COMMISSION OF THE EUROPEAN COMMUNITIES

DIRECTORATE GENERAL FOR SOCIAL AFFAIRS

HEALTH PROTECTION DIRECTORATE

SCIENTIFIC COLLOQUIUM

on

MEDICAL SUPERVISION OF WORKERS EXPOSED TO IONIZING AND NON IONIZING RADIATIONS

Brussels - 28 and 29 November 1974

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I N T R O D U C T I O N

The general principles of medical surveillance for workers exposed to ionizing radiation were defined in the Euratom Basic Standards in 1959.

These principles, which are in accordance with the early ICRP publications, have been adopted by the national authorities and implemented without difficulty. However, because of the forthcoming publication of the revised Basic Standards in accordance with recent ICRP recommendations, the Commission decided to organize a meeting of doctors responsible for the medical surveillance of workers exposed to ionizing radiation in order to disseminate as widely as possible the results of experience gained in the field of radiological protection and to pinpoint the practical difficulties which might arise when the principles were applied.

The Commission also considered it important to inform doctors specializing in radiological protection about the principles to be followed by those responsible for the health protection of workers exposed to non-ionizing radiation, particularly microwaves and Laser beams.

This volume contains the English translation of all reports presented. An edition in the original languages has been published in May 1975.

Dr. P. RECHT

Director of Health Protection
Commission of the European Communities

Luxemburg, September 15, 1975

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OPENING ADDRESS

Dr. P. RECHT (CEC)

Ladies and gentlemen, today's colloquium is the latest in a series of meetings of which the most recent was held in 1970. We felt that the time had come to hold a meeting of doctors responsible for supervising the health of workers exposed to ionizing radiation, and to give the delegates of the three new Member States of the Community a chance to meet their colleagues from the six original countries, who have achieved such full and profitable cooperation under our auspices. I am very happy to welcome, on behalf of the Commission, all the participants from the nine Community countries and from the international organizations, and to open this valuable and important colloquium which will help the Commission to gather the information it requires for the next stage of its work and for the revision and application of the Basic Standards. As you are no doubt aware the Basic Safety Standards for Protection Against Ionizing Radiation were adopted for the first time by the Council of Ministers in 1959 and are now undergoing revision, so as to finalize the procedure laid down in the Treaty. A number of questions, however, remain to be answered; we are still trying to find ways of reconciling the points of view expressed by particular European countries in the discussions within the Council. Some of these problems will no doubt be mentioned in the course of this morning's session and others will be touched on when we come to discuss medical records. As in the past, your discussions and exchanges of opinion at this colloquium will be of considerable interest to the Commission. You all have a great deal of experience in the medical supervision of workers exposed to radiation. We wish to hear your suggestions and comments, since they will help us improve the formulation of the directives to take account of progress and practical aspects. The work is of course nearing completion, but the final decision has not yet been taken and we will be able, to a certain extent, to make suggestions for changes on any important points. I should like to thank you in advance for your contributions and to declare open this colloquium on the medical supervision of workers exposed to radiation.

Thursday, 28 November 1974

FIRST SESSION

PRACTICAL ORGANIZATION OF MEDICAL SUPERVISION FOR THE VARIOUS CATEGORIES OF EXPOSED WORKERS

Chairman : Dr. H. JAMMET

Dr. JAMMET (France)

As Chairman of this first session I should like to thank the European Communities and in particular the Health Protection Directorate for resuming an old tradition after a break of several years - the much appreciated tradition of periodically holding meetings of doctors responsible for the supervision of workers exposed to ionizing and non-ionizing radiations, to give us an opportunity to compare our ideas and experience in this field. In this first session we shall be examining the problems of practical organization of medical supervision for the different categories of workers affected.

I am also very pleased that for the first time in this series of meetings we shall be studying all types of radiation, not just ionizing radiation, but also non-ionizing radiation. Our field of study and concern has been widened considerably and we will have to deal with all electromagnetic radiations, thus completing the spectrum of radiation taken into consideration. But we should not neglect other types of radiation - both particulate and nuclear radiation, which are more familiar to the medical services responsible for surveillance. The problems of radioacitivity are included in the programme, and we shall be discussing radioactive toxins which, as you know, are liable to emit electromagnetic and/or particulate ionizing radiation. In this session we shall also have to discuss the hazards to which workers are exposed, in order to define the forms of supervision to be undertaken by medical services. These hazards are associated with three categories of exposure: exposure to high radiation doses in acute accidents, which can be caused by both ionizing and non-ionizing radiations; medium-dose hazards and concommitant risks of occupational disease with primarily haematological symptoms; and hazards linked with low radiation doses. At present there is a great deal of scientific discussion over the extent of damage caused by the last-mentioned type of exposure. Generally speaking, though, with low dose levels and particularly in the case of radiation workers, the problem is one of random effects and the possibility of the induction of cancer by certain types of radiation. These low doses are in the same range as the maximum permissible radiation levels laid down in the European Community Directives.

A third important point to be examined is the definition of workers exposed to radiation. Radioactivity is present everywhere and all workers, and indeed all human beings, are permanently exposed to radiations and radioactivity. It is clear, then, that for the purposes of industrial medicine, we must know which workers are to be considered as being exposed to ionizing radiation. From the workers' point of view, "exposed to ionizing radiation" means that a particular risk exists. We must therefore fix the dividing line between everyday risks and the risks of exposure above a certain level, beyond which we can speak of occupational exposure to radiation.

Subsequently we might consider whether the workers exposed to radiations should or should not be divided into categories. At present this matter is being discussed in several circles at international level, with the aim of deciding whether these distinctions between workers should be retained. The European Directives only stipulate one permissible limit for exposed workers, but they also specify that workers should be divided into categories, and describe different systems of medical surveillance based on these categories. Thus there is only one series of exposure limits for all exposed workers, but for the purposes of practical organization of supervision, workers have to be divided into categories.

Furthermore, the role and the functions of the doctors responsible for medical supervision of workers will require to be clarified. Above all it is important to know whether workers are or are not fit to carry out their duties, whether they remain fit and whether they show any abnormal symptoms which could be connected with exposure to radiation. Then we must discuss the problem of the part the doctor must play in certain circumstances, especially in emergency and accident situations. We must therefore decide on the best methods of practical organization for assessing the fitness of workers, for medical supervision during their working life, and for medical intervention in the case of accidents. Lastly, the practical organization of medical supervision concerns doctors and the need for special training. Can all works doctors cope with this situation or do we, in certain cases, need works doctors specializing in this particular field? Is the concept of the approved medical practitioner viable and desirable in practice? Finally, we must of course bear in mind that at present the situation is not the same in all nine countries of the European Community. If we manage to arrive at the best common denominator for all countries, we will have succeeded in the task which we have been set for these two days.

PRACTICAL ORGANIZATION OF MEDICAL SUPERVISION FOR THE VARIOUS CATEGORIES OF EXPOSED WORKERS

Dr. E. Strambi

1. Introduction

1.1.- The main aim of today's meeting is to provide an opportunity for the doctors responsible for radiological protection in the various Community countries to exchange ideas and experiences, on the basis of the laws and regulations in force in each country. The time has perhaps come to define more clearly what medical supervision for purposes of radiological protection consists of and what its objectives are, and to discuss in greater detail the professional attainments and status of doctors authorized to practise in this field. This work should in fact be considered in the wider context of the prevention of diseases resulting from the environment and deterioration of the organism. Modern social medicine has been paying increasing attention to such diseases following the fundamental progress wrought by antibiotics.

In this connection, a critical review of their own role by doctors who have been active in this specialized branch of industrial health and medicine for many years might prove worthwhile. As far as the Community is concerned, this seems to be a particularly good time for such a review, as the basic Euratom Safety Standards, drawn up in 1959, are about to undergo extensive revision in order in particular to take into account the principles and recommendations laid down in the report drawn up by the International Commission on Radiological Protection (ICRP).

1.2- As an introduction to the discussion of the practical problems of organizing medical supervision for the various categories of workers exposed to the hazards of ionizing radiation, the following points will be investigated :

a) the kind of activities which should be subject to special medical supervision;

b) the authorization of doctors responsible for this supervision;

c) the extent of medical examination.

These are really three aspects of a single problem which has already been brought up frequently on other occasions and which could be expressed in the following way : are we still justified at this stage in asking doctors (who should be highly qualified in the specialized field of radiological protection) to devote their professional time and energy to preparing, interpreting and assessing costly checks on the health of vast groups of workers exposed in fact to a low risk? Would it be better to devote more time and energy to the individual supervision of small selected groups whose work involves a higher risk coefficient? The second alternative, undoubtedly offers more advantages, particularly as far as epidemiology is concerned; there are, nevertheless, many arguments in favour of the first alternative, and these should be discussed in detail, bearing in mind differing local situations.

2. Activities which should be subject to special medical supervision

2.1- The present Euratom directives establish the principle of compulsory individual medical supervision, carried out by authorized medical officers, for 'occupationally exposed' workers who, in a 'controlled area', may be subject to an overall irradiation dose of over 1.5 rem per year; 'certain groups of people' on the other hand, are exempt from this compulsory supervision :

a) occasionally exposed workers;

b) workers exposed to a risk below 1.5 rem per year;

c) persons usually working within a supervised area.

For these 'special groups', as we know, physical supervision only is prescribed. According to the present standards, the basic condition calling for compulsory medical supervision is thus related to the ambient environment, since it is linked to the performance of work in a controlled area. However, the definition of what constitutes such an area is not altogether satisfactory.

On the other hand, in the draft amendment to the Community directives on radiological protection which the Commission has recently addressed to the Council of the European Communities, the classification of workers is based solely on a quantitative evaluation of the risk without reference to the working environment or the duration of exposure. Article 20 of this draft in fact considers 'any worker liable in the course of his work to receive more than 1/10 of the annual maximum permissible doses' (MPD) as 'exposed to ionizing radiation', irrespective of whether the exposure is 'occupational' or 'occasional'. Depending on the type or risk, the workers are then divided into two categories, A and B, according to whether or not they are likely to exceed 3/10 of the annual MPD. Medical supervision is prescribed for both categories, but must be carried out by authorized medical officers only for workers in category A.

2.2- Analysis of the risks actually run by each worker is of prime importance in the new draft Community directives, where the problem is regarded in a way that is entirely in keeping with the general principles of industrial medical practice. The following requirements are laid down :

a) a knowledge of the place, equipment and operating conditions for the various kinds of work, with particular reference to the tasks assigned to each worker;

b) an examination and assessment of devices and methods for protecting workplaces and individuals;

c) the collection and interpretation of data relating to the monitoring of the various ambient hazard factors.

In standard industrial medical practice, these tasks are usually the responsibility of the works medical officer who can call upon an expert to carry out surveys and special measurements (e.g. of the chemico-physical characteristics of powders, the chemical composition of toxic gases, etc). This sort of collaboration is becoming more specialized and therefore more important, with the increasing complexity of modern technology. The professional quality of the work of the expert assisting the industrial medical officer is thus becoming more apparent. The importance of surveys and measurements of the ambient environment is now so obvious even to the general public in the context of present-day industrial health, that there is frequently a tendency to give the expert exclusive responsibility for industrial health, while the medical officer is left to deal with preventive medicine and prophylactic vaccination. This idea is hotly disputed - at least in our country - not only by scientists, but also by workers' organizations, which regard medical officers as the only persons in the health and hygiene field capable of assuming complete responsibility for health. Arguing from that premise, it is clear that the industrial medical officer must know and be able to assess the individual tasks and occupational risks of each worker from the aspect of prevention and health protection; he must also be able to give an opinion on the standard of environmental and workplace hygiene.

2.3- Specific Community Safety standards, which now appear in all national legislation, define the professional qualifications and authority of experts in the specialized field of radiological protection. The new draft European Community Directives, which are however open to amendment, define qualified experts very precisely as 'persons having the knowledge and training needed to carry out physical and/or technical tests, to carry out radiotoxicological tests, and to give advice in order to ensure effective protection of individuals and correct operation of protective installations and whose capacity to act in this respect is recognized by the competent authority'. This shows quite unambiguously that ambient and dosimetric monitoring come within the field of the qualified expert. The problem arises when it comes to the assessment of risks and the corresponding classification of workers in categories A and B already mentioned. As the standards do not make this point clear, it should be established in practical terms whether this sort of classification is to come exclusively within the scope

of the expert or whether it should, at the very least, be worked out jointly by the expert and the medical officer.

One or two further points should be made in introducing this first subject for discussion.

a) A quantitative estimate of the risk of exceeding 3/10 of the annual MPD can be achieved fairly easily in the case of external exposure but is definitely more difficult for radioactive contamination. We know that in the second case, secondary or derived standards such as maximum permissible concentrations (MPC) must be used, but these can be applied with accuracy only to individuals who fit the ICRP description of the "standard man" as far as possible.

b) It should be established whether this kind of risk assessment for dividing workers into categories A and B should take into account protection afforded by personal protective equipment (e.g. masks, gloves, etc.), or only that provided by stationary environmental protection devices mounted in a fixed position. Experience has in fact shown that the protection provided by individual or easily portable appliances is unreliable as a result both of technical deficiencies and human error.

c) Quite apart from the risk factor, medical supervision of the category A type, i.e. supervision carried out by authorized medical officers, might prove necessary, at least in nuclear centres, in order to assess fitness for specific tasks or for the use of special protective devices.

3. Authorization of medical officers responsible for medical supervision in the field of radiological protection

3.1- According to the Euratom directives, the legal qualifications of the authorized medical officer responsible for medical supervision in the field of radiological protection are based on two requirements:

qualification and authority. Recognition of these basic qualities and the subsequent guarantee of freedom to practise are the responsibility of the relevant authorities in each country.

3.2- An examination of the conditions governing the first requirement - qualification - in each country might be useful. Information can be exchanged on them during the discussion following this introduction. In Italy, the 1972 law relating to this question lays down three conditions:

a) (post-doctorate) professional practice during the past 3 years at least;

b) a specialist diploma in industrial medicine, radiology or nuclear medicine, or equivalent experience of industrial medicine;

c) a special probative examination to be taken before a national committee.

The authorization is subject to a 5-year review, when documents providing evidence that the authorized medical officer has practised during this period must be submitted.

Apart from the qualifications required for these doctors in each country (i.e. diploma in industrial medicine and/or supplementary examination in radiological protection), another important subject should be discussed; should the individual Member States make independent decisions about the scientific and professional knowledge which the authorized medical officer is expected to have, or should the Community produce special directives or at least recommendations? In the latter case, an analytical list would have to be available giving the subjects with which the authorized medical officer should be familiar, with an indication of the standard required (e.g. working knowledge of dosimetry).

3.3- The second requirement for our consideration is the recognized professional authority of the authorized medical officer.

The word 'authority', which is controversial today in every field, should be taken to imply that the opinions of the authorized medical

officer are official and, therefore, compulsory for both employer and worker. In the first case, these opinions are basically concerned with the aptitude of workers for specific tasks and in the second, it is the medical officer who decides on the type and frequency of the clinical and supplementary medical examinations to be carried out (specialized, radiotoxicological, spectrometric, etc.).

One important problem which has perhaps not yet been adequately discussed is the position of the authorized medical officer in the medical world or in relation to the use of ionizing radiation for medical purposes. It is necessary to specify whether his activities are restricted to protecting exposed workers (doctors, nurses, radiologists) or whether they also cover protection of the patient and the general public. As we know, the second problem is a matter of considerable concern in the field of radiological protection today, where the aim is to reduce 'unnecessary risk' as far as possible, particularly in relation to genetic effects. The authorized medical officer obviously cannot be given the same authority in this field as when he is supervising workers and must, therefore, be restricted to giving 'advice' and not 'orders'. In other words, his job should be to make medical colleagues (general practitioners, radiologists, dentists) aware of the situation, and this should be achieved with the close cooperation of a qualified expert.

