account of excessive spurious oscillations.	During attempt to operate at 300 kv.
K-39	K-2	8/27/59	---	---	Propose removal in Nov. 1959 on account of low efficiency (25 per cent).	Not fully processed before installation in MK-IV.

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