BRITISH AND FOREIGN OFFICIAL PUBLICATIONS

Medical X-Ray Protection up to Two Million Volts. Handbook 41, U.S. Department of Commerce, National Bureau of Standards, 1949. Pp. vi+43; six figures. Price 15 cents.

This little handbook is one of a series prepared or being prepared by a number of subcommittees drawn from the U.S.A. National Committee on Radiation Protection and sponsored by the National Bureau of Standards. The importance of the information and expert guidance contained in this issue is out of all proportion to its size.

It is inevitable that even the safety aspects of radiation should at the present time be permeated with conceptions and measurements of a highly technical kind. Ultimately, it may be presumed, the maintained application of radiant energy or atomic energy to peaceful ends will render possible so wide a dissemination of knowledge on the practical fundamentals of the subject that workers and technicians will be able to handle the external problems without any knowledge of the existence of Planck's constant as effectively as an engine-driver does an engine without any necessary appreciation of the second law of thermodynamics.

In the present stage of development it is obvious that codes of safety rules for the protection of workers cannot be couched in absolutely non-technical language, nor can the responsibility for safe working be placed on anybody other than well-trained experts. In fact the little handbook, in its excellent introductory definition, describes such an expert thus: "A person having the knowledge and training needed to measure radiations and to advise regarding radiation hazards. The physician or dentist employing him shall be responsible for seeing that he has the necessary training and education. Certification by competent authority by a board set up for the purpose is desirable."

Although it is claimed that the "recommendations are intended primarily for the protection of the radiation worker and not for the patient," in fact considerable guidance is given in the safe practice of radiation therapy from the patient's point of view. It will be known, even to non-radiologists, that there has been a good deal of difference of opinion as to the maximum total dose of radiation of the hazardous kinds that is permissible for the human subject, whether a patient treated with a primary radiation passing through a controlled aperture, or a worker exposed to direct radiation from the source, to secondary radiation arising from the surrounding matter struck by the primary radiation, or to scattered and stray radiation.

The International X-ray and Radium Protection Commission at the Fifth International Congress of Radiology in 1937, and the British X-ray and Radium Protection Committee's revised recommendations of 1938, led to the more or less general acceptance of 1 international Röntgen (r) per week as the tolerance limit for normal persons working in satisfactory conditions. This limit was accepted by, among others, the Australian Department of Health, which on the basis of a seven-hour-a-day continuous radiation and a five-day

week laid down as the toleration dosage approximately 10^{-5} r per second. The precise reason for setting this limit is by no means clear.

The Atomic Sciences Committee of the Association of Scientific Workers in 1948 issued a pamphlet entitled "Protection of Workers from Radiation Hazards" and indicated that 0.1 r per eight-hour day and 0.5 r per five-day week was a generally accepted tolerance-dose. But, while it was pointed out that this level was at that time accepted in the U.S.A., it was added that future work might tend towards lowering this figure, and that all effort should be made to keep below the so-called permissible maximum of that time.

As in all cases in which it is necessary to lay down maximum permissible concentrations—whether of gases, dusts, fumes, or radiations—the problem is in part to find the maximum concentration which will not adversely affect, acutely or chronically, any system or organ in the body. Thus, in the case of x rays and γ rays, it is quite conceivable that a maximum dose could be laid down which would not manifestly harm any organ system and which yet would in the long run exercise severe genetic effects on succeeding generations of descendants of the exposed persons.

Considerations of this kind, we imagine, have led the compilers of this little handbook to drop the maximum permissible dosage rate to 0.3 r per week or, based upon a forty-eight-hour week, $0.17 \times 10^{-5} \frac{\text{r}}{\text{sec.}}$, which is about $\frac{1}{4}$

of the dose per unit time of the 1938 standard.

This is an important revision for it is manifestly less pessimistic than that of the International Commission on X-ray and Radium Protection which brought down the tolerance dose to 0.02 r per day, which (as stated by L. F. Curtiss in Patty's "Industrial Hygiene and Toxicology," 1948) was "intended to take care of genetic injuries and may be subject to further revision as additional information on this subject becomes available." Having regard to the fact that L. F. Curtiss served in the preparation of the handbook (issued in 1949) here reviewed, and was responsible for the statement quoted, it is apparent that second thoughts may appear overnight in this matter.

It is interesting to note that Koelsch, in his revised *Lehrbuch der Arbeitshygiene* issued as late as 1947, still gives the tolerance dose as 0.25 r per day and 1.25 r per week, but discretion was given by a German Government decree in 1941 to the Factory Inspectorate to forbid the employment of certain age-groups of workers if the daily dose exceeded 0.025 r.

It seems reasonable to conclude that even 0.3 r per week may not be a final agreed maximum: much must yet remain to be discovered on perhaps subtler actions of the penetrating rays, and modifications may still be necessary. Judged from the results of the well-known experiments on *Drosophila melanogaster*, it must be kept in mind that the rise in mutation rate brought about by radiation is proportional to total dose, so that a small dose repeated over many years will have the same genetic effect as a large dose given on a single occasion.

