national accelerator laboratory

TM-227
1101.1

SHORT-TERM RADIOACTIVATION OF LINAC COMPONENTS BY 66 MeV PROTONS

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I. INTRODUCTION

It has been suggested that a 66 MeV proton beam be taken from the third linac tank and injected into the booster as a test of the beam transport system and beam capture by part of the booster. On its way through the linac enclosure to the booster, this diverging beam would pass through linac tanks in various states of completion. Drift tubes already in place in these tanks will be variously irradiated by the beam, and thus radioactivated.

Depending on the intensity and duration of the 66 MeV proton losses, the residual activity in drift tubes and other components may be high enough to interfere with subsequent assembly and adjustments. In order to estimate the severity of this potential problem, we have calculated the residual activity and resulting exposure rate from a drift tube for various irradiation and cooling times.

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II. RESULTS AND DISCUSSION

The method of calculating residual gamma activity caused by proton-induced reactions was discussed in TM-210 and its Appendix.

The present calculation was characterized as follows:

1. Geometry: The proton beam was assumed to hit the front face of a drift tube; the exposure rate at a point inside the tank and 30 cm away from the beam line was calculated using a point-source geometry and no gamma ray absorber.

2. The buildup of each radionuclide during irradiation was treated explicitly. The calculation presented in TM-210 assumed that all activities had reached saturation, as would be the case after several years of irradiation.

3. In interpolating to 66 MeV proton energy, the induced activity level was taken to be proportional to the nonelastic interaction probability; where $P_{NE}(E) \sim E^{1.562}$, E in MeV.

Figure 1 gives the residual exposure rate (R/hour) per incident proton/sec. for 1, 3, 10, 30 day and infinite irradiation times, and cooling times ranging from 8 hours to 30 days.

The actual exposure rate will be proportional to the linac beam current and loss rate. Don Young believes that it would be possible to run the 66 MeV portion of the linac with an intensity as low as 7×10^{12} protons/sec. (10 mA pulses, 25 μsec wide, at 5 pulses/sec). Operation at lesser intensity would be harder and more erratic.

After emerging from tank 3, the highly diverging beam will be focused into a parallel beam by quadrupoles located where tank 4 would normally be. (Tank 4 would have been moved aside to make room for these beam elements). The beam would then enter tanks 5, 6 and 7. Some quadrupoles in these tanks would have to be energized to keep the beam from blowing up.

This mode of operating these tanks is radically different from the mode for which they were designed. It is very difficult to predict what fraction of the beam will be lost in tanks 5-7. However, a reasonable estimate is that if the improvised beam transport system were carefully lined up, one might expect to lose less than 5% of the beam at a single point, and less than 20% more or less uniformly in tanks 5-7. Table I gives the resulting exposure rates near a single point loss for various beam intensities, loss rates, and irradiation and cooling times. (The exposure rates resulting from losses distributed continuously through tanks 5-7 are much lower than the exposure rates resulting from the loss of the same number of protons at a single point).

Exposure rates after 3 days of cooling resulting from the low current and loss rate given in the first lines of Table I would not be high enough to interfere with further linac assembly. However, if the beam current and loss rate were each to increase by factors of 2 or 3, the exposure rate after 3 days of cooling would be uncomfortably high, and additional cooling time would be required before further work in that area could proceed.

III. CONCLUSION

These results indicate that although any attempt to transport 66 MeV beam through subsequent linac tanks must be planned carefully so that a minimum amount of beam is accelerated and lost, such an exercise would not interfere seriously with the subsequent assembly and tuneup of tanks 5 through 7. Operation of the linac at 66 MeV should be carefully monitored so that large losses will be detected when they occur. If preliminary beam transport calculations indicate the locations of significant point losses, then disposable aperture stops should be used at those points.

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TABLE I

Linac Current Protons/sec.	Loss at Single Point	Time on, Days	Exposure Rate in mR/hr after cooling period of		
			1 day	3 days	10 days.
8×10^{12}*	5%	3	48	5	1
		10	54	7	3
	10%	3	96	10	2
		10	108	14	6
2.5×10^{13}	5%	3	144	15	3
		10	162	21	9
	10%	3	288	30	6
		10	324	42	18

* Minimum current estimated by D. Young.

