HEALTH PHYSICS ENGINEERING

A. H. EMMONS
Research Reactor Facility, University of Missouri, Columbia, Missouri, U.S.A.

Abstract—The first obligation of the health physicist is the *prevention* of radiation exposures. The earliest opportunity to practice this prevention is in the design and engineering of nuclear installations. The function of health physics engineering is to reduce all accident risks to the lowest level compatible with the economic and technical requirements of the proposed facility.

This paper describes the health physics problems encountered in the design, construction and operation of a ten megawatt university reactor facility. The total facility to be described consists of the highest flux university reactor facility in the United States together with a laboratory complex of 18 radioisotope labs, a 5000 Ci cobalt irradiator, 300 kV X-ray irradiator, hot cell, shops, library, and offices.

The tendency in all fields of science is toward specialization. Health physics is no exception. Each topic within the framework of the discipline is being further differentiated. Health physics engineering must include an integration of all relevant topics (factors) as they influence design and engineering. It is then a systems engineering problem.

The engineer is an applied scientist. He uses the findings, facts and formulas of all sciences in attaining a problem solution. The health physicist must have a diverse background of science from which to withdraw information applicable to the solution of an engineering problem. These inter-relationships and dependencies are defined.

DISCUSSION

B. W. Emmerson (*U.K.*):

In addition to the contaminants reported, have you made an analysis of the surface contamination for the presence of low energy emitters such as S^{35}? This nuclide represents a considerable proportion of the total surface dose in CO_2 coolant circuits on the U.K. Civil Reactors and is difficult to detect, being a low energy, pure beta emitter.

J. Barbier:

Oui, nous les avons observés. Nous pensons qu'ils proviennent d'une activation de certaines huiles. Cependant ce n'est pas une préoccupation majeure. Le Hg^{203} nous préoccupe davantage, car il a lui aussi un β mou que l'on ne détecte pas avec les compteurs en verre. Nous sommes dans l'obligation de rééquipper les centrales de Chinon avec des compteurs à fenêtre mince.

L. de Franceschi (*Italy*):

Può l'autore fornire qualche esempio di ambienti nei quali il superamento di un determinato livello di radiazione provoca la chiusura automatica delle porte? In particolare, vi sono persone che lavorano in tali ambienti quando il sistema automatico è innestato con il pericolo conseguente di rimanere chiuse all'interno dell'ambiente stesso?

H. de Choudens:

Certains locaux tel le local des échangeurs ou la cellule chaude se trouvent automatiquement verrouillés lorsque l'intensité de rayonnement à l'intérieur est trop forte. Les serrures électromagnétiques assurant ce verrouillage par exemple dans le local des échangeurs ont une sécurité qui leur permet d'être toujours ouvertes de l'intérieur pour le cas où justement un agent s'y trouverait enfermé.

D. K. Craig (*South Africa*):

Mr. Barbier, would you perhaps like to speculate as to the source of the free uranium which you have routinely observed to be present in the coolant CO_2 gas? It seems to be rather strange that you should observe such uranium, as I would not normally expect there to be any free uranium in the CO_2.

J. Barbier:

Les produits de fission observés dans le CO_2 proviennent de l'uranium ayant résisté au nettoyage des gaines du combustible. C'est ainsi que pour le 1er chargement de EDFI nous avons estimé la quantité d'U libre à 1 gr pour 17.000 cartouches. C'est une valeur importante qui vaut sensiblement 100 cm^2 d'uranium dégazant sur une épaisseur de 6 microns. Cette épaisseur est celle généralement admise pour la diffusion du Xe et du Kr.

On voit que dans ces conditions une rupture normalement détectée n'apporte que quelques pourcents de plus de Xe et Kr dans le CO_2 (globalement, bien entendu).