Still, it has to be remembered that mutations are being produced in nature all the time, that defective genes in the enormous majority of cases fail in the process of mitosis, and that the likelihood of two defective genes meeting is significant only when both parties have worked in radiations. In medical radiological practice it requires a good deal of careless ignorance to produce even temporary sterility in males (300 to 700 r) and permanent damage in female technicians having regard to the significant protection layer between the surface and the ovaries.

Maximum dosage at 0.3 r per week should be quite safe hæmatologically: radiologists in this country have found that even 0.17 r per day for twenty months produced no effect, clinically or hæmatologically. As for effects on the skin, it is probably true to say that one Röntgen per day (1 r) can be tolerated by the normal skin indefinitely without damage. Still, it must be recorded that some American workers consider that 0.1 r per day is a safer maximum to work to for the skin.

From the industrial medicine point of view the recommendations include some interesting points. Pre-employment examination is essential and must include an occupational history, a description of any unusual radiation exposure from previous examinations, diagnostic radiographic examinations or any radiation therapy, a detailed family history for hereditary disease, a complete physical examination, x-ray examination of the chest, and a complete blood count (including platelets). In the case of childless married persons, a record must be kept as to whether childlessness was due to birth-control measures. It is recommended that blood counts should be performed at 3 p.m. on two or three successive days to indicate in some measure the variations characteristic of the individual. A total white count of less than 4,000 should lead to rejection. Unless monitoring of installations and personnel (pocket ionization chambers or films) is practised, blood counts should be made every three months, otherwise not less frequently than every six months. A fall in white counts of 2,000 or more may indicate injury and should be investigated, but such a fall is often a normal variation. Notable authority has sometimes been scathing on the value of blood counts: reliable quantitative deviations from "normal" as an index of early radiation disease are not yet available.

In addition there should be a routine annual physical examination and a review of the medical history for all workers exposed to radiation as a routine.

A significant omission in the health precautions is any recommendation as to the length of holiday to be given and the maximum time to be worked in a single day. The German decree of 1941 laid down that workers in non-medical radiation and radio-active work must be given a minimum of eighteen days' holiday, of which fourteen days must be consecutive. The same decree states that not more than eight hours must be worked in one day under any circumstances, and not more than forty-eight hours a week, but, further, if more than twenty-four hours per week are worked, for every additional two hours worked one hour's free time on full pay must be allowed by deduction from the working time in the same

week, and no other work given in that free time. This signifies that a forty-eight hour week on this kind of work is really thirty-six hours' actual work and twelve hours' free time which, the decree says, should as far as possible be consecutive. The American maximum of 0.3 r probably is low enough to obviate the necessity of a regulation such as that in the German decree, but there can be no doubt of the need, or at least desirability, of a holiday interval of at least fourteen consecutive days per year in addition to the monitoring control which may determine longer periods of freedom from all exposure.

Many of the sharply indicated precautions in this handbook deserve appreciative comment. We wonder how frequently in dental x-ray work in this country the following precaution is practised: "Under no condition shall the operator or any regular assistant hold a film in place when an x ray is taken. In case of emergency a relative or other person not habitually exposed to x rays may hold the film." (Precaution for Dental Roentgen Installation operated at Potentials up to 70 Kv peak.) Or in hospital radiographic departments, how often the following rule is infringed: "No persons other than the patient and those needed to hold the patient shall be in the radiographic room during exposure."

Very valuable is the reminder that "grenz rays" (soft x rays produced at less than 15 Kv) "may cause the same kind of injurious effects as harder x rays, although limited to superficial layers of tissue."

Whilst it is reasonable to assume nowadays that clinicians do not engage in the long conversations they were wont to enjoy in the x-ray departments, it may yet be wise to apply the recommendation by the authors of the handbook that where therapeutic work is going on at potentials over 250 Kv there should be a notice such as "X-rays! Do not loiter" at all infrequently occupied spaces where radiation hazards exist, and it is desirable to have such notices illuminated. It seems almost redundant to include among the recommendations on electrical protection one forbidding installation or operation of x-ray apparatus in dangerous locations, such as an anaesthesia room, unless it is explosion proof; but evidently the authors prefer to be safe rather than sorry.

The severely practical nature of this handbook has obviously necessitated a great deal of compression and a minimum of theoretical treatment. Valuable curves of radiation attenuation for potentials from 75 Kv to 2,000 Kv are given in thickness of Pb and concrete. Tables giving primary protection-barrier requirements (in Pb or concrete as necessary) for potentials from 400 Kv to 2,000 Kv for different target currents, and target distances enable calculations to be made for barrier thicknesses required as protection at occupied points around the tubes.

Although this handbook is meant for operators of medical x-ray apparatus, it can be read with some pleasure if not with ease by anyone who understands a little about medical radiography and desires to appreciate the great strides being made towards safety in this specialized and potentially very dangerous field.

M. W. Goldblatt.