4. The extent of the medical examination

4.1- The ICRP recommendations in paragraph 121 of edition 9, 1965, set out the following principles : 'The assessment of health, both before and during employment, is directed towards determining whether the health of the worker is compatible with the tasks for which he is employed. The type and extent of the surveillance should be essentially the same as in general industrial medical practice and should include both pre-employment and routine examination, the frequency of the latter being determined mainly by the individual's general health and the conditions of work. Workers whose exposure may exceed 3/10 of the Maximum Permissible Dose may require more detailed surveillance to provide a background of information which could be useful in the event of a serious over-exposure, and to detect any conditions contra-indicating employment on specific tasks. Provisions should also be made for any necessary tests and examination on individuals referred to the medical

officer under the terms of paragraph 102 (accidental exposures).[1]

This paragraph has been quoted in its entirety because it seems to cover the main aspects of the problem.

The first point is the choice of the type and frequency of examination, which should be based on clinical considerations and on the occupational risk involved.

The second point is the aim of special examinations for radiation risks, which might be summed up as follows:

a) assessment of ability for specific work (i.e. whether the general health of the worker is compatible with the risks attached to the workplace);

b) documentation on the background of the subject examined - this is useful in cases of accidental exposure (for both diagnostic and forensic purposes);

c) assessment of fitness for specific tasks, presupposing the use of special protective clothing.

The occupational hazards due either to radiation or to other harmful agents must be investigated on an individual and overall basis, with specific reference to the ICRP recommendations on 'general industrial medical practice'.

4.2- We are, however, concerned here not so much with discussing the guiding principles behind the objectives of routine or special preventive medical supervision,as with making a critical study of the objectives themselves. The problems which deserve our particular attention seem to be the following :

1) The advisability of providing authorized medical officers with general information on the type and programming of the examinations required in the most common cases. This applies to both routine examinations and examinations carried out after accidental exposure, particularly where risk of radioactive contamination is concerned. This information should also cover basic technical details, so that methods can be brought into line and results compared. There are three types of examination for consideration:

a) Clinical, specialized and biological;
b) Chemico-physical (radiotoxicological);
c) Physical (whole-body counting).

2) The list of unsuitability criteria for the pre-employment examination, routine examinations and examinations after accidental exposure. These criteria should, of course, relate to both the interpretation of the examination results and to the assessment of other factors (psychological, socio-economic, etc.).

3) The need for the content and programming of the medical examinations chosen by the authorized medical officer to be brought into line with those provided for by other public health services in the field of preventive medicine and the early detection of cancer.

It will be very interesting now to hear our colleagues' opinions on these three points and on the other problems mentioned in this introduction.

DISCUSSION

Dr JAMMET (France)

I should like to thank Dr Strambi for his paper on various aspects of the practical organization of medical supervision, and to open the discussion on the three points tackled. Let us begin with the first point, that is the identification of activities which should be subject to special medical supervision. The question is, how should activities involving a certain risk be classified, and how should workers be classified? Should we take account of individual protection, rather than just collective protection, or not? Who should be responsible for classification? Works doctors, qualified experts, the authorities, employers, or some other party?

Dr GIUBILEO (CEC)

We feel that employers should be responsible for the classification of work involving occupational exposure to radiation, and for the classification of exposed workers. Employers should draw up lists of workers exposed to radiation (with a 'contamination sheet' for each worker) and give these to the approved medical practitioner, who should then decide on the medical supervision required by each worker. Doctors must however check that the documentation corresponds to the real situation (insofar as this can be assessed from the worker's medical history and site inspections), and doctors should ask for workers' records to be amended or updated, after consulting the qualified expert if appropriate.

Dr BONNELL (United Kingdom)

The Electricity Supply Industry in the U.K. produces by nuclear power about 15% of the total electrical units. There are over 6,000 radiation workers employed by the Central Electricity Generating Board and the South of Scotland Electricity Board in total.

Radiation exposure is merely one factor amongst the requirements for the health surveillance of workers. I am concerned with the proposal which suggests that special examinations by specially trained doctors are required. What special examinations? What are the special qualifications which are required of the examing doctor?

I suggest that persons may be certified fit for exposure to ionizing radiation who are totally unfit for carrying out job of work whilst some being exposed. There is no contra-indication to the exposure to ionizing radiation of persons suffering a pulmonary or a CU disease, but such persons would be quite unsuitable for boiler inspection at power stations. It is the job that matters not the ionizing radiation; for these reasons we believe that a properly constituted medical service, composed of nurses and doctors, should review and interview radiation workers some of whom may require medical examination. In addition it is vital that any person who asks to see the doctor has the right to do so: i.e. there should be an "open-door" policy.

The main problem arising with the work force is anxiety caused by the widespread propaganda about the terrifying effects of small doses of ionizing radiations; we as doctors should not compound this fear.

Dr FABER (Denmark)

As regards the type of doctor engaged as a "physician" Dr Strambi has proposed three types of background. I can accept industrial medicine as a background in the nuclear industry.

In hospitals, radiologists instructed in nuclear medicine are suggested as being the most suitable. I have reservations about this; it could well result in them examining both themselves and other members of their working group. It would be preferable for such examinations to be carried out by a doctor not involved in the use of ionizing radiation in the same hospital.

Dr McLEAN (U.K.)

In considering the conditions under which doctors may be approved it is important to bear in mind that radiological protection necessarily embraces many disciplines in addition to medicine. I believe that the requirements of a physician in this field are, in order of importance :

1. Good, sensible clinical ability;
2. Experience in occupational health;
3. If possible, experience in radiology.

He requires no academic qualification other than a degree in medicine and the best way of acquiring knowledge of the requirements of radiological protection is by practical experience "on the job" over a period of 6-12 months.

Dr RECHT (CEC)

Although I am in no doubt as to the qualifications of the English doctors accompanying Dr McLean today, I should like to ask him what exactly is meant in his country by 'appointed doctor'? What is meant by the 'appointed doctor' responsible - in our translation, which may be slightly in error, it is taken to be equivalent to the 'médecin agréé' or approved medical practitioner.

Dr McLEAN (U.K.)

The appellation arises entirely out of the demonstration that he is capable of assuming the responsibilities. It is in no way related to the fact that he is required to have certain academic qualifications. It is a matter of showing by experience that he is responsible and reliable.

Dr GIUBILEO (CEC)

The fact that the doctor is approved should be confirmation that he is capable of assuming his responsibilities. For this he will need extensive experience in industrial protection of workers and a good knowledge of radiation hazards. The differences between the qualifications required in different countries is due, in several cases, to the different stress laid on occupational medicine and radiation pathology in university courses on general medicine.

Dr JAMMET (France)

In my opinion, good doctors with sufficient knowledge of public and occupational hygiene, and basic training in radiation protection, are capable of doing this job and being approved. But I should like to comment on Dr Faber's statement - I do not think it is normal for the doctor responsible for medical supervision of workers to be the same person as their boss; in other words, a hospital radiologist should not be responsible for the medical supervision of his own staff.

Dr STRAMBI (Italy)

The problem of approval of doctors is linked with that of their training. The main thing is to emphasize the need for specialized training leading to a proper qualification in occupational medicine and hygiene and radiation protection, and thus to approval by the competent authorities. Doctors with this training would then be able to practise on the basis of identical criteria and to draw up harmonized programmes on fitness for work, for example.

Dr RECHT (CEC)

Our ideas on this point have developed with time. The experience of experts in radiation protection is most valuable, and the entry into the Community of countries with different traditions and different systems and practices in occupational medicine has given us food for thought. The definition of the approved medical practitioner in the revised Standards simply means that the doctor responsible for medical supervision of workers exposed to radiation must be acquainted with the principles and methods of occupational medicine and have fundamental and adequate knowledge of radiation protection. This is the basic minimum, but it does not mean that the works doctor cannot obtain this basic knowledge of radiation protection 'on the job'. The Standards do not stipulate that specialized training is required. Some countries, for example Belgium, have instituted this type of training; in Belgium trainee doctors can attend courses in radiation protection, followed by a special examination, and they must be approved before they can work in a nuclear installation. This I think is preferable. Doctor Létard reminded us that the doctor belongs to a multidisciplinary team,

and if he is to play a satisfactory role in this he must have some basic notion of, for example, the units used in radiation protection, dosimetry, and radiation pathology. Without this knowledge the doctor will be unable to give a valid opinion on measures to be taken for medical supervision of workers in normal and accident conditions, and he will run the risk of being a mere figurehead. In radiation protection the clinical aspect is not the most important one. We know that the levels of radiation normally encountered in the course of work in nuclear installations do not cause lesions which can be detected by the doctor or the clinic. But this is not central to the problem and I think there has been enough discussion on this point. Can we assume that there is general agreement on the wording of the Basic Standards, which state that an approved medical practitioner must have special knowledge in the field of occupational medicine and radiological protection?

Dr MOEHRLE (FRG)

My opinion, after 14 years of radiological practice, is that the approved doctor must be able to show that he possesses knowledge of occupational medicine and radiation protection in order to be approved, as the proposed Basic Standards indicate. He must possess knowledge of occupational medicine, because medical supervision of occupationally exposed persons overlaps to a great extent occupational medicine. He must possess specialized knowledge of radiological protection for the specific requirements for the job. As well as this, in accordance with art. 35 of the Basic Standards he must have sufficient knowledge to at least initiate first-aid measures (internal or external decontamination) in the case of over-exposure, and other emergency measures. The approved doctor will need special training if he is to be qualified for all these duties.

Dr POLVANI (Italy)

I would like to make a comment on the meaning of the 'approval' the physician undergoes at present in the field of radiation protection (approved physician, médecin agréé). The approved physician is a medical doctor whose specific training and role have been recognized and 'approved' by the competent authority.

Let us consider the training first. As Dr. Létard and others already pointed out, it is necessary for the occupational physician engaged in radiation works to get a general knowledge of some technical aspects of the plants and installations and in the operations involving the presence of radiation and radioactive substances, in addition - obviously - to the specific knowledge in radiation protection, radiation pathology and radiotoxicology. This wide training is the ground for a good participation of the physician in the occupational hygiene teams. In 1958 the common opinion was that such training was something special not obtainable by the occupational physician in the university programmes. This is one of the reasons why the Directives stated that a recognition (approval) given by the competent authority is requested for this group of physicians. We were then aware that an approval was not requested for physicians dealing with other working risks, and that the 'approved' physician represented something rather peculiar. At present the situation has evolved in some countries, and the question becomes the following : in the interest of the health of radiation workers, is it useful or not to have 'approved' physicians?

Let us now consider the rôle of occupational physicians. In the fifties in certain countries the occupational physician was partially, under some aspects, a kind of advisor to the management, for the goals of the latter. In recent years, and particularly in certain countries, the prevailing opinion is that the occupational physician has a kind of 'public' role in evaluating situations and medical matters, under the viewpoint both of the worker's health and of the public interest. It might be useful for the physician to be recognized (approved) by the competent authority, especially in order to gain an adequate position, role and autonomy enabling him to fulfil his tasks.

You see, Mr. Chairman, that I am not suggesting any solution or change of attitude. I only wanted to stress some aspects of the problems under discussion.

Dr JAMMET (France)

We have just heard the case for approval of the doctors responsible for medical supervision; I think it is generally agreed that this type of approval is necessary. But there are some differences of opinion

as to the requirements for this approval. Although the situation varies from country to country, we must not forget that the worker wants to be supervised and treated by a good doctor, a competent doctor, and a doctor who has the necessary knowledge to fulfil special functions connected with radiation exposure. The requirements for approval must be such that, given the educational system of each country, there is a guarantee that the doctor has this degree of competence. The authorities have an obligation to guarantee the doctor's competence and this can only enhance the authority of the medical profession in this field, in dealing with employers, workers and with other qualified experts in the field of radiological protection.

Dr STRAMBI (Italy)

The opinions issued by the approved doctor are authoritative and therefore binding on employers as well as workers. They are binding because the Basic Standards state that no worker may be employed in work involving occupational exposure to radiation risks if the approved physician opposes this. His opinion is authoritative and thus apparently indisputable. Here another problem arises - that of the position of the approved doctor in a hospital environment, where the doses received by patients and medical staff are much higher than those likely to be received by workers in the nuclear industry. At present everyone is trying to cut down doses, especially the population dose. I think it would be useful to give a better definition of the role and duties of the approved doctor in the hospital environment. Must he give opinions or simply advice? In what way should he collaborate with radiologists and health physicists?

Dr MIRO (France)

It would indeed be desirable for qualified doctors to give advice to those of his colleagues who use radiological methods as to the danger of repeating certain types of examination. But this would be bound to lead to a storm of protest on the part of our colleagues because it would of course amount to direct interference by an expert in the doctor's freedom of treatment. We must, therefore, make the doctors using ionizing radiations more aware and better informed of the danger these entail for patients and ask them to exercise a certain degree of restraint in the treatment they use.

of over-exposure. Are there any fitness or unfitness criteria based on factors other than the therapeutic contra-indications in the event of an accident? The conclusion I draw from this is that in your opinion a person subject to the standards cannot be considered unfit in any circumstances. This is an important point. The Director of Health Protection and myself must assume - and I shall report this to the ICRP - that in the opinion of occupational physicians there are no criteria of unfitness for workers.

Dr STOTT (U.K.)

Your conclusion is absolutely right, Mr. Chairman, that this audience apparently cannot provide criteria for exclusion for radiation work other than the suggested one that a person may not respond to treatment in the accident situation. However, I would like to hear from the members of the group who drew up the draft directive what they had in mind for the list which member states are required to compose.

Dr FABER (Denmark)

I remember the meeting in Stresa where the same problem as today was in the discussion. It was suggested that persons with a low constant level of lymphocites should be excluded from radiation work. Is anybody still using this criterion?

Dr FAES (Belgium)

In my opinion it is quite inadequate to restrict pre-employment medical examinations to the criteria which show whether the patient can tolerate the treatment required in the event of an accident. We must take account, among other factors, of biological criteria which if they deviate from the accepted norms even before exposure to radiation, are of no value whatsoever when it comes to assessing radiation damage in the event of an accident.

Dr RECHT (CEC)

It is true that we have been discussing this problem for a very long time and I should like to thank Dr Faber for reminding us of this. We came to the conclusion that it was not possible to draw up a mandatory list of contra-indications for radiation work. We still take this approach, but radiation work nevertheless imposes certain restraints which are quite normal. What medical criteria should be used to assess the fitness of individuals who have to wear protective suits or masks for their work, or who work in glove boxes? There are some particular contra-indications for this type of work, such as pulmonary, cutaneous and psychiatric conditions. Although these contra-indications are not connected with ionizing radiation, they do nonetheless exist. The approved doctor must be more than a mere figurehead and must be a fully-fledged occupational medical officer in the widest sense.

Dr JAMMET (France)

So these problems are to be considered in the wider context of the worker and his fitness for the job. Ionizing radiations are a particular case, and one which is quite rare in occupational medicine, of pollution which is almost perfectly controlled. Once the irradiation or contamination limits are observed, it is obvious that unfitness for exposure to radiation as such, within these limits, will only be found in exceptional cases, as normally healthy people can be subjected to radiation within these limits without danger.

SECOND SESSION

HEALTH CHECKS OF WORKERS RESPONSIBLE FOR MAINTENANCE, INSPECTION AND REPAIR WORK IN NUCLEAR ELECTRICITY-GENERATING PLANTS IN THE NETHERLANDS

Chairman : Dr. A. LAFONTAINE

HEALTH CARE DURING REACTOR SHUT DOWN FOR MAINTENANCE, INSPECTION AND REPAIR OF NUCLEAR POWER PLANTS IN THE NETHERLANDS

H. W i j k e r

Summary

The health care for workers in power plants has medical-biological aspects and physical-technical ones. It requires a close collaboration between the medical doctor and the health physicist.

A combination of prevention, supervision and checks provides an optimum health care. It includes plant design, medical examination, whole body counting, radiological passports, dose reserve calculations, dose measurements, radiation supervision services, physical and medical checks.

The discussion of the subjects comprises organization and experience in the Netherlands.