G. Lewis (*U.K.*):

Mr. Chairman, I would like to thank you for this opportunity to say something more about my paper. I am prepared in detail to read the paper, but I will briefly enlarge the details which are given in the abstract. When the stations were designed and before they came into operation, there was a great deal of speculation as to the doses that would be received by the personnel and it was only during the first years of operation that the facts of the situation really became clear. My paper just presents the first three complete years of operation of the stations at Berkeley and Bradwell and gives the actual doses received by classified workers at those two stations. Making recourse to the table of the results given in the paper itself, during the years 1963 to 1965 the percentage of workers at Bradwell and Berkeley receiving not more than 0.5 rem per year lay between the ranges 45% and 87%. I think this is an illustration of the extremely low doses to be received at reactor stations of the type chosen by the Generating Board for power production. Among the people receiving larger doses than this, those receiving for example more than 1.5 rem per year amounted to not more than 4.3% at the biggest. The sources of these radiations are described in the paper and at this point I feel I should make clear what may appear to be a discrepancy between what I have to say and what Mr. Barbier mentioned in his paper to do with N^{16}. He was dealing entirely with a question of contamination of circuits and I am dealing with external radiation doses from the circuits. While N^{16} may not contribute anything to the contamination, it certainly does contribute to the external dose. Gamma spectrometry carried out at various places on the nuclear power stations sites does reveal the rather high energy gammas from N^{16} decay as a prominent part in the external dose received by the personnel. N^{16} certainly is important in the doses to be received during the operations of the stations and another factor which significantly contributes to doses at nuclear stations run by the Generating Board is one mentioned by Mr. Emmerson, namely doses received during maintenance and refuelling operations with material which has been irradiated in the core of a reactor. Here it is generally a question of radiation dose to the extremities, finger-tips or hands which have to carry out the work on irradiated material. A table given in my paper makes it clear that, although a careful control is required in these situations, doses can be kept well within those specified by ICRP, enabling necessary maintenance to be carried out for reactor stations to be kept in good conditions. The conclusions of the paper are that during these first four years of operation of the civil nuclear power stations in the United Kingdom, the operation of the stations has not been embarrassed by external radiation doses received by the personnel. One final point is that experience of the earlier stations fed back to the design departments concerned will certainly lead to reduction of doses at later designed stations.

A. H. EMMONS (*U.S.A.*):

Thank you, Chairman Nishiwaki, for the opportunity of talking for a few moments. There is no doubt in my mind that the health physics people are doing a fine job in radiation monitoring, dosimetry and environmental control. However, I should like to make a plea that we enter the picture in the design stage more frequently and depend less upon feed back of information lately gained. Specifically, let me make the suggestion that there are design problems which should be a basic concern to the health physicist.

D. K. CRAIG (*South Africa*):

I would like to comment upon Dr. Emmons' plea that health physicists be given greater opportunity to participate in the planning of nuclear facilities at the design stage. I agree that it would greatly minimize our subsequent problems in the control of contamination if we were heeded. I have been given the opportunity of participating in the review of building plans, but have frequently found that my requests for the positioning of change rooms, over-shoe barriers, etc., in order to provide for the efficient separation of contamination areas, from areas where contamination should not normally arise, have often been overruled in the interests of economy. Does Dr. Emmons have any solution to offer to this problem?

A. H. EMMONS:

Well, first I should say that you can't be economically careless; secondly, I should suggest that one way is to become the head man in the operation and then you can dictate the facilities to be put in.

L. DE FRANCESCHI (*Italy*):

Con quale metodo viene controllata la contaminazione dell'aria negli ambienti di lavoro? Come vengono fissati gli allarmi per evacuare l'edificio?

A. H. EMMONS:

(a) We monitor by means of scintillation counters located in wells in the off-gas ducts.
(b) These counters (and associated circuitry) initiate alarms.
(c) Personnel are instructed to vacate the labs and reactor by a defined pathway in any instance of an alarm (independent of the identity of the initiating event).

M. DENNET (*U.K.*):

Mr. Bertron mentioned in his paper that operations and maintenance personnel carry out certain Health Physics duties. I should like Mr. Bertron to enlarge on the extent of this work. In addition could Mr. Bertron say something about the number of permanent Health Physics Staff at Chinon. A figure of 40 personnel is typical for U.K. Civil Nuclear Stations.

L. BERTRON:

Tous les agents de la Centrale sont intéressés à la radioprotection. Notre organisation repose cependant sur un certain nombre d'agents ayant des responsabilités particulières dans ce domaine. Ce sont:

—les techniciens de radioprotection—chefs de bloc: grosso modo 1,5 agent par quart et par tranche fait de la radioprotection; il y a 5 équipes de quart en roulement par tranche;

—à l'entretien, les chefs de travaux: pour les 3 tranches de Chinon, environ 80 techniciens ont reçu une formation qui leur permet de conduire des travaux dans des zones à risques nucléaires. Ces techniciens sont responsables d'une équipe d'exécutants. Ils travaillent indifféremment à l'intérieur et à l'extérieur de la zone contrôlée;

—au Service Technique, 6 agents sont plus spécialement chargés des mesures de radioprotection.

Il faut noter que sur le site de la Centrale de Chinon, 50% des travaux de décontamination du matériel, le traitement des effluents liquides et des déchets solides sont entrepris dans un atelier indépendant de la Centrale qui possède ses propres agents de radioprotection.

Le développement des films dosimètres et le contrôle de la chaîne alimentaire ne sont pas effectués à la Centrale.

Y. NISHIWAKI (*Japan*):

Do you have the practice in the United States of comparing the dose rates after the operation of the nuclear installations with those at the original design stage and to re-evaluate the validity of the design? I think such a comparison would be extremely useful for the improvement of the design.

A. H. EMMONS:

To the best of my knowledge no formal comparison technique exists. However, in most instances the designer is also the operator of a facility and then has the opportunity to compare design criteria to actual operational results. I agree that we should more frequently make these comparisons even if they embarrass us!