Residual exposure rate after 1, 3 and 10 days of cooling for several possible 66 MeV operating conditions.

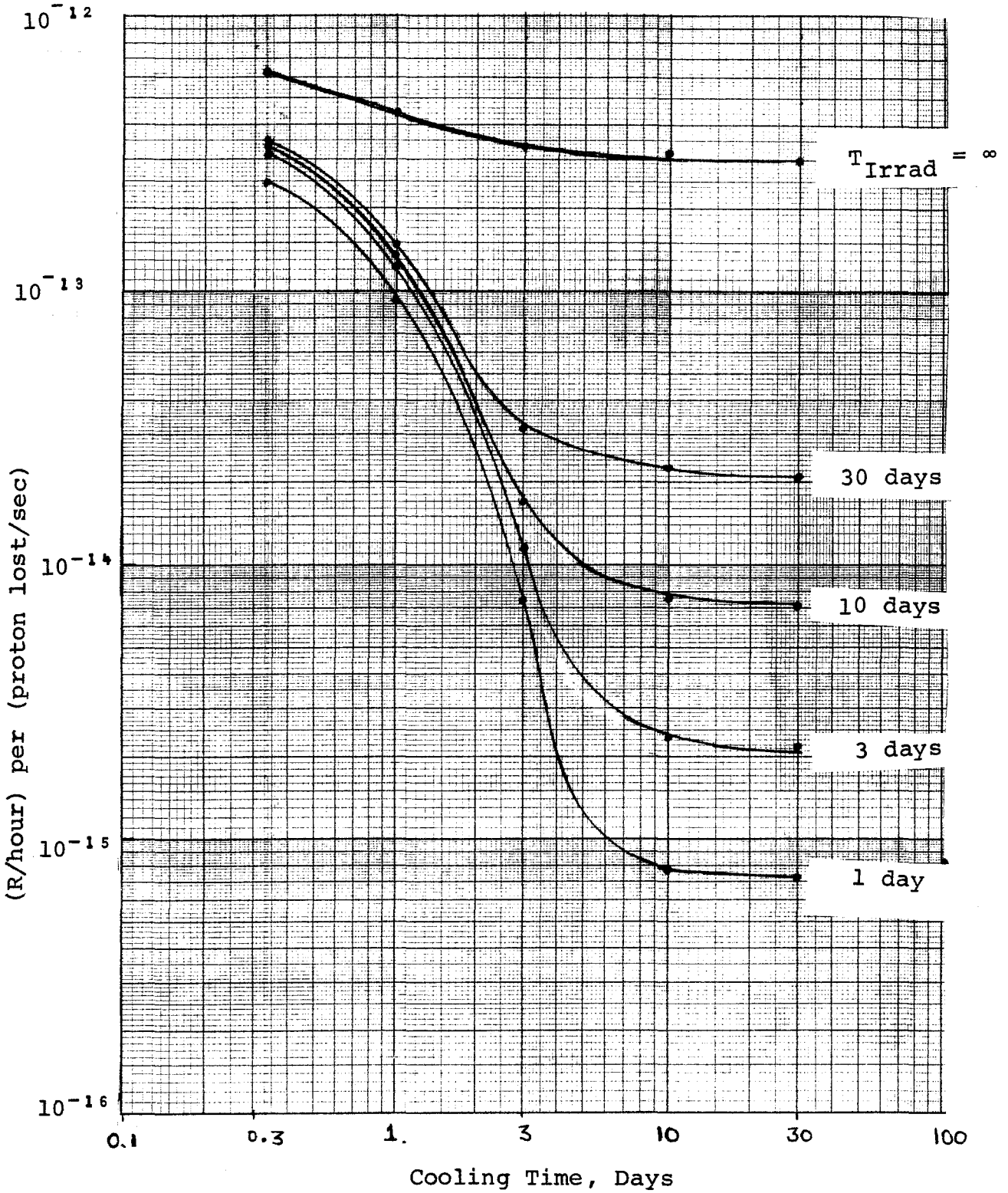

Figure I. Residual exposure rate per incident proton/sec for various irradiation times, and cooling times ranging from 8 hours to 30 days.