1. Introduction. Cooperation between the Medical Doctor and the Health Physicist.

It was with great hesitation that I accepted the honour to present a paper at this colloquium, as the main subject is medical supervision. I am a health physicist and not a medical doctor. But the organizers convinced me that the subject they had in mind for me, also has many physical and technical aspects. It concerns the care of health for all those people who are involved in maintenance, inspection and repair of nuclear power reactors.

The health care is partly medical-biological but mainly physical-technological. A close contact between the medical doctor and the health physicist is vital. This contact can only be fruitful if each understands the language of the other and also his train of thought. Do not think this is easy - the approach to solve the problems is quite different because of the differences in the education of both disciplines. Therefore, it will be clear that I consulted my medical colleagues concerning their part in the care of health, as discribed in this paper.

2. Characteristics of the Shut Down Situation.

The characteristics of a shut-down for maintenance, including refuelling, inspection and repair where necessary, are :

a) The great number of outsiders who work in the plant during the stop.
b) The high speed of work that is needed. It requires rapid decisions from the staff in unexpected situations.
c) The avoidance of unnecessary delay.
d) Probability of higher exposure and contamination.
e) Negligible neutron radiation, high beta radiation.

3. Prevention and Checks.

The health care is partly preventive, partly a check whether the preventive measures worked as expected. The preventive measures serve the purpose of restricting radiation dose and radioactive contaminations as much as possible (i.e. physical-technical) and to limit the consequences of unavoidable low doses and contaminations to the utmost (medical). To that purpose, medical men and biologists set maximum acceptabel limits to dose

and external and internal contaminations and the doctor examines the radiation worker in advance.

The whole body counting to assess internal contamination is more a physical measurement. Other preventive physical and technical measures are the determination of the dose reserve obtained from the results of individual monitoring and general and special instructions for the working procedure. The latter are based on measurements of dose rate and contamination in the working environment. Together with the dose reserve, the maximum time allowed to stay in a high radiation field can be determined. After the work has been done, dose and external contamination are verified and internal contamination is checked. The physical checks are followed by a medical check only then if strong indications exist, e.g. if the dose or contamination is beyond the limits set up for it.

4. Total Dose and Dose Distribution.

As said before, during shut-down many more people than usual are exposed and often to relatively high doses. Not only employees of the plant itself but also many people from outside, among which a number of specialists, such as inspectors and highly skilled welders. As the available number of specialists of these qualities is restricted, it is clear that not only on moral grounds the utmost care must be given to restrict doses, but also on practical grounds.

The plant itself has roughly about 100 employees - I restrict myself to the situation in the Netherlands where the power reactors are both light water reactors, a BWR and a PWR. During a shut-down of usually 5 to 7 weeks many hundreds of outside people are involved in the work in the plant, partly from contractors and special firms, partly from the central laboratory of the electrical utilities in the Netherlands, which serves as a manpower reservoir, particularly of specialists. Inspectors of the Government also have to enter high radiation fields from time to time. Table 1 shows the distribution of work amongst people of different origin.

It is clear that the total dose to all workers, expressed in manrem, inherent to the exploitation of the plant, will increase at a much higher rate during shut-down than during the period of reactor operation. A rough

estimation indicated that it may differ a factor of 10 to 100 for different situations. Measures to restrict the number of manrem for a certain job have to be realised by the health physicists. It is, however, the responsibility of medical specialists and biologists to answer the question whether this unavoidable total dose has to be spread over more or fewer persons, though we, physicists, are eager to help them solve this problem.

If the dose-effect-relationship is a linear, without threshold, the total chance of an effect is the same whether a certain number of persons get a dose D_1 each, or half the number receive double the dose (fig. 1). In this case the manrem concept can be used to judge the risk. For many effects, however, the real curve "dives" underneath the straight line and for these effects the risk is lower if the total dose in manrem can be spread over more persons. For such cases even a somewhat higher value for the number of manrems to perform the job can be accepted without loosing the advantage of spreading the total dose. This higher number may be caused by a lower overall average workrate per man caused by the greater number of starting and finishing work.

The Euratom directives of 5th July 1974, are not in accordance with this philosophy, anyhow as I see it. The first sentence of article 6 says that the irradiation has to be kept as low as possible - I read this as a minimization of the number of manrems - and that the number of exposed persons has to be minimized - which means that the exposure of each person involved in the job, will be the maximum permissible. Possibly this will be a point for further discussion.

5. Medical Examinations

5.1. Categories Involved

We have now considered the first point of the preventive medical care in some detail and will go on to the second point : the medical examination of persons who will start radiological work. This concerns persons who may be exposed to 5 rem a year or 3 rem a quarter to the whole body i.e. the A category of workers following art. 20 of the Euratom directives of July 1974.

In the Netherlands it has been agreed not to surpass this 5 rem in any period of a year during routine power plant exploitation, including maintenance. That means that e.g. the D = 5 (N-18) rule only will be used in exceptional cases and when the necessity is accepted by Labour Inspection.

Table 2 shows in which case it is customary to have a pre-employment medical examination, to repeat it annually and when whole body counting before and after shut-down is carried out. The question mark denotes that the situation decides whether or not it is done.

Table 2. Pre- and post examinations.

Category	Medical examination		Whole body counting	
	preoccup-ational	annual	preoccup-ational	after the shut-down
A (5 rem/year)				
frequently	+	+	+	?
ad hoc	+	-	?	?
B (1.5 rem/year)	-	-	-	?

5.2. Organization

The number of employees of a nuclear power station, roughly around hundred, is too small for full-time employment of a radiation doctor. But the Government as well as a number of institutes and industries have medical services with well-equipped centres and medical officers, specialized in labour hygiene. A number of these labour hygiene specialists have had a special training in the field of radiation. Moreover, there are close contacts between the services and hospitals when necessary. In some cases, as for instance at the Kema, the radiotherapist of the hospital serves as a specialist for radiation problems next to, and co-operating with, the medical man of the institute. The advantage is that radiation problems are daily problems of a radiotherapist; he has built up great experience in this field. Of course he also has knowledge of radiation problems beyond his hospital practice.

Both nuclear power stations in the Netherlands have contact with a labour hygiene service in their neighbourhood: Dodewaard with a university center, whereas Borssele joined an industrial one, caring for 6500 employees of a number of industries. This system of ad hoc solutions will - as we see it now - be maintained when the number of nuclear power stations in the Netherlands will increase. Furthermore, a close contact with the therapeutical departments of the hospitals must be maintained, especially for urgent cases after radiological accidents.

5.3. Items of the Examinations

The pre-appointment medical examination is outlined in art. 31 (section a) of the Euratom directives of July 1974. The main part of this examination is the normal labour hygienic examination concentrated on the prospective operations. This includes a history (anamnesis), a general impression of physical and mental condition and a general examination, blood pressure, urine, reflexes, eyesight etc. In the special case of a radiation worker the blood smear is determined and countings are done. Special attention is paid to the skin in connection with external decontamination and to mental stability. As for the eyes, it is considered of less importance to map cataracts in the eye-lenses as a part of pre-occupational examination, especially in case of the activities during shut-down because there is no neutron radiation in that case and the beta radiation can be stopped by safety glasses. Only on indication, when eye-sight deteriorates, a more intensive examination of the eye is carried out.

As for the blood the well-known series of determinations and countings shown in table 3 are carried out. For acceptability a blood smear does not require as a must that the number of each of these blood corpuscles separately lies between fixed values. The smear as a whole and the differential distribution are decisive and have to be judged by a doctor, experienced in this field.

Annual reexamination of the blood does not serve the purpose to determine the dose to which a person has been exposed - I assume exclusion of radiation accidents - but to look at a gradual change, year after year, in one direction or another. The automatisation in handling and counting blood smears as it was developed during the last decade, makes the results more

reproducible and reliable. Not too long ago the results between different haematologic laboratories and even in one and the same laboratory, could vary appreciably, but now the variations are, apart from thrombocytes, greatly reduced. However, the human influence is not totally excluded. It may play a part in taking blood samples. We separated the results of the blood samples taken by medical analyst A from those taken by analyst B (together about a hundred samples). We found two Gauss-curves with a small significant shift, small enough to be of no importance, however. Obviously, one analyst stung the needle systematically deeper in the fingers than the other one did.

Sometimes the medical pre-occupational examination has to be cut down to a minimum lower than indicated above. An example occurred this year, when suddenly, on very short notice, about a hundred persons had to be chartered from a number of firms and put into a rather high radiation field, up to a few röntgens per hour, in order to clean the outside of the reactor core vessel from the soot from a little p.v.c. fire and therefore, containing chlorine, very dangerous for vessel corrosion. As it happened in the summer period, the physicians already had to act as locum tenens for one or more colleagues. So after the consent of the medical doctor of labour inspection, the labourers were allowed to do the job as category A workers under stringent work conditions after pre-occupational medical examination restricted to anamnesis, general impression, mainly of the skin, palpation of spleen, liver and lymph nodes, inspection of urine and leucocyte number. The results of the countings of the other blood cells could not be obtained from one day to another, but were taken in the file later on. Of course, such a situation has to be considered as an exceptional, only accepted in urgent cases.

6. Physical Examinations, Whole Body Counting.

Persons, taken as employees for radiation work in nuclear power plant, are initially measured in a whole body counter to determine the gamma emitters already present in their bodies. In the Netherlands this is done by the Radiological Service Unit TNO, an independant technical-physical research and development institute, belonging to the Organization for Health Research TNO, a semi-governmental organization. Here I restrict myself to the whole body counters used for the power plants - those at the Reactor

Research Center at Petten and at the academical hospital at Leiden are left out of consideration. The results of the countings are fixed on paper tape and can be used later on in case of low-level contaminations. The subtraction of individual zero level spectra are especially of interest in the case of quantitative determinations of nuclides with extremely low MPBB*. However, the important nuclides for internal contamination during a shut-down (^{59}Fe, ^{58}Co, ^{60}Co, ^{54}Mn, ^{51}Cr), all activation products, do not require this counting sensitivity. Instead of large sodium-iodine crystals as used by TNO, a solid state detector can be used. Herewith, a contamination of 1% of the MPBB can reasonably be measured for these nuclides. It has the advantage of the higher resolution.

It is desirable that during a shut-down the whole body counter can easily be reached by the radiation workers. As the Dodewaard power plant is situated not far from the TNO whole body counter, there has not been a problem until now. However, it requires half a day travelling from Borssele to TNO. And the same might be the case for the power plants which are planned in the future. Therefore, the nuclear power plant in Borssele purchased its own whole body counter, which will be in operation next year. Moreover, TNO is considering to procure a mobile whole body counter, with which legal measurements can be made locally at the plant. Such a unit can also be used for health physics and nuclear medicin applications in hospitals. In that situation all workers involved in shut-down can be measured in the whole body counter after the job has been done. Up to now, only a representative sample was taken.

7. Radiation Supervision.

7.1. Organization

During a shut-down a large team of health physicists and radiation supervisors is required, much larger than the plant can provide. Some 20 people for day and night supervision, and help, all the week through, during 6 to 7 weeks continuously. They form the SCD, the Radiation Supervision Service.

Up to now, the reservoir of the extra manpower consists of the volunteers from the KEMA employees, the Assistance Radiation Supervision Group.

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* Maximum Permissible Body Burden

We use two levels of education. The first level is the group of the well trained members of the health physics teams. We call them the health physics engineers. Second level is the group of radiation supervisors who get a 2 to 3 weeks training course and have to take only limited responsibility. During shut-down they are the supervisors on the spot who have to guard the normal routines and to carry out the required radiation and contamination measurements. They have their backing in the first level physics engineer for abnormal situations which require a higher knowledge and experience. The health physics engineer can - if necessary - always ask advice from the health physicist on academic level at the KEMA.
The health physics engineer is based in the Main Entrance Supervision Room. Each person, who wants to enter the supervised zone has to pass this room. Here the written working instructions for each person are listed and health physics instructions are added, included those about the protective clothes that have to be worn. As a rule, private clothes, including underwear, are prohibited in the supervised area during a shut down.

7.2. Supervision

7.2.1. Measurements

Each worker receives a pen-dosimeter and those who belong to category A and partly those of category B - namely those working frequently at the plant - wear also a filmbadge to assess legal doses.

7.2.2. Central Dose Registration System.

This year, TNO has introduced a computerized dose-data registration system, especially on behalf of the electricity supply utilities. This system will in future be extended to a national dose-data bank.

7.2.3. Radiation Passport.

It implies that each person who wants to start work in the supervised area, and therefore has to pass the Main Entrance Supervision Room, delivers his radiation passport to the health physics engineer. It shows the dose reserve at the end of the last radiological job performed as well as the date of the last medical examination. If the worker has forgotten to take his passport with him to the plant, then the health physics engineer asks information from the employer or from TNO. If no passport has been issued to the

worker, the health engineer provides him with one on behalf of TNO.

These passports stay in the SCD file as long as the owner works at the plant. At the end of this work the SCD fills up the passport and sends it to the worker's employer. Each week the Central Dose Registration provides the SCD with a list of dose reserves of the people working at the plant.

7.2.4. Dose Reserves.

Two kinds of dose reserves are used, the legal dose reserve DR_l and the working dose reserve DR_w, which has been chosen 80% of DR_l. So $DR_w = 0.8\ DR_l$.

Pre-planned doses for an individual never may surpass the working dose reserve. The legal dose reserve at any time is :

for category A workers: the lower of $5000 - D_y - P/0.8$ mrem as year reserve
and $3000 - D_q - P/0.8$ mrem as quarter reserve;

for category B workers: the lower of $1500 - D_{cy} - P/0.8$ mrem as year reserve
and $1000 - D_{cq} - P/0.8$ mrem as quarter reserve.

Here D_y and D_q are the legally measured doses in mrem received during the last perdiod of a year or a quarter, respectively. It has been measured by an authorized institute with a monitoring device provided by this institute, for which the filmbadge is still in use.

P is the dose in mrem measured at the plant with the pen-dosimeter since the time the last filmbadge dose became available. In the formula it is divided by 0.8 to provide a safety factor for discrepancies with the readings of filmbadges - not yet known at that time. Differences between pendose and filmbadge dose are expected not to exceed 20%.

In order to simplify the calculations it was agreed to use the calendar year (cy) and calendar quarter (cq) in the formula for category B workers instead of sliding periods.

Each week the P-values are sent to TNO and the computer provides lists of working dose reserves in which the last legal dose reserves are incorporated. During the week, from day to day, sometimes for shorter periods, P is

measured and P/0.8 subtracted so that at any time a safe preliminary dose reserve is obtained, neglecting possible increments by changes during the corresponding week, a year or a quarter ago.

There are plans for changing the individual monitoring system in the Netherlands. TNO is studying to replace the filmbadge by officially issued devices, based on thermoluminescence dosimetry. It offers the possibility to read the dose at any moment in a short time by an automatic reader system, developed by TNO. Then it is considered to replace the TLD pens and filmbadges, now in use at the plant, by TNO-TLD-badges and to install automatic TLD-readers at all plants for evaluation under supervision and responsibility of TNO, which carries out calibrations and maintenance of the equipment. Then the dose read at the plant can be taken as the legal dose, so that the term P/0.8 in the formulas for DR_1 can be omitted.

Fig. 2 shows an example of legal dose reserve variations for a category A worker.

8. Conclusions from Dose Measurements.

8.1. Dose Distribution.

All the radiation workers being recorded in the Central Dose Registration System, it is easy to provide information on total dose distributions via the computer.

This year we had an exceptionally long shut-down of 21 weeks at the Dodewaard reactor, because of very special repair on reactor vessel nozzles during which the fire occured that I mentioned before.

This resulted in the abnormal high total of 630 manrem, 1/3 of which was taken up during the short cleaning period after the fire. We have tables, produced by the computer, showing in detail how this dose is distributed over personnel of plant and different firms, over the various jobs carried out, over the groups of workers in the plant etc. From these tables we gather the experience where the main doses come from, so that we can give information to the designers where to make changes in the design, to obtain a more dose-friendly plant.

