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PROPOSED RADIATION POLICIES FOR PROJECT M

In our proposal for the construction of a two-mile linear accelerator at Stanford (April 1957), we stated the following policy regarding radiation tolerances:

> "Since the general tendency has been toward more conservative radiation tolerances, we are adopting here for design purposes the following tolerances:
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> 1) 30 mr/40-hr working week for 'radiation workers';
> 2) A level equal to natural background radiation (or 0.002 r per elapsed week) for all areas outside the project boundaries will be maintained. This is about a third of the 'doubling dose.'"

Since that time, the AEC has adopted specific regulations (given in AEC 0524-02-F) which essentially adopt the recommendations of the National Committee on Radiation Protection ("Maximum Permissible Radiation Exposures to Man," 8 January 1957). In addition, the Federal Radiation Council was established during the last year, and has issued its first report, "Background Material for the Development of Radiation Protection Standards" (13 May 1960).

Clearly, the radiation standards adopted in connection with the design of the two-mile accelerator should meet the AEC regulations, but in addition, considering the long-range nature of the project, a more conservative approach is indicated for the following reasons:

1) Past experience has been that radiation doses considered reasonable have decreased. For example, the average population exposure recommended as a guide for radiation protection standards by the FRC for large populations is half that given in the AEC Manual and in the recommendations of the NCRP.
2) The intensity estimates provided by accelerator designers at the inception of projects have been realistic; in some cases, in fact, intensities of the completed machines have exceeded the original estimates.
3) It is recognized that there is no level of exposure below which the expected statistical genetic effects will be zero, and therefore any

exposure must be justified in terms of the benefits derived; in the words of the FRC report,

> "Under the working assumptions used, there can be no single 'permissible' or 'acceptable' level of exposure, without regard to the reasons for permitting the exposure. The radiation dose to the population which is appropriate to the benefits derived will vary widely depending upon the importance of the reason for exposing the population to a radiation dose."

For this reason, the FRC concludes, "... all exposures should be kept as far below any arbitrarily selected levels as practicable."

For these reasons, the policies adopted in designing the accelerator will under any circumstance rely on our best judgment, and will also be affected by the problem of relations between the project and the neighboring communities.

In connection with this project, we are concerned almost entirely with the control of penetrating whole-body radiations. There will be some problems with the handling of irradiated targets and other materials involving short-range radiations, and also with inhalation of short-lived radioactive gaseous isotopes which would be produced in closed target areas [for example, N^{13} formed by the reaction $N^{14}(\gamma,n)N^{13}$]. We believe that these can be controlled quite readily by appropriate handling procedures in the first case and ventilation in the second.

A summary of various whole-body exposures to penetrating radiations and recommended levels is given in the following table:

RECOMMENDATIONS ON MAXIMUM ANNUAL EXPOSURE TO WHOLE-BODY PENETRATING RADIATION

	Occupational	Non-occupational Individual	Non-occupational General Population (30-yr average)
AEC Manual 0524-02-P	5 rem	0.5 rem	0.33 rem
Federal Radiation Council, Report 1 (13 May 1960)	5 rem	0.5 rem	0.167 rem
Stanford Project M Proposal, April 1957	1.5 rem	0.1 rem	0.1 rem
For comparison:			
U.S. genetically significant per capita average exposure from natural sources			0.08 - 0.170 rem[1]
U.S. genetically significant per capita average exposure from man-made sources (mainly medical)			0.08 - 0.220 rem[1]

[1] Summaries of Federal Radiation Council, Background Material for the Development of Radiation Protection Standards, Tables 3.1 and 3.2 (13 May 1960); See that report for discussion.

Our recommendation therefore proposes to limit radiation exposures to persons not directly involved in the project to levels below the average per capita level to which the population in the U. S. is now exposed. We do not consider it advisable to adopt a different standard for persons in the neighborhood of but not directly involved in the project from the standard for the general population. Apart from the great difficulty of justifying any other position to neighboring communities, we believe that giving substantial radiation exposures to persons not directly concerned with the project is not in accordance with the general guide-lines of the FRC quoted above. In addition, considering the general downward trend of occupational maximum permissible radiation exposures, we should like to retain as an objective the design figure of 30 mrem/week as given in our original proposal, which is a third of that allowed by the AEC.

The technical problems of radiation control of the project are such that our ability to meet the tolerances specified depends both on initial design of the shielding, target area arrangements, etc., and on the actual procedures used during machine operation. It is not feasible to design the target area so that it is absolutely impossible to cause excessive radiation levels arising from human error or equipment malfunction. The target area facilities must therefore include radiation detection devices and monitors which will automatically shut off the beam in a short time so that the accidentally high radiation levels will not contribute significantly to the long-time average exposure of the population. In addition, physical barriers must be provided so that even in the very short time before the beam can be shut off excessive exposures are prohibited for the most unlikely and extreme condition in which the entire beam is made to miss the shielding arrangements within the target area.