8.2. Dose Restriction and Plant Design.

It must be possible to construct nuclear power plants with a total dose of no more than about 100 manrem per year whereas the older generation of reactors lead to 300 to 400 manrem per year. Of course, a plant in which these dose restrictions are built-in will be more expensive. However, the exploitation costs can be lower in such plants so that the total costs over reactor life time has not to be higher (ref: R. Wilson, Man-rem economics and risk in the nuclear power industry, Nuclear News 15, 2, Febr. 1972, p. 28).

The feed back from this reactor experience to designers - and contructors - is only slowly developing. These problems can be considered as technical problems in connection to health care.

9. Medical Inspection.

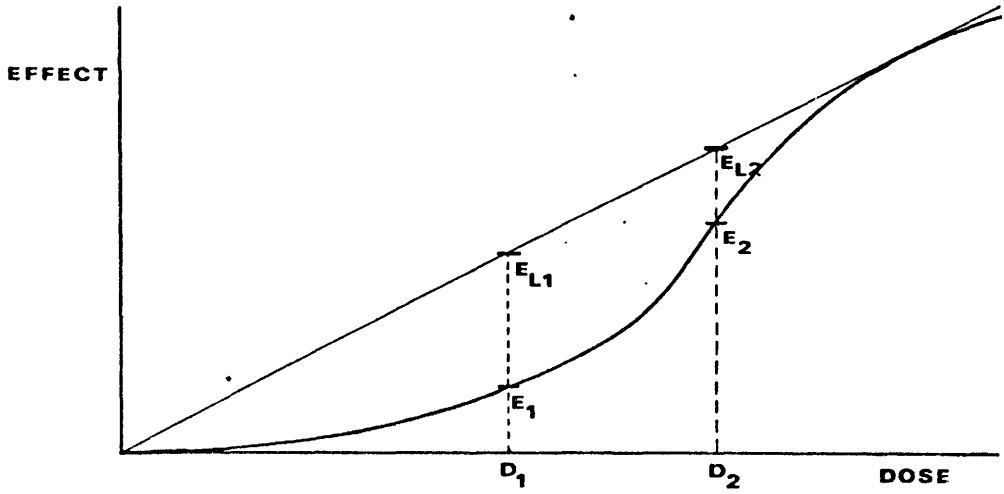
To finish my talk, just a few words about medical inspection after the shut down. If no abnormalities have occurred there is no need for it. However, a number of measures have been taken to cope with contingent casualities. In the plants e.g. tablets or dosed solutions of KI are at hand to ingest after an abnormal ^{131}I inhalation. Taken within one hour after the accident this competitor greatly reduces the uptake of the radioactive nuclide in the thyroid.

The governmental medical service has distributed a guide for first aid after radiation accidents. It contains lists of actions that have to be taken urgently, lists of radiation specialists who can be consulted, lists of hospitals capable to receive victims of radiation and contamination accidents. A special case is the isolation ward of the academical hospital of the university of Leiden. This hospital is experienced in nursing isolation patients and a number of beds are reserved for victims who have received a high radiation dose, higher than 100 rem whole body radiation. A plan of action for admittance has been distributed by the director of this ward.

10. Conclusion. Cooperation between the Medical and the Health Physics Services.

You will have noticed that I switched from medical to physical problems and the other way round. It shows the necessity for the close cooperation of both disciplines for the optimum health care of radiation workers.

Fig. 1. Dose-Effect Relations



Elucidation.

Number of persons with dose D_1 is N_1, say. Number of persons with dose $D_2=kD_1$ is $N_2=N_1/k$. So the number of manrems is the same for both groups. For the approximation of the linear dose-effect relation $E_{12}=kE_{11}$ so that $N_2E_{12} = N_1E_{11}$, i.e. the total effect is the same for the same number of manrems, independent of the dose distribution.

For the real dose-effect relation $E_2 > kE_1$ so that $N_2E_2 > N_1E_1$. That means that the total effect is larger if the same number of manrems is distributed over a smaller group of persons.

Fig. 2. Example of Dose-Reserve vs. Time

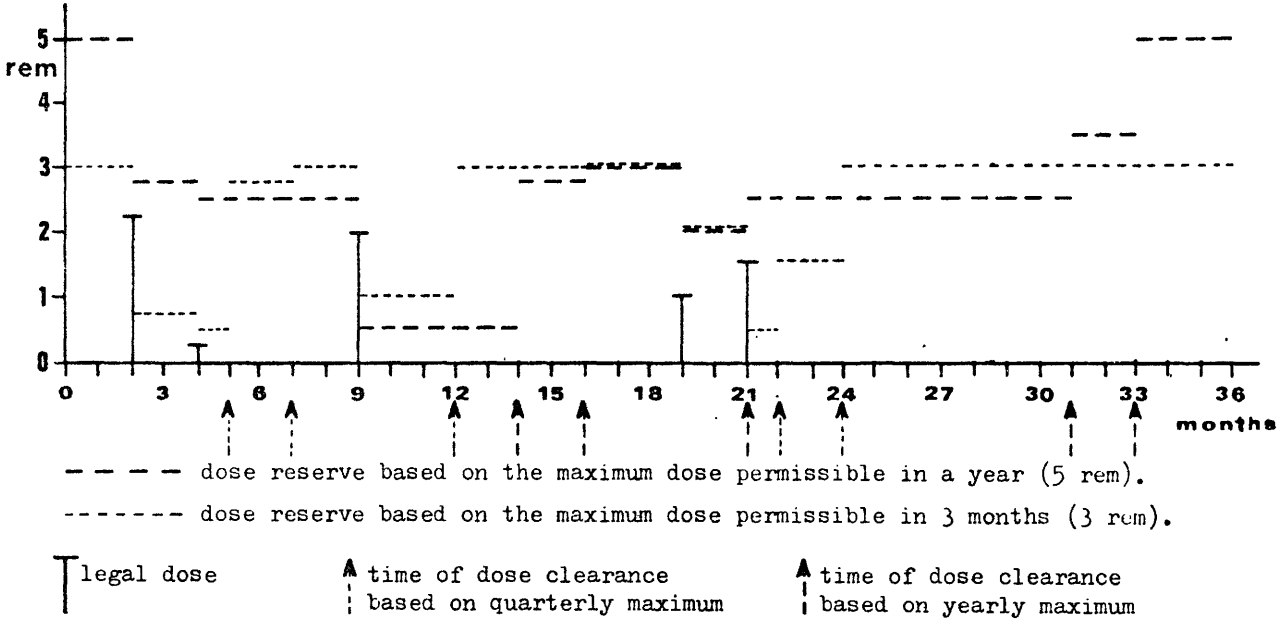


Table 1.

Activities → / Workers from: ↓	Inspection	Repair	Cleaning	Other maintenance	Health advices	Medical examination	Radiation supervision
Plant itself	+	+	+	+	+	+	+
KEMA (central lab electric utilities)	+	+	+	+	+	+	+
Contractors	+	+				+	
Special firms		+	+	+			
Government	+				+		

+ work carried out by the group

Table 3.

BLOOD SMEAR.

ESR (erythrocyte sedimentation rate)

Haemoglobine

Countings

- erythrocytes
- leucocytes
- thrombocytes

Differentiation:

- basophils
- eosinophils
- stabs
- polymorph granulocytes
- lymphocytes
- monocytes

DISCUSSION

Dr LAFONTAINE (Belgium)

I should like to thank Dr Wijker most sincerely for his well-documented paper and to thank him, too, for drawing our attention to the need for collaboration between health physicists and doctors. I would add that workers are, after all, human beings and we must not forget the medical, that is human, aspects of the problem. I therefore call for discussion of the topic of Dr Wijker's paper.

Dr FABER (Denmark)

In your discussion you mention that during normal shut down you permit workers to work up to 80% of permissible whole year dose - this is correct for category A workers - but how can you have category B workers in a situation where under 'normal working conditions' you work with a risk above 1.5 rem?

Dr WIJKER (Netherlands)

As a rule most people who work in the reactor plant during reactor shut down are category A people. But suddenly some other people may have to enter the plant to do some work in a radiation field as for instance a photographer or people from other firms who have to do clean-up work or to paint some pipelines. For these people we use an upper limit of 80% of 1.5 rem. From a practical point of view we experienced it as very useful that such people are available from other firms to do these jobs so that our own plant people keep more dose reserve available for their daily, often more specialist work.

Mr GABRIEL (FRG)

I should like to ask three questions:

1. Why does Dr Wijker make a distinction between category A workers and category B workers, although both groups are in effect exposed to the same doses and thus to the same risks?

2. Do you think that the 20% margin you mentioned for dose monitoring makes sufficient allowance for the possible effects of work in non-homogeneous radiation fields?

3. The 'radiation pass' you showed us does not give any information on the holder's exposure as a result of medical diagnosis and/or treatment, although these entail a significant risk. What is the reason for this?

Dr FERNANDEZ (U.K.)

Dr Wijker has stressed the vital combination of the health physicist and the doctor in controlling the health of exposed workers. We in the Central Electricity Generating Board would also add to this team, the nurse.

In my opinion 80% of the assessment of a worker's health comes from the history. The doctor visits the power station regularly but in the day to day visit with the worker it is the nurse who regularly observes working behaviour patterns.

I remember being informed by a nurse of a worker who had an uncontrollable hand movement - a tic of rubbing his eye. Because he worked in a contaminated zone the health physicist and myself felt he was unsuitable for the work.

My reason for speaking is to stress the important role of the nurse in helping to control the health of ionization radiation workers.

Dr RECHT (CEC)

It was never our intention that the A and B classifications in the Basic Standards be applied once and for all, so that workers are definitively classified as A or B for a range of activities exposing them to ionizing radiations. A B worker can become an A worker if he is liable to receive more than 1.5 rem per year. This means that anyone can be used for maintenance work as long as he or she is fit for work with ionizing radiations, and is subjected to individual dosimetry and adequate medical surveillance.

Dr LETARD (France)

In major maintenance work on Electricité de France power reactors, a minimum level of irradiation per head has been established. This arrangement makes it possible, in the great majority of cases, to avoid exceeding the maximum permissible quarterly doses, which is important from the psychological point of view. It also means that personnel at the nuclear power station are available for occasional minor maintenance work.

It goes without saying that before personnel start on any such work they are subjected to the whole range of clinical and biological examinations to determine their fitness, from the medical angle, for radiation work. This arrangement has been used on several occasions, for example on the large site at St Laurent-des-Eaux a few years ago.

I would add that in these cases the works doctor is given very precise information of the operations the work will involve and he knows what tasks will be assigned to each worker.

Dr LAFONTAINE (Belgium)

You have just raised an extremely important point, as many of our colleagues here have a certain responsibility, as works doctors. I should also like to mention other responsibilities of a more general kind. The decision to permit a certain degree of exposure is one which should not be taken lightly, for we do not want to lay ourselves open to criticism, justified or otherwise.

Dr RECHT (CEC)

We have found that there is a tendency, which is clearly shown in the organization of maintenance work at nuclear power stations, to use unqualified personnel on contract from outside companies. It appears that these workers are not subject to the same medical and physical surveillance rules as power station personnel. This has aroused the concern of the Commission; surely it is quite unacceptable for there to be differences in the treatment of people exposed to the same risks? Is this fear justified?

Dr BONNELL (UK)

It is of the utmost importance that personnel who may be brought on to power plants to assist in maintenance work should be subject to the same requirements, rules and regulations as personnel permanently employed on site: and they must be seen to be so treated.

CEGB plants are maintained by power station personnel, but on the occasions that contractors are brought in to carry out special duties, the employer of these men retains the responsibility for maintaining records and provides proof of the validity of these records before the men are allowed to commence work on the plant. No short-cut should be permitted for the sake of expediency, otherwise rules will fall into disrepute.

Dr WIJKER (Netherland)

I quite agree with what you have said, namely that there must be no difference between dose limits for people from outside and those for employees of the plant. Differences can only be made on category. Therefore it is important that it can be seen in the plant from the passport whether the last medical examination was done less than a year ago. To that purpose the passport has to show a doctor's signature or paraph and the date of the examination for the workers in the 5 rem per year group, As I pointed out before we do not consider the 1 1/2 rem per year group as radiological workers. We consider them as a special group out of the population, a small special group to which, in certain cases, it is allowed to receive somewhat more radiation during their work in the plant. A dose higher than the normal maximum permissible population dose can be motivated by two arguments, firstly that the group will not include children and weak people unfit to do the necessary jobs, and secondly that this special group is a very small group out of the population.

The case of a somewhat restricted medical examination I mentioned in my talk is an exceptional case which could only have taken place after a special consent of the labour inspection because it concerned a very urgent situation. As there is always a certain medical responsibility, the starting point in this case was the examination programme the 5 rem per year group.

Dr MAZAURY (France)

French legislation covers all workers without any distinctions as to their particular industrial sector.

At the CEA, our radiation protection services require all outside contract labour working in our plants on jobs involving a routine risk of exposure to ionizing radiation, to be medically fit for radiation work.

Dr MECHALI (France)

The French regulations also apply to workers from private companies who come to give assistance or do maintenance work in a nuclear power station, as well as to power station personnel; before they can work in a controlled area, they must have the required degree of medical fitness, and thus to have undergone the appropriate medical examinations.

Dr MOEHRLE (FRG)

Dr Recht has just described the situation in German nuclear power stations. I should like to make the following comment. Outside labour is used for repair and maintenance work in nuclear power stations, but these workers are subject to the same controls as permanent category A workers occupationally exposed to radiation. There are special safety regulations, laid down by the trade association, for outside maintenance and repair workers, extending even beyond the German regulations for nuclear research, and these workers must also be provided with the radiation protection pass used as a matter of course in nuclear power stations, which gives all data on radiation protection monitoring and medical supervision.

Dr PECHE (FRG)

Dr Moehrle has just told you about the surveillance arrangements in the Federal Republic of Germany. I should like to point out, in reply to the question asked earlier, that it is not up to the doctor to decide how many people are engaged on repairs or maintenance work, but there are several good, medically- founded, reasons for protecting the permanent power station personnel from constantly high exposure.

Dr HILL (U.K.)

The question has been raised as to whether it is better to give a small dose to a large number of persons or larger doses to a smaller number. Some years ago I was asked this question when maintenance work was required on the Dounreay Fast Reactor which involved penetration of the biological shield.

I authorized eight persons to be exposed up to 10 rems each because these persons were familiar with the reactor and expert in their speciality, so that the work would be completed in the shortest possible time. In the event no person received more than 7 rems and the total man rem dose was about 50 man-rem. If a larger number of less skilled persons had been employed, the total dose might have been almost doubed and in my opinion it is the total man-rem dose required to complete the job which is the important factor.

Dr WIJKER (Netherlands)

I should like to make one comment on the last remark. The total dose in man-rem is not the most important thing. The crucial point is the total effect of that total dose. In reality this effect is not in ratio with the number of man-rems in most cases. Therefore it is advisible - and I especially wanted to stress this point - to spread the total dose over more persons if you have the opportunity to do so, keeping in mind that the total effect - or rather the total risk - may be decreased by it.

Dr LAFONTAINE (Belgium)

This problem is a serious one, as it could result in a tendency to increase the number of category B workers. This attitude could well exacerbate the genetic hazards, and I should like to hear the Health Protection Directorate's opinion on this.

Dr RECHT (CEC)

The 1959 Basic Standards still in force stipulate that the exposure of persons and the number of persons exposed to ionizing radiation must be kept as low as possible. The new version states that exposure of persons must be 'as low as reasonably practicable', which shows that we are trying to optimize radiation protection in this field. We have to find a balance. The example given just now by our British colleague is a logical one, as he stayed within the dose limit of 10 rem, the maximum dose which can be permitted at any one time over a single period of exposure. I should like to give an example of an actual case that occurred in an EDF power station. Repair work had to be done at the power station, and the doctor responsible had to choose between two approaches: allowing a small number of individuals to be exposed to doses above 3 rem or exposing more people to lower doses. This shows the high degree of precision and planning which went into the organization of the work. The doctor decided that it was preferable to expose individual workers to doses below 3 rem, by increasing the number of workers exposed. This new tendency, which is also found in the Euratom Standards, seems to be more realistic, as it allows doctors and health physicists to make the best choice as to the number of persons exposed and the dose they receive. At all events, the dose of 10 rem at any one time is still valid for each worker, as long as the other regulations are observed. There is no question of damage or injury. The most realistic approach is to examine each case according to its merits, the particular working environment, and the circumstances of the accident to be offset.

Dr LAFONTAINE (Belgium)

This, I think, is a special case and it is most fortuitous that we have chosen this topic of workers engaged in maintenance, inspection and repair work. In these cases, how often should medical examination and inspection of medical records take place? Note that I emphasize the difference between medical examinations and inspection of medical records. Do these take place annually? Every 6 months? Or every five years? Dr Wijker, could I have your opinion on this point?

Dr WIJKER (Netherlands)

The medical examinations are repeated each year for the 5 rem per year group. As a rule a man is not allowed to enter the plants for radiological work if the date of his last medical examination on his passport is more than a year ago. If necessary medical examinations will be done more often, namely if there are indications to do so. As for the physical supervision the pen dose is read within short times after the irradiations, each day or more often, whereas the legal dose, measured with the film badge, is determined every fortnight or every month - that depends on the organization giving this service.

Dr LAFONTAINE (Belgium)

This does give some indication, although the medical examination is linked with a calculation of the radiation dose. Nevertheless I find it very difficult, as a doctor, to believe that only ionizing radiation is significant here. It is rather like saying, in a different context, that doctors should only examine patients with a temperature of more than 37.5°C. It is not enough to consider only workers in the nuclear industry - we must consider all workers exposed to radiation.

THIRD SESSION

THE MEDICAL FILE AND RECORD OF IRRADIATION

Chairman: Dr. MEHL

THE MEDICAL FILE AND RECORD OF IRRADIATION

Dr. Mazaury and Dr. Sarbach

I - INTRODUCTION

According to the Law of 11.10.1946 setting up Industrial Medicine in France (1) a medical file must be kept in respect of each worker.

Moreover, French legislation (2) imposes heavy obligations on the industrial doctor responsible for the medical supervision of staff regularly exposed to ionizing radiations; these obligations apply, in particular, to the number of examinations to be carried out and the recording of medical files.

Indeed, it is a legal requirement (3) that the complete case history of a worker occupationally exposed to ionizing radiations, be kept throughout the whole of his working life and for at least 30 years after he leaves the industry. The medical file contains the results of routine examinations and all clinical, paraclinical, biological and toxicological examination which are of vital importance for preventing risks (industrial in general or nuclear) and for assessing the man's suitability for his activity.

In short, medical files of workers in the Nuclear Industry must meet numerous requirements. They must also present certain features which are set out below.

(1) - Law of 11 October 1946
(2) - Decrees of 20.6.1966 and 15.3.1967
- Orders of 18 to 24.4.1968
- Medical recommendations (O.J. of 8.6.1968)
(3) - Art. 30 of the Decree of 15.3.1967
(4) - Annex I of the Decree of 20 June 1966 'Personnes directement affectées à des travaux sous rayonnements ionisants'
- Workers directly assigned to tasks under ionizing radiations.

II.- THE PRESENTATION OF THE MEDICAL FILE

1. - Clarity

The medical file has been complicated by the number of records which it must contain and so the first requirement is that it should be clear.

Its presentation should be such as to make searching unnecessary and the doctor who consults it should immediately be able to pick out the required information.

2. - Ease of handling

The updating of the medical file and the recording of results of examinations as follow-ups to medical observation should present no problems.

3. - Ease of reproduction

The medical file should be able to facilitate relations with the attending physician; hence it should be possible to photocopy the various records so that they can be sent to him.

4. - Flexibility

The medical file should be easily adaptable to each doctor's personality and to each Nuclear Centre.

5. - Ease of revision

It should be possible to improve separately the presentation or composition of each record.

6. - Comprehensiveness

The medical file should include full records relating to every aspect of medical observation involved, including all files.

III. - THE FORM ADOPTED FOR THE MEDICAL FILE

In order to meet the sum-total of these requirements, early in 1962 we designed a medical file in the form of a booklet with an index, bound by a plastic cover. Since then the documents contained in it have been regularly revised and at present it covers the following records:

1. - Pre-employment medical file

All the observations following the first medical examination after recruitment including examinations by specialists, aptitude tests, results of additional biological and radiological or other examinations are recorded in this file.

2. - Personal record card

Gives information on :

- Civil status
- Previous employment
- The employee's vocational training and career.

Source: Personnel Department.

3. - Employment and noxae medical record card

It includes the following records:

- Working conditions
- Specific duties
- Radiological noxae { contamination
  Non radiological noxae { irradiation
- Sensory, motor and dynamic, and neuropsychic demands. Record for the use of the industrial doctor.

Contribution from :

- The Head of Department
- The Safety Expert
- The Head of R.P.S. (Radiation Protection Service)
- The Industrial Doctor

Signed by the person concerned.

4. - Medical observation file

The purpose of this file is to record written medical information by means of automated data processing. The file is in booklet form and findings made during medical examinations can be entered in boxes designed for that purpose.

The boxes are set out in such a way that medical observations can be entered in words along with the coding required for data processing.

A full description of the file is given later on.

5. - Record chart of absences due to illness and accidents at work.

6. - Summary card of X-ray examinations

7. - X-ray photography record card

This card is in the form of a cardboard frame in which the two latest X-ray photographs 10 x 10 are inserted.

Thus the two latest photographs can be compared at any time.

8. - Biological record card

9. - Radiotoxicologic and spectrometric record card

10. - Irradiation record card

This card is of particular importance, since the industrial doctor is accountable for the amount of irradiation to which the worker is exposed.

The total amount of irradiation is made up of external irradiation due to the monthly dosimetric films and internal irradiation as a result of possible internal contamination. The dose incurred is calculated and determined after every contamination incident.

Every contamination incident is described in detail on the back of the record card. The overall total is updated each year.

11. - Ophthalmological record card

12. - O.R.L. record card

13. - Audiometric record card

14. - Cardiological record card

15. - Envelopes

These envelopes contain :

- Special examinations: basic metabolism, specific examinations etc.

- Correspondence with the family doctor (G.P.)

16. - 'Archives' sheet

This sheet contains two jackets of microfilms each with 5 rows by means of which all the case histories of filed records can be classified.

IV. COMPUTERIZATION OF THE MEDICAL FILE

It is not hard to imagine the sheer volume which a medical file will amass for an employee who joins the undertaking at 19 and works in a controlled area for 46 years; furthermore, the medical file will then have to be kept for 30 years after the retirement of the employee concerned.

An enormous amount of filing must therefore be carried out: on the one hand, the most elementary security measures oblige us to keep records in duplicate in case of loss or destruction, and on the other, records must be filed on a medium resistant to wear and the vagaries of the weather. (In what state are we likely to find one of our present files which may have been started 76 years previously?) Moreover, work exposing to ionizing radiations is a relatively recent occupation and it is still impossible to assess the full effects on the health of individuals. Therefore, we need to carry out a continuous theoretical study which will lead to frequent consultation of all the data recorded

in the medical file.

In the case of an individual, micro-film dosimetry is a neat solution for keeping medical data in a small volume, on a reliable medium; furthermore, the data are presented in an immediately visible form and lend themselves readily to duplication. However, this system is unsatisfactory when investigations are carried out on a group of workers, requiring consultation of a large number of medical files; automated management is the only solution to this problem.

For this reason the medical file has been designed so as to be readily adaptable to computerization.

Data processing is indeed the only way to double filing on a safe, indestructible and compact medium.

Moreover, it is the ideal solution for recording epidemiological statistics of our various categories of workers.

The chosen system, developed from a study carried out at C.E.A.* VALDUC, is being put into general use within the whole of the C.E.A.

A full description will be given at a later date.

V. - MEDICAL OBSERVATION FILE

1. - Presentation

The medical observation file is in the form of a 22 page booklet (21 x 27). The last 17 pages are divided into boxes for recording medical findings. (Numbered 1 to 68).

The booklet can easily be inserted between the plastic sheets of the document file. In theory there are enough boxes for the continuous medical observation of a worker for half of his working life.

2. - Advantages

All the medical findings made during the employee's working life (routine examinations, examinations on return to work, voluntary examinations, emergencies etc.) can be recorded in one type of printed book.

* Commissariat à l'Energie Atomique - Atomic Energy Commission

Pages 4 and 5 give a general survey of the worker's present and previous employment, particular stress being laid on any marked inaptitudes.

By consulting the cover page an overall view may be obtained of the diseases detected which may require special medical observation.

To bring about the transition to data processing, a code is used for examinations, medical observation, illnesses, occupational ethology and medical decisions; the code is summarised in the end paper of the file.

A large proportion of the space is reserved for medical findings.

Indeed, in traditional files the organs or systems to be examined by the doctor are noted down in words.

This arrangement considerably restricts the space available for comments.

We felt it more logical to use a code (in clear, in an abbreviated form) to record this information, followed by a box, in which the figure Ø or 1 is to be written according to the result of the examination.

Example: DIGE: Digestive system
CARD: Cardiovascular etc.

If the doctor finds an anomaly in the system under examination (hence figure 1), he can use the space below which is large enough for writing his comments.

In practice, indeed, the doctor rarely has to enter comments for more than three systems examined, which makes the spaces left opposite other systems in the traditional file superfluous.

To sum up, the presentation of the file in booklet form has the advantage of revealing at a glance all the findings made during the employee's working life, in chronological order.

3. - Directions for use

The first page indicates the employee's identity and contains his photograph along with a summary of important medical information.

The second page - the so-called end paper - indicates the code to be used by the doctor. It can be readily consulted.

The synopsis of the following two pages forms a record of the jobs held by the employee in the undertaking.

Left page : For marked suitability

Right page: Inabilities. The number corresponding to the box of the file in which the judgement of inability was recorded should be entered in the final column.

The following pages contain boxes for medical examinations and findings. Each box has a number.

On the first line the name of the examining doctor should be entered. On the second line :

- on the left the reason for the examination should be coded by a number.

Examples: 07 : annual medical examination
05 : return to work examination after an accident at work

On the right : the date

The two spaces below offer the following information :

- on the left (left space) the results of the examinations carried out as a minimum basic requirement
- on the right (right space) examinations left to the doctor's discretion.

The examinations to be carried out as a minimum basic requirement have been studied and codified by a group of doctors of the CEA. These examinations have undergone full analysis.

Findings made during the medical examination should be recorded in two forms :

- Detailed form in which the doctor will write out in words his findings if any (space left blank)

- Coded form for data processing

GENERAL CODING PRINCIPLE

- [ ] = Examination not carried out
- [Ø] = Examination carried out and normal or NAD in comparison with the previous examination
- [1] = Examination carried out and abnormal

A) - LEFT SPACE - Result of the basic examination

- There is an abbreviation (usually in 'clear abbreviated' form) followed by a box for each organ or system examined :

  Example: DIGE[ ] (digestive system)

The doctor is the judge in this matter and he alone decides whether he should put a [Ø] or a [1] for an old chronic disease or a sequela or a hereditary disease.

If he puts a [Ø] he considers the disease stabilized and does not think it necessary to draw another colleague's attention to the system in question.

If he puts [1] he feels that a change, an aggravation or an improvement is still possible, and that particular attention should be paid to the system in question.

Example : Stomach ulcer detected in 1973

1973 DIGE | 1 |

Medically treated 1974 - 1975.

1974 DIGE | 1 |

1975 DIGE | 1 |

The figure | 1 | indicates that the examination has been carried out, that a pathological (or abnormal) symptom has been detected, or that a disease already known has become worse or requires particular observation of the system concerned.

The comments noted in words in the space left blank and if necessary coded, should correspond, in theory, to this figure | 1 |.

B) RIGHT SPACE - Examinations left to the doctor's discretion

- Visual acuity right eye AVOD | | | as a 10th example | 0 | 8 |
- Visual acuity left eye AVOG | | as a 10th example | 1 | 0 |
- Ophthalmology OPHT | | ocular pathological symptom detected at the medical examination.

Use the same code for the left space:

| | | ø | or | 1 |

- PSYC | | = (abbreviation for psychology) means: no psychological examination has been carried out.

  PSYC | ø | = a psychological examination has been carried out, result normal.

  PSYC | 1 | = a psychological examination has been carried out, result abnormal.

- Tobacco NICO | | | number of grammes of tobacco consumed daily. (One cigarette = 1 gramme)

- Alcoholism ETHY [ ] alcoholism suspected

- Sugar SUC [ ] - Albumin ALB [ ] - Cytology CYT [ ]

for departments which systematically carry out these tests at the medical examination.

Same coding [ ] [ø] or [1] as before

- Long X-ray examination IMTH (radioscopy, or radiography or X-ray photography).

IMTH [ ] no X-ray examination carried out.

IMTH [ø] X-ray examination normal or NAD in comparison with the previous examination.

IMTH [1] X-ray examination abnormal.

- Electrocardiogram ECG [ ]
- Audiogram AUDI [ ] } Same coding
- Ruffier-Dickson RD [ ]

C) SPACE LEFT BLANK

Enter here comments arising from the medical examination. In particular, write diagnosis IN WORDS.

D) LOWER SPACE

For coding :

1. Diagnoses made during the medical examination or arising from an interview with the person concerned, the cause of the illnesses and the stage of development (three possibilities) (WHO code).

2. Cause of accidents at work, or occupational diseases or other accidents in accordance with the CEA code.

3. Number of days off work - if any.

4. Professional conclusion to be drawn after every examination.

5. Medical directions given to the employee.

6. Sickness declarations.

Thus the last three lines are reserved for the coding of medical findings, professional conclusions, directions and declarations.

This coding is essential to the storage by means of automated data processing of all the information concerned.

The description of the computerised medical file, the codes used and the abbreviations will be included in a future publication which we will gladly consider compiling within the framework of a symposium organized on this subject by the European Communities.

Annexes:

- Recruitment medical file,
- personal record card,
- employment and noxa medical record card,
- medical observation file,

CHU - SMPT

DOSSIER MEDICAL D'EMBAUCHE

NOM : **Née :**

Prénoms : **Sexe** [M] [F] **Situation de famille :**

Né (e) le : **à :** **N° S.S. :**

Adresse :

ANTECEDENTS PERSONNELS

NATURE, DATE, SEQUELLES DES AFFECTIONS, TRAITEMENT DE LONGUE DUREE, SEJOURS EN ETABLISSEMENTS SANITAIRES, HOPITAUX, SANAS, HOPITAUX PSYCHIATRIQUES, CLINIQUES, MAISONS DE REPOS etc

AFFECTIONS CONGENITALES

MALADIES

ALLERGIES

INTERVENTIONS CHIRURGICALES

ACCIDENTS DU TRAVAIL **I.P.P.**

AUTRES ACCIDENTS

MALADIES PROFESSIONNELLES **I.P.P.**

Indemnisables **Non indemnisables**

Intoxications autres que les M.P

SEJOURS HORS DE FRANCE (Régions tropicales - Sub tropicales)

SITUATION MILITAIRE Service Armé Auxiliaire [ ] **Sursitaire** [ ] **Exempté** [ ]

Réforme [ ] **Temporaire** [ ] **Motif :** **Pension** [ ] %

Definitive [ ]

FORMATION SCOLAIRE ET PROFESSIONNELLE - ANTECEDENTS PROFESSIONNELS

ACTIVITES SPORTIVES

RADIODIAGNOSTIC : (Examens radiologiques : lesquels, quand, motif)

RADIOTHERAPIE : (Rayons X, Co 60, Radium, Radioéléments artificiels, etc .)

ANTECEDENTS PROFESSIONNELS D'IRRADIATION OU DE CONTAMINATION :

Vaccinations	Date dernière vaccination		Dates	Résultats		DATES - MOTIF
Variole		T Tuberculinique			SERUM	
Diphtérie						
Tétanos						
Polio						
T.A.B.		B C G			TRANSFUSION	
Autres						

ANTECEDENTS FAMILIAUX

PERE

MERE

CONJOINT

COLLATERAUX

ENFANTS (Date de Naissance)

Interrogatoire Minimum (1)	EXAMEN MEDICAL — Date	Docteur	
APPAREIL LOCOMOTEUR — Arthralgies ? ⌊_⌋ — Myalgies ? ⌊_⌋ — Névralgies ? ⌊_⌋ — Séquelles ? ⌊_⌋	Force musculaire . Main Dte . Main Gche :		Taille ⌊_⌋⌊_⌋⌊_⌋ Poids ⌊_⌋⌊_⌋⌊_⌋
O.R.L. — Audition correcte ? ⌊_⌋ — Acouphènes ? ⌊_⌋ — Angines fréquentes ? ⌊_⌋ — Sinusites ? ⌊_⌋ Rhinites ? ⌊_⌋ — Epistaxis ? ⌊_⌋ Otorrhées ? ⌊_⌋	Tympans : O. D : O. G. :		
OPHTALMOLOGIE — Fatigue oculaire ? ⌊_⌋ — Sécrétions ? ⌊_⌋ — Douleurs ? ⌊_⌋	Couleurs :		Près Loin O. D. ⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋ O. G. ⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋
PEAU - MUQUEUSES — Allergies ? ⌊_⌋ — Psoriasis ? ⌊_⌋			
HEMATOLOGIE ET GANGLIONS — Tendances hémorragies ? ⌊_⌋ — Tendances écchymoses ? ⌊_⌋ — Tendances adénopathies ? ⌊_⌋	Rate : Ganglions		
RESPIRATOIRE — Toux ? ⌊_⌋ — Expectoration ? ⌊_⌋ — Dyspnée ? ⌊_⌋	Auscultation pulmonaire Consommation tabac g/j		C. V. V. E. M. S. TIFFENEAU
CARDIO-VASCULAIRE — Palpitations ? ⌊_⌋ — Précordialgies ? ⌊_⌋ — Oedème Mbres inférieurs ? ⌊_⌋ — Douleur à la marche ? ⌊_⌋ — Dyspnée d'effort ? ⌊_⌋	Auscultation cardiaque : Varices		Pouls ⌊_⌋⌊_⌋⌊_⌋ T. A Minim. ⌊_⌋⌊_⌋ Maxim ⌊_⌋⌊_⌋
ABDOMEN — Hernie ? ⌊_⌋			
(1) Répondre par ∅ ou 1			

Annexe 1

DIGESTIF

— Régime ? ___ Gastralgies ? ___
— Pyrosis ? ___
— Douleurs abdominales ? ___
— Appétit ? ___
— Constipation ? ___
— Diarrhée ? ___
— Hémorroïdes ? ___
— Rectorragies ? ___

DENTURE :

GM	GM	GM	PM	PM	C	I	I	I	I	C	PM	PM	GM	GM	GM

Examen du foie.

CONSOMMATION D'ALCOOL

GENITO-URINAIRE

— Mictions nocturnes ? ___
— Dysurie ? ___
— Pollakiurie ? ___
— Dysménorrhée ? ___
— Leucorrhée ? ___

ORGANES GENITAUX :

SEINS :

REGLES :

GROSSESSE

NEURO-PSYCHISME

— Insomnies ? ___
— Céphalées ? ___
— Anxiété ? ___
— Claustrophobie ? ___
— Vertige ? ___
— Perte de connaissance ? ___
— Crise nerveuse ? ___
— Irritabilité ? ___

REFLEXES :

Tendineux

Oculaires

Cutanés

Chvostek

TREMBLEMENTS :

ENDOCRINO-NUTRITION

— Soif ? ___ Faim ? ___
— Frilosité ? ___

THYROÏDE :

EXAMEN DES SPECIALISTES

Spécialité	Docteur	Conclusion

TESTS POUR APTITUDES AUX POSTES PARTICULIERS

Caisson : Tolerance à l'oxygène : **Plongée :**

Chaleur : Test d'efforts :

CONCLUSIONS DU MEDECIN DU TRAVAIL

EXAMENS BIOLOGIQUES

Folio n°

NOM : N° INSEE

Prénom

Date de naissance

Date de l'examen						
N° examen						
Code Labo						
HEMATOLOGIE	1	2	3	4	5	6
Erythrocytes						
Hematocrite						
Hemoglobine						
C.G.M. Hb						
V.G.M.						
T.G.M. Hb						
Reticulocytes						
Leucocytes						
Poly. Neutro						
Eosino						
Baso						
Lymphocytes						
Monocytes						
Thrombocytes						
F. Anormales						
T. Saignement						
T. Coagulation						
S. Ventouse						
V.S. 1 heure						
V.S. 2 heure						

OBSERVATIONS

1

2.

3

4

5

6

(suite) BIOCHIMIE SANG	1.	2.	3	4.	5	6.
Uree						
A. urique						
Glucose						
Lipides totaux						
Triglycerides						
Cholesterol						
URINES						
Proteines						
Glucose						
Corps ceton						
Sang						
pH						
Signature DIR. LAM.						

Annexe 1.

DOCTEUR **2**

Visite (A) MOVI

Date

PDKG

TA POUL

CARD LOCO
RESP GGLI
DIGE ENDO
ABDO NEUR
GENI TEGU
GROS ORL

AVOD AVOG
OPHT PSYC
NICO ETHY
SUC ALB CYTO
IMTH ECG
AUDI RD

DOCTEUR **3**

Visite (A) MOVI

Date

PDKG

TA POUL

CARD LOCO
RESP GGLI
DIGE ENDO
ABDO NEUR
GENI TEGU
GROS ORL

AVOD AVOG
OPHT PSYC
NICO ETHY
SUC ALB CYTO
IMTH ECG
AUDI RD

DOCTEUR **4**

Visite (A) MOVI

Date

PDKG

TA POUL

CARD LOCO
RESP GGLI
DIGE ENDO
ABDO NEUR
GENI TEGU
GROS ORL

AVOD AVOG
OPHT PSYC
NICO ETHY
SUC ALB CYTO
IMTH ECG
AUDI RD

DOCTEUR **5**

Visite (A) MOVI

Date

PDKG

TA POUL

CARD LOCO
RESP GGLI
DIGE ENDO
ABDO NEUR
GENI TEGU
GROS ORL

AVOD AVOG
OPHT PSYC
NICO ETHY
SUC ALB CYTO
IMTH ECG
AUDI RD

IMPRIMERIE DU CENTRE DE MARCOULE

Annexe 2

N° DE CARTE DE SERVICE

CONFIDENTIEL - SERVICE MÉDICAL

DATE ÉMISSION

FICHE DE POSITION

N° SÉCURITÉ SOCIALE

NUMÉRO

NOM JEUNE FILLE / Mlle / Mme	DATE NAISSANCE	SIT. FAM. ET NBRE ENF.	OR ACT. NATIONALITÉ	SITUATION MILITAIRE	OBLIG.

ADRESSE CODE POSTAL

CONJOINT	NOM	PRÉNOM	DATE NAISSANCE	DATE MARIAGE	C.	PROF.	N° CARTE

ORIGINE : ACTIVITÉS PROFESSIONNELLES ANTÉRIEURES

QUALIFICATION	EMPLOYEUR	DATE DÉBUT	DATE FIN	CODE

ORIGINE : FORMATION

PROMO	ÉCOLES - DIPLOMES

CARRIÈRE : AFFECTATIONS

DATE	ÉTAB.	DIR.	DÉP	SERVICE	SECTION	CODE
DERNIÈRE POSITION	ÉT G. F	ÉT LOC.	CODE SERVICE			

CARRIÈRE : CLASSEMENT

STATUT	CLASSEM	DATE	FIL	S/F	QUALIF. PROFESS	DERNIER CODE D

FORMATION PROFESSIONNELLE

NATURE	DURÉE	ORGANISME DE FORMATION

CMDLM 600 - PERMAFICHES PARIS-PITHIVIERS 40 368

C.E.A. S.M.T.

Centre :

FICHE DE POSTE & DE NUISANCES N°

J M A Date

Motif et fiche

NOM - 1er prénom - Initiale des autres prénoms

N° carte service

N° CEP

Code employeur

Sigle – Unité –

Code

Bat

Pièce principale

Autre piece – Lieu de travail –

CATEGORIE DE TRAVAILLEURS

Numéros des postes occupés dans l'entreprise

Exposé détaillé des fonctions :

CONDITIONS DE TRAVAIL 01

Inscrire horaire en clair	011				
Travail posté particulier	0103	Masques filtrants	0120	Basses Températures	0130
Permanences - Astreintes	0111	Tenue Non Ventilee	0121	Hautes Températures	0131
Déplacements hors domicile	0112	Tenue Anti Sodium	0122	Lumière Artificielle	0140
Travail à l'extérieur	0113	Tenue Ventilée	0123	Tahiti	0141
Station debout prolongee	0114	App Respiratoire Autonome	0124	Atolls d'expérimentations	0142
		Travail Sous Air Comprime	0125	Autres Sites	0143

ACTIVITES PARTICULIERES 02

Poste de Sécurité	0201	Travail en Hauteur	0220	Travaux Photographiques	0243
Conduite Auto	0202	Travaux Sous-Marins	0221	Imprimerie	0244
Conduite Poids Lourds	0203	Tirs d'Explosifs	0222	Galvanoplastie	0245
Conduite Automoteurs	0204	Travail sur Explosifs	0223	Tirage de plans	0246
Conduite Ponts Roulants	0205	Pompiers	0224	Soudure à l'Arc	0250
Conduite Grues	0206	Prod Aliment Restauration	0225	Soudure Autogène	0251
Manutentions	0207	Boites a Gants	0230	Soudure Electronique	0252
		Boites a Pinces	0231	Soufflage de Verre	0253
Chantiers Souterrains	0211	Telémanipulateurs	0232	Meulage Polissage	0254
Travail dans les Egouts	0212	Vision a travers Hublots	0233	Manip Laine Verre ou Roche	0255
Jardinage	0213	Ecrans Cathodiques	0234	Peint Vernis par Pulvéris	0256
Menuiserie	0214	Decontamineurs	0235	Sablage	0257
Blanchisserie du Linge	0215	Mecanographie	0240	Animalerie	0260
Collecte des Ordures	0217	Standard Telephonique	0241	Electricité	0280
		Microscope	0242		

CODE : 0 = NEANT - 1 = OCCASIONELLE - 2 = FREQUENTE - HABITUELLE OU PERMANENTE

NOTA IMPORTANT : Pour remplir cette fiche veuillez consulter la notice explicative que vous pourrez vous procurer au Service Medical du Travail

IMPRIMERIE DU CENTRE DE MARCOULE

NUISANCES

NON RADIOLOGIQUES

CODE des EXPOSITIONS . 0 = Nulle ou Potentielle — 1 = Occasionnelle — 2 = Fréquente, Habituelle ou Permanente

R Infra-Rouge 0501	Bases caustiques 1500	Métaux sans précis 2300	HC Alicycliques 3500	Alcools 5300	Matières plastiques Thermoplast 7600
R Ultra-Violet 0502	Chaux 1501	Beryllium Poussières 2311	HC Aromatiques 3800	Ether Ethylique 5503	Matières plastiques thermodurc. 7700
Laser 0503	Ciments 1502	Sodium metal 2321	Benzene 3801	Cétones 5700	Polyesters 7720
Bruit 0521	Métalloïdes 1700	Ac Chromique et Sels 2402	Dér non fluorés des Alcanes 4000	Acétone 5701	Polyépoxydes 7730
Vibrations et outils vib 0522	Silicium 1751	Nickel et composés 2440	Chloroforme 4003	Aldehydes 5800	Insecticides 7800
Ultra-sons 0525	Amiante 1753	Nickel carbonyle 2442	Tetrachlorure de carbone 4004	Formol 5801	Maladies infect et parasitaires 8300
Poussières végétales 0700	Graphite Charbon 1801	Mercure 2870	Dér non fluorés des Alcenes 4100	Esters sans précis 6000	
Poussières Animales 0800	Oxyde de carbone 1803	Plomb 2890	Der non fluores des Alcynes 4300	Tributyiphosphate 6402	
Halogenes 0900	Oxydes d'azote 1902	HC sans précis 3000	Trichlorethylène 4302	Cyanures 6800	
Fluor 1001	Ammoniac 1904	Huile de coupe 3008	Freons 4400	Amines aliphatiq et alicyclq 6900	
Ac Fluorhydrique 1002	Anhydride Sulfureux 2102	Lubrifiants 3009	Dér halogenes des HC aromatiq 4900	Amines Aromatiques 7000	
Anhydride organique 1200	Hydrogène sulfuré 2105	Goudrons et Brais non definis 3050	Dér Nitrés des HC aromatiq 5000	Diphénylamine 7042	
Acides minéraux 1300	Sulfure de carbone 2106	HC Aliphatiques 3100	Phenol 5201	Silicones 7311	Uranium Naturel 9601

RADIOLOGIQUES

CODE des EXPOSITIONS 0 = Nulle — 1 - Potentielle — 2 Occasionnelle — 3 = Frequente, Habituelle ou Permanente

IRRADIATIONS	X, γ < 100 Kev 9101 A	X, γ > 100 Kev 9102 B	β Purs 9103 C	α Purs 9104 D	Rayonnements Multiples 9105 E	Neutrons Thermiques 9106 F	Neutrons Rapides Protons 9107 G
CONTAMINATIONS							
^{3}H 9201	PF 9301	^{210}Po 9501	U Naturel 9601			^{238}Pu 9702
^{14}C 9202	PA 9302	^{226}Ra 9540	^{233}U 9602			^{239}Pu 9703
^{32}P 9203	^{125}I 9303	Th Naturel 9560	U Oxyde enrichi < 5% 9605			Pu sale 9704
^{35}S 9204	^{131}I 9304	^{237}Np 9580	U Oxyde enrichi > 5% 9606			^{241}Am 9720
^{90}Sr-Yt 9206	^{137}Cs 9305					^{244}Cm 9740
^{45}Ca 9207	^{60}Co 9306					^{252}Cf 9780
^{36}Cl 9209						

OBSERVATIONS :

Le chef de Service	L'ingenieur de Sécurité	Le responsable S P R	L'Intéressé
SIGNATURE	VISAS		
NOM	NOMS		
DATE	DATES		

RESERVÉ AU S M T

	VM	NF	TS+TC L PL	HP	VS	UR	AI B	S		CO	Pb		Ni	Be	B		SP CE PL	SP		0		AU	ORL		E
	RAE	^{14}C AE		SP γ HE	SP γ BE	Thy		^{35}S	^{32}P	^{3}H	^{14}C	^{36}Cl	$^{238}U_{Y}$	^{233}U	^{235}U	Sr	PF	Th	Pu	Po	Ra	Am			
	0401	0402	0403	0404			0410			0420	0421	0422	0423	0424	0425			0430			0440	0441	0442		
	0450	046	047		048	048	048	048	048	CODE MEDICAL								CODE RADIOTOXICOLOGIQUE							

Annexe 4

C.E.A.
SERVICE MÉDICAL DU TRAVAIL

DOSSIER DE SURVEILLANCE MEDICALE

Nom .....

Prénoms .....

Date et lieu de Naissance: .....

N° INSEE ou S.S. | | | | | | | | | | | | | | | N° carte C.E.A. .....

Entré au C.E.A. le ..... A ..... le .....

..... A ..... le .....

..... A ..... le .....

5003 I

RENSEIGNEMENTS MÉDICAUX

CET AGENT EST A SURVEILLER TOUT PARTICULIEREMENT SUR LES POINTS CLINIQUES SUIVANTS.

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RUBRIQUES	CODE	SIGLE CASE
MOTIF VISITE (A) (MOVI)		
MISE AU TRAVAIL		
Embauchage	1	MOVI
Reintegration	2	MOVI
Depart	31	MOVI
REPRISE TRAVAIL		
Maladie	3	MOVI
Maternite	4	MOVI
Accident travail	5	MOVI
Maladies professionnelles	6	MOVI
SURV. MED. SYSTEMATIQUE		
Annuelle	7	MOVI
SURV. MED. PARTICULIERE		
Poste Securite - Cond. vehicule	8	MOVI
Risque Maladies Professionnelles	9	MOVI
Deficients - Handicapés	10	MOVI
Trav. moins de 18 ans	11	MOVI
Migrants - Chang. Activ	12	MOVI
Agents postes	32	MOVI
Mere enfants - 2 ans	33	MOVI
SURV. MED. OCCASIONNELLE		
A la demande de l'interesse	13	MOVI
A la demande de l'employeur - Titular	14	MOVI
Urgence	15	MOVI
Autres	16	MOVI
Apt. Spec. sur dossier	17	MOVI
A la demande du Med. Trav.	18	MOVI
TESTS APT. POSTE PARTICULIER		
Caisson	19	MOVI
Plongee profondeur	20	MOVI
Tolerance a l'oxygene	21	MOVI
Travaux en temperature	22	MOVI
Test d'effort	23	MOVI
SURV. MED. SPECIALISTE (B) (1)		
O.R.L.	24	MOVI
Ophtalmo	25	MOVI
Cardiologie	26	MOVI
Pneumologie	27	MOVI
Neurologie	28	MOVI
Dermatologie	29	MOVI
Autres	30	MOVI
PROTOC. MINIM. D'EXAMEN		
Poids	en kg	PDKG
Tension Arterielle	Chiff	TA
Pouls	Nb Mn	POUL
Cardiovasculaire	∅ ou 1	CARD
Locomoteur	∅ ou 1	LOCO
Respiratoire	∅ ou 1	RESP
Hemato-Ganglions	∅ ou 1	GGLI
Digestif	∅ ou 1	DIGE
Endocrino-Nutrition	∅ ou 1	ENDO
Abdomen	∅ ou 1	ABDO
Neurologie	∅ ou 1	NEUR
Genito-Urinaire	∅ ou 1	GENI
Teguments	∅ ou 1	TEGU
Grossesse	∅ ou 1	GROS
O.R.L.	∅ ou 1	ORL
AUTRES EXAMENS		
Acuite Visuelle O.D.	Nb 10ème	AVOD
Acuite Visuelle O.G.	Nb 10ème	AVOG
Ophtalmo	∅ ou 1	OPHT
Tabac	Gr Jr	NICO
Ethylisme	∅ ou 1	ETHY
Psychologie	∅ ou 1	PSYC
Glycosurie	∅ ou 1	SUC
Albumine	∅ ou 1	ALB
Cytologie	∅ ou 1	CYT
Electrocardiogramme	∅ ou 1	ECG
Audiogramme	∅ ou 1	AUDI
Radiophoto. Pulmonaire	∅ ou 1	IMTH
Ruffier Dickson	∅ ou 1	R.D.
BILAN MÉDICAL		
ORIGINE MALAD. AFFECT. (ORMA)		
Affection a Caract. Prof.	AP	ORMA
Affection Medicale	ME	ORMA
Affection Chirurgicale	CH	ORMA
Affection Contagieuse	AC	ORMA
Accident Travail	AT	ORMA
Accident de Trajet	TR	ORMA
Accident de Sport	AS	ORMA
Accident (divers)	AD	ORMA
Maladie Professionnelle	MP	ORMA
Handicape	HA	ORMA
Grossesse	GR	ORMA
Cure Thermale	TH	ORMA
Contamination	CO	ORMA
Irradiation	IR	ORMA
STADE EVOLUTIF (STEV)		
Possibilite de	E	STEV
Diagnostic confirme	D	STEV
Non traitee	N	STEV
En traitement	T	STEV
Stabilisee (fin)	F	STEV
Rechute de	R	STEV
Sequelles de	S	STEV
Aggravation de	A	STEV
Amélioration (mieux)	M	STEV
Predisposé a	P	STEV
Opere de (interv. chirurg.)	O	STEV
Decede de	X	STEV
DIAGNOSTIC (DOMS)	OMS	DOMS
CAUSE PROFESSIONNELLE (CEA)	CEA	CEA
ABSENTEISME NBRE DE JOURS (ABST)	Nb Jr	ABST
CONCL. PROFESS. (C) (COPR)		
Apte Poste de Travail	APT	COPR
Inapte	INA	COPR
Apte Trav. expose R.I. (DATR)	ADA	COPR
Apte non direct. affecte	AND	COPR
Exclusion Temp. Poste	ETP	COPR
Exclusion Defin. Poste	EDP	COPR
Exclusion Z.C. Temporaire	EZT	COPR
Exclusion Z.C. Definitive	EZD	COPR
Reclassement Obligatoire	RO	COPR
Aptitude Activ. Reduite	AAR	COPR
Aptitude a Temps Partiel	ATP	COPR
Apte Sous Surveillance	ASS	COPR
Apte sur Dossier	ASD	COPR
Rayé des Contrôles	RDC	COPR
CONCLUSIONS MÉDICALES (D)		
ORIENTATION (CMOR)		
Médecin - Traitant	MT	CMOR
Medecin Specialiste	MS	CMOR
Hospitalisation	HO	CMOR
Service Social	SO	CMOR
Service de l'Emploi	SE	CMOR
Autres	AU	CMOR
Ex. compl. dem. par Med. Trav.	EC	CMOR
DECLARATION (CMDE)		
Malad. Profess. Indemnis.	Chf	CMDE
Maladie Caract. Profession.	DEC	CMDE
Maladie Contagieuse	DEC	CMDE

(1) Code à inscrire uniquement sur la fiche de surveillance.

POSTES OCCUPÉS

HORAIRE & CONDITIONS DE TRAVAIL

Aptitudes prononcées

DATE	CENTRE	SERVICE	FONCTIONS	No Fiche de Poste	CATÉGORIE	DÉCISION

DANS L'ENTREPRISE

ACTIVITÉS PARTICULIERES

Inaptitudes prononcées

DATE	CENTRE	SERVICE	POSTE (horaire condition trav. Activ. partic.)	DECISION	MOTIF D'INAPTITUDE	Voir N°

DOCTEUR **1**

Visite (A) MOVI

Date

PDKG

TA POUL

CARD LOCO

RESP GGLI

DIGE ENDO

ABDO NEUR

GENI TEGU

GROS ORL

AVOD AVOG

OPHT PSYC

NICO ETHY

SUC ALB CYTO

IMTH ECG

AUDI RD

ORMA	STEV	DOMS	CEA	ABST
			COPR	
			CMOR	CMDE

MEDICAL RECORDS AND RADIATION EXPOSURE CARDS

Dr C. Vigán

When I was asked to tell you about our experience in the Euratom Medical Service, I noted from the programme that my contribution would follow that by my colleague and friend Dr Mazaury on the same subject and I was immediately assured that he was going to give a very full and well documented account, as you have just found.

Under these circumstances and to avoid any repetition, I shall be brief. I shall also omit the legal aspects according to which opening of medical records constitutes a statutory requirement, the actual procedure depending on the Community country, and I shall merely put forward some of my ideas concerned with the work at our Ispra Centre.

One interesting point is the difference between conventional industrial medical records and those used for staff exposed to ionizing and non-ionizing radiation.

Leaving aside dosimetry, I would say the main difference is that certain headings are treated in more detail rather than that any new ones are used. The approved medical practitioner has in fact two main tasks : he must gather enough relevant information to decide on the worker's suitability and also to determine his physical condition, normal or otherwise, and he must record it with enough detail to permit comparison with findings at later examinations.

My colleagues and I attach a great deal of importance to the occupational medical history and to the detailed description of the workplace given by the person concerned, which often differs considerably from the information provided by management.

Account-keeping of radiation doses administered for diagnostic or therapeutic purposes should be more strict. These are indeed high doses, out of proportion with the very moderate ones from occupational exposure which are nevertheless a great cause for concern to us.

For the purposes of medical records, clinical examinations and complementary investigations, a large proportion of the measurements are of course made on the critical organs. I will not go into any further detail since these were discussed by Dr Strambi this morning and will be covered again tomorrow by Dr Renz in connection with non-ionizing radiation.

On the other hand, I think it would be useful to consider the problem of the container or, if you prefer, the physical medium receiving the information to be recorded.

The written style of medical records, although subject to heavy competition, is still very much with us, and other methods seem unlikely to replace it in the near future. It comes in various models, the luxuriousness of which varies depending on the funds available, but the practicality of which varies also.

Broadly speaking, we are torn between the need for chronological recording and the advantage of simultaneous display of successive results, not forgetting the usefulness of having different types of information (clinical, X-ray, laboratory data, etc.) laid out side by side.

The system and type of printed form used are a matter of individual preference. A serious deficiency, however, shows up whenever one wishes to make statistical studies, and this is one of the major arguments in favour of other methods such as punch card systems, which are already at an advanced stage of development and, more recently, data processing systems.

What should one choose? It seems that the decision must be based on the number of individual records to be handled, which is necessarily high (for data processing I would certainly say more than 10 000), and the funds available, unless it is possible to share an existing computer with other departments of the undertaking, of an institute or university, or even with other undertakings.

As we are all aware, even if it is relatively easy to handle numerical values at the start, such as haematological or biochemical findings, clinical data must unfortunately be coded. Finally, it has been said that use of the computer jeopardizes medical secrecy and undermines the doctor's independence in exercising his profession.

I will not examine this problem further, since it is a matter for specialists and has already been the subject of interesting work in our countries.

This brings me to the problem of storage. I do not need to remind you that records on exposed personnel must be kept for 30 years and that the space provided is generally inadequate. This leads us to consider using microphotography which moreover facilitates mailing of records.

As regards transferring records, perhaps we should get down to clarifying to whom - a company doctor working in his country or in the Community? - and how or in what form - as a summary or in full? It should also be possible to transfer these documents and still guarantee medical secrecy.

The free movement of labour is increasing and we must therefore reach a decision on this matter.

In this connection I should like to know the opinions of the experts present on the introduction of a health record book, which I personally consider an absolute necessity. Ideally each person would receive one at birth and keep it throughout his life, thus obviating the need to recite or reinvent his medical history each time he consulted a new doctor. This document would contain summaries of the different files kept on him since birth, at the maternity hospital, at school, during military service, by the doctors treating him in hospital (if applicable) and of course by industrial doctors. There is no reason why there should not be, if necessary, one or more special additional sheets, for example to record dosimetric data on exposed workers. I am thinking in particular of Euratom safeguards experts who are constantly travelling between the nuclear installations in the nine countries. Such a solution would unfortunately not eliminate the need to keep a copy somewhere in case of loss.

A computer used as a data bank would be a wonderful tool, making it possible, by means of a magnetic key held only by the person concerned, to show the records on a visual display unit or printer, even in any desired language (this is technically possible), wherever such terminals were available, provided of course that the networks were connected.

Please forgive my departure from the subject, but I do not think this is really in the realm of science fiction.

I was also going to speak about the radiation exposure card but I think that my colleague, Professor Giubileo, is better qualified to do this. I therefore call on him to speak and I hope that I have provided some points for discussion.

MEDICAL RECORDS AND RADIATION EXPOSURE CARDS

Dr Giubileo

Occupational exposure to ionizing radiations is authorized in accordance with the maximum permissible doses laid down for workers. Since these limits were adopted, it became necessary to record individual dosimetric data on special forms.

Two general tendencies have been observed for cases when the risk is connected with the use of X-ray generators and devices of industrial gammagraphy :

- for workers subject to regular control by an industrial medical officer, the dosimetric information is recorded side by side with the results of other additional examinations noted in the medical record;

- for other persons (such as radiologists and health personnel in general), dosimetric data often forms a separate source of information and as such are kept by the person responsible for physical monitoring.

Later, with the development of nuclear research for peaceful purposes and the increasingly widespread use of radioisotopes in medicine, the health surveillance of exposed persons became more specialized, particularly in Nuclear Centres where the health personnel responsible for controlling hazards due to radiation drew up a new type of card which, apart from simply recording the dosimetric count, also gives various details of the type of protection used.

We are all familiar with various types of form, some of which supplement personal dosimetric data with information on the location of the dosimeter on the individual, monitoring devices in the working environment and results of blood tests.

The European Atomic Energy Community subsequently drew up 'Basic Safety Standards for protection against radiation hazards', also known as the 'Euratom Basic Safety Standards'. Article 26 of the Basic Standards covers health records for exposed workers. It specifies that 'the medical file shall include information regarding the duties to which the worker has been assigned, personal doses received by the worker and the results of medical examinations'; it also requires Member States to bring in regulations for the practical procedures for keeping medical records up to date.

It should however be mentioned that the official text of the Basic Standards and the national legislation in the Member States concerned have since been supplemented by the work of the Committee of experts referred to in Article 31 of the treaty of Euratom. In April 1959, the latter examined a draft 'radiation card' and, the following December, adopted an improved version containing the following details :

- general information on the place of work and on the individual (marital status);
- technical qualifications of the worker;
- detailed anamnesis covering former activities involving exposure to ionizing radiation, type of radiation, individual and environmental monitoring and doses absorbed for occupational reasons (under normal and exceptional circumstances);
- similar information (in the same detail) in connection with the individual's present position;
- regular records of individual dosimetric data with quarterly and annual totals.

This model radiation card was adopted by the Euratom Medical Service in Brussels and has indirectly influenced the cards now in use in the various Community countries.

The radiation card prepared by our Medical Department which is now being used at the JRC at Ispra (Fig. 1-4) includes all the above

Fig. 1

EURATOM
C.C.R. - ISPRA
SERVIZIO SANITARIO

SCHEDA DI IRRADIAZIONE

COGNOME E NOME	*REPARTO*	N° MATRICOLA
DOMICILIO	*QUALIFICA TECNICA*	
DATA DI NASCITA		DATA DI ISTITUZIONE DELLA SCHEDA
SESSO		
STATO CIVILE	*ETÀ ALL'INIZIO DEL LAVORO CON RADIAZIONI*	
FIGLI		

ANAMNESI

A. ATTIVITA' PRECEDENTI CON ESPOSIZIONE A RADIAZIONI IONIZZANTI

1. IMPIEGATO PRESSO:
   - ..... dal ..... al .....
   - ..... dal ..... al .....
   - ..... dal ..... al .....
2. OCCUPAZIONI *
   - a) Sorgenti non sigillate
     - ..... dal ..... al .....
     - ..... dal ..... al .....
   - b) Sorgenti sigillate
     - ..... dal ..... al .....
     - ..... dal ..... al .....
   - c) Reattori nucleari
     - ..... dal ..... al .....
     - ..... dal ..... al .....
   - d) Apparecchi a raggi X
     - ..... dal ..... al .....
     - ..... dal ..... al .....
   - e) Grandi macchine acceleratrici
     - ..... dal ..... al .....
     - ..... dal ..... al .....
3. NATURA DELLE IRRADIAZIONI *
   - esterne: raggi X dal ..... al .....
   - raggi γ dal ..... al .....
   - particelle β dal ..... al .....
   - neutroni dal ..... al .....
   - altre particelle: ..... dal ..... al .....
   - interne (radionuclidi .....) dal ..... al .....

B. TIPO DI CONTROLLI EFFETTUATI IN PASSATO

1. CONTROLLI AMBIENTALI .....
2. CONTROLLI INDIVIDUALI:
   - a) irradiazione esterna: .....
   - b) contaminazione esterna: .....
   - c) contaminazione interna: .....

C. DOSI RICEVUTE IN PASSATO PER MOTIVI PROFESSIONALI

1. VALUTAZIONE (in rem) DELLA DOSE ACCUMULATA AL PRESENTE:
   - a) corpo intero: .....
   - b) estremità: .....
   - c) organi interni: .....
2. IRRADIAZIONE CONCORDATA: **
   - dose ricevuta ..... il .....
   - provvedimenti .....
3. IRRADIAZIONI ACCIDENTALI **
   - dosi ricevute: ..... il .....
   - ..... il .....
   - ..... il .....
   - totale: .....
   - provvedimenti .....

* Sottolineare nettamente la natura delle occupazioni e delle irradiazioni e fornire le informazioni disponibili.

** Indicare, se possibile, se si tratta di una irradiazione interna o esterna o di una irradiazione mista. Se si tratta di una irradiazione interna, indicare il nuclide.

EVENTUALI OSSERVAZIONI .....

Mod. 4-65

Fig. 2

Cognome e Nome	N° Matricola	N° Progressivo

ATTIVITÀ E TIPO DEL RISCHIO ATTUALE DA RADIAZIONI *

DATA DI INIZIO DELLA ESPOSIZIONE ATTUALE _____

A. REPARTO

B DESTINAZIONE LAVORATIVA

C OCCUPAZIONI **

a) Sorgenti non sigillate

b) Sorgenti sigillate

c) Reattori nucleari

d) Apparecchi a raggi X

e) Grandi macchine acceleratrici

D NATURA DELLE IRRADIAZIONI E VALUTAZIONE DEL RISCHIO **

esterne: raggi X

raggi γ

particelle β

neutroni

altre particelle

interne: (radionuclidi:

)

E TIPO DI CONTROLLI EFFETTUATI

1 CONTROLLI AMBIENTALI

2 CONTROLLI INDIVIDUALI

a) irradiazione esterna

apparecchio

localizzazione

periodicità

b) contaminazione esterna

apparecchio

localizzazione delle misure

periodicità

c) contaminazione interna

metodo

organo interno considerato

periodicità

F. RIFERIMENTI

OSSERVAZIONI:

DATA DI INIZIO DELLA ESPOSIZIONE ATTUALE _____

A. REPARTO

B. DESTINAZIONE LAVORATIVA

C. OCCUPAZIONI **

a) Sorgenti non sigillate

b) Sorgenti sigillate

c) Reattori nucleari

d) Apparecchi a raggi X

e) Grandi macchine acceleratrici

D. NATURA DELLE IRRADIAZIONI E VALUTAZIONE DEL RISCHIO **

esterne: raggi X

raggi γ

particelle β

neutroni

altre particelle

interne: (radionuclidi:

)

E TIPO DI CONTROLLI EFFETTUATI

1 CONTROLLI AMBIENTALI

2. CONTROLLI INDIVIDUALI

a) irradiazione esterna

apparecchio

localizzazione

periodicità

b) contaminazione esterna

apparecchio

localizzazione delle misure

periodicità

c) contaminazione interna

metodo

organo interno considerato

periodicità

F RIFERIMENTI

* Un nuovo foglio è aggiunto alla scheda se un cambiamento di attività modifica la natura dei rischi.

** Sottolineare nettamente la natura delle occupazioni e delle irradiazioni e fornire le informazioni disponibili

Fig. 3

TABELLA D'IRRADIAZIONE (ANNI ....)

COGNOME E NOME .... ETÀ ...... Nº. MATR. .... Nº. PROGR. ....

1	2	2 bis	3	3 bis	4	5	6	7	7 bis	8	9	10	11	12	13	14	15
	IRRADIAZIONE TOTALE (mrem)							IRRADIAZIONE PARZIALE (mrem)									
Mesi	esterna				interna		somma	estremità				pelle	organo interno				ANNOTAZIONI
	X	Y	n.v.	n.l.	tox.	amb.		X	Y	β	somma		nuclide	tox.	emb.	somma	
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Off. 21/70 I.

Fig. 4

SPIEGAZIONI DELLA TABELLA DI IRRADIAZIONE

colonna 2. Di regola il dato fornito dal film-badge per raggi X e γ. Talvolta i dati forniti dalle camere di ionizzazione portatili.

» 3. Di regola il dato fornito dal film-badge per neutroni veloci. Talvolta i dati forniti dai monitori di ambiente.

» 4. Valore stabilito in base ai dati del laboratorio tossicologico.

» 5. Valore stabilito in base ai dati dei controlli ambientali, per nuclidi con il corpo intero come organo critico; o per miscele di nuclidi con vari organi critici.

» 6. Somma di 2 + 3 + (4 o 5). Tra 4 e 5 scegliere il valore più alto.

» 7. Di regola il dato fornito dal film-badge per raggi X e γ. Talvolta i dati forniti dai monitori corporei.

» 8. Dati ricavati dai monitori corporei.

» 9. Somma di 6 + 7 + 8.

» 10. Somma di 6 + i risultati di misure eseguite per valutare dosi specifiche alla pelle.

» 11. Nome del nuclide, forma chimica, stato fisico, solubilità.

» 12. Valore stabilito in base ai dati del laboratorio tossicologico.

» 13. Valore stabilito in base ai dati dei controlli ambientali, per nuclidi con organo critico diverso dal corpo intero.

» 14. E' la somma di 6 + (12 o 13). Tra 12 e 13 scegliere il valore più alto.

Abbreviazioni

↓ durata di tempo cui si riferisce la misura

< minore di

O insignificante < 5 mrem/settimana nell'irradiazione totale
< 60 mrem/settimana nell'irradiazione dell'estremità
< 30 mrem/settimana nell'irradiazione della pelle
< 15 mrem/settimana nell'irradiazione di un organo interno

P misura perduta, misura non eseguita ancorché prevista

— misura non eseguita e non prevista (rischio insignificante)

AFS Archivio Fisica Sanitaria

ALT Archivio Laboratorio Tossicologico

Note

Le irradiazioni concertate e le irradiazioni accidentali sono segnalate nella colonna « Annotazioni »

DOSI ACCUMULATE SULL'INTERO CORPO (rem)

Anno	Età	Dose massima accumulabile	Dose assorbita nell'anno	Dose accumulata	Bilancio	Anno	Età	Dose massima accumulabile	Dose assorbita nell'anno	Dose accumulata	Bilancio

information with two differences:

- the dosimetric table has been modified with a resulting reduction in the available space (4:1) to provide for the present monthly periodicity of the dosimetric counts;

- a column allowing long-term (20 year) integrated dose balances has been added.

By and large we are satisfied with this type of card owing to its versatility and comprehensiveness; however, our extensive experience leads us to make some critical comments:

1. The Basic Standards call for obligatory recording of the above data though these need not all appear on the radiation card;

2. the approved medical practitioner who conducts the anamnesis when making periodic visits is in the habit of transcribing the details of place of work, means of prevention used and any incidents in the medical record before his clinical examination. Thus the updating of the radiation card with regard to 'posting and controls' occurs at some other time (e.g. when a new radiation card is received) and is usually carried out by other personnel in the Medical Department;

3. suitable space should be allocated to accidents (radioactive contamination - even if slight, exceptional concerted radiation, established incidents). I propose that quite simply a small box entitled 'incidents and over-exposure' should be included with provision for the date, a summary of the incident and a reference to an appended health report. Indeed, the ICRP (in Publ. 9 § 102) recommends that doses connected with an abnormal event should be recorded separately.

The possibilities offered by computer techniques in this area both for calculations and for access to personal doses should certainly be taken into consideration. Indeed, these are already being used in practice. One example is given in the last number of the 'Health Physics Journal' (27, 396, 1974). I feel that this is a useful tool for drawing up and communicating data although it does not exclude the conventional card in the individual medical record.

I hope that most of my colleagues who have listened to my paper agree with my observations and trust that at this colloquium it will be possible to give practical guidelines on the adoption of radiation cards (perhaps standardized at the international level) which satisfy all the practical requirements of radiological protection.

DISCUSSION

Dr OBERHAUSEN (FRG)

It is clear from the first two papers, that the examinations and records can be made as complicated as you wish.

We can, for example, call in specialists from a major clinic every six months and increase radiation exposure even further by compulsory X-rays.

On the other hand, we were told this morning by our British colleagues that these medical examinations are not effective for the purposes of radiation protection. I should therefore like to ask our French colleagues what percentage of employees have been excluded from work because of radiation effects observed in medical examinations, and if so, what were the medical grounds for this exclusion?

I am asking this question because I have the impression that we are confusing two factors which should be clearly separated from each other:

1) Medical examinations in connection with work involving exposure to radiation.

2) General aspects of occupational medicine and public health.

Dr MAZAURY (France)

When we talk about medical surveillance of workers exposed to ionizing radiations, we are not necessarily speaking only of the workers to be excluded from this work. Under French legislation we are

obliged to give all exposed workers special medical surveillance. At the Commissariat à l'Energie Atomique the number of occupationally exposed workers is in the region of 50-60%, and sometimes 70-80%. Fortunately the number of persons judged unfit for work because of contamination or exposure is very low, and if such cases were frequent I would consider that we were not doing our job properly. If we judge a worker unfit, as things stand at present, it is for external reasons connected with the individual's state of health and fortunately these reasons are rarely the consequence of exposure or contamination. In a nuclear centre like Marcoule, where I have been working as the medical practitioner for a long time, about ten workers were judged unfit as a result of exposure in 1958/59 and 1960, and at present the number of such cases can be counted on the fingers of one hand.

Dr GABRIEL (FRG)

As a representative of the employees being discussed here today, I should like to make a few basic comments:

- The explanations given today in connection with the 'health card' have referred exclusively to the administrative aspects. Hardly a word has been said about the objectives from the point of view of the worker involved. To my mind there is a danger of medical surveillance for radiation protection being conducted for its own sake.

- What are the objectives?

  a) Supervision to detect any damage to health;
  b) judgment of a worker's fitness to remain in a certain post;
  c) definition of damage symptoms?

For this purpose, all types of exposure, including exposure during diagnosis and therapy, should be included.

Dr MEHL (FRG)

I think that here we are distinguishing between two components; you have mentioned a third component, the radiation pass. We are discussing medical records and exposure cards, and there is a third

factor, which is not in fact on the programme, the radiation pass - as used in the Netherlands, the Federal Republic and Switzerland. These three things must be kept separate. Here we are discussing only medical records and radiation exposure cards.

Dr FABER (Denmark)

I have been considering :

1) is your document meant only for CEA employees or also for hospital employees?

2) In what form and at what rate have your lung pictures been taken - are they taken as full pictures or as micro pictures?

3) What is the test of 'Ruffier-Dickson'?

Dr MAZAURY (France)

The file in question has been developed by doctors at the Commissariat à l'Energie Atomique, and anyone can use it. As for the frequency of X-ray examinations, these are given once or twice a year, at least once in each case. You will have noticed that these are 10/10 X-rays, and we have used this format for ten years. We thought these were preferable to large radiographs which tend to emphasize certain non-pathological images. Finally, the 'Ruffier-Dickson' test is a test of fitness for exertion, for certain jobs calling for special physical endurance such as those for which protective suits must be worn. In some of our nuclear plants, workers are exposed to contamination hazards and have to be completely isolated from the atmosphere in which they are working. For this we can either use self-contained breathing apparatus or make workers wear proper protective suits with an air hose linking them with the outside atmosphere. The work is difficult and taxing, and the medical practitioner must therefore ensure that such workers are absolutely fit.

Dr MEHL (FRG)

I am sure there are many more questions to be asked on the French papers. I should like to know, for example, whether these X-rays can be by-passed if another X-ray has already been taken, for example in connection with cancer detection in the pre-employment examinations. I imagine that this is the case and that they are not simply a matter of routine. I should like to give you an opportunity to comment further on the papers read by our colleagues from Ispra, and I invite any questions or remarks.

Dr STRAMBI (Italy)

1) Are there any plans for quantitative evaluation of the risks to which workers are exposed, which would be most useful both for classification of workers and for devising supplementary examinations? Who should be responsible for this type of evaluation - the employer, the health physicist or the medical practitioner?

2) We should discuss the need to inform workers of the risks their work entails and to see that they are prepared to accept these risks.

3) We must also think about the possibility of a written clinical record of major events which have a bearing on the worker's health, including abnormal exposure, and perhaps use computers for processing. This would have certain advantages, as the medical practitioner would be able to analyse such events critically and thus follow the situation of each worker with greater ease.

Dr MAZAURY (France)

I should not like there to be any misunderstanding about the 'fiche de position' (record card) which is in reality a record of civil status showing the professional activities, background and training of the employee, and the position he has filled in various postings. It is in fact a record of the individual's civil status at work. It has nothing to do with the 'fiche de poste' or 'fiche de nuisances' (exposure card) which we have developed, but which we have been unable to

discuss in much depth here, because of lack of time. You also speak of quantitative evaluation of hazards. What in fact are the criteria which have enabled us to decide and to specify whether a given worker should be assigned to radiation work? As far as we are concerned, one of the first criteria is that of exposure to the risk of contamination and we think that whenever there is a risk of exposure to contamination, workers must be classified as being assigned to radiation work. This evaluation is the responsibility of the radiation protection service, and we, as doctors, feel that the works doctor should play a part in this and should assist the radiation protection service and the employer in such decisions. Lastly, we do our utmost to ensure that workers are well-informed, because French legislation stipulates that we may not assign a worker to radiation work unless he has had suitable training and signed a document stating that he has had this training. From now on we will also require workers to sign the exposure card so that they cannot contest the exposure levels recorded on the card. I would ask my colleague, Dr Sarbach, to reply to the question on the use of computers.

Dr SARBACH (France)

Since computer facilities are available at the CEA, we felt that doctors should make use of them. That was why we decided to computerize all of the medical records, although this will entail a number of difficulties for other concerns which do not have the same facilities. You spoke of the difficulties experienced by all doctors when the number of documents in the medical file was considerably increased. As far as we are concerned, there has never been any question of cutting out the 'paper' medical record and replacing it with a computerized file. The computerized file exists alongside the 'paper' file; we keep these files and, to minimize the rather tricky problem of archives, we have decided to microfilm all the documents which were previously kept in the two little folders at the back of the file - which will mean that we can store at least two or three files on each individual's medical background. Finally, the use of computer techniques will enable us to keep a duplicate of every entry in the medical file, so that if the file is lost, there is still a record of all the entries made by the doctor during the individual's working life.

Dr CABAL (France)

The various types of file which have been described are all of great value for exposed workers. In some countries these files must be preserved even when the worker is no longer occupationally exposed to radiation hazards (for example, after retirement). However this is not sufficient and we must devise a system which guarantees long-term continuity of medical supervision, especially for retired persons.

Dr MEHL (FRG)

Unfortunately we must now bring the discussion to a close and Dr Recht will close the session with a summary of today's conclusions.

Dr RECHT (CEC)

At the end of this first day of the colloquium, I should like to present a few brief conclusions and make a number of comments. One of the aims of the Commission of the European Communities is to harmonize the conditions of safety prevailing in all industrial activities and especially in those activities where workers are exposed to ionizing radiation. The legal instrument used is the 'Directive laying down Basic Safety Standards' which, taking due account of national traditions and existing organizations, sets out a number of objectives, leaving national authorities to choose how they are to be attained. These objectives must be sufficiently precisely formulated to allow harmonization and the achievement of a uniform level of safety in all Member States. At present the free movement of workers is relatively low in the nuclear sector, but it is by no means impossible that it will increase in the future and the idea of an 'exposure passport' might well be envisaged; but it would be premature to discuss such a concept now. In any event, the Commission is not at all 'upset' by any differences between the various systems for applying regulations, as long as the Basic Safety Standards are applied and observed, and as long as the objectives are attained. Currently the greatest differences are connected with the various approaches to occupational medicine in different Member States. Obviously occupational medicine is not sufficiently harmonized over all nine Member States. This is because occupational medicine is going through a critical period and there are

differences of opinion as to the significance, extent and make-up of medical examinations for preventative purposes. The range of medical supervision of exposed workers is wide and is increasing. I have just done a quick calculation based on the population of the nine Member States. If we take it that one person in a thousand in the Community is at present exposed to ionizing radiation for occupational reasons, there are, in the whole of the Community, at least 250,000 persons who should be considered as being 'exposed'. Taken in relation to the working population, this figure is not one per thousand but three per thousand, since the working population in the Member States varies between 35 and 40% of the total population. Three workers in a thousand, then,are exposed to ionizing radiation. Of these 250,000 persons, only 1/5 work in industries using nuclear energy (nuclear power stations and nuclear industries). This means that 4/5 of the exposed workers are working in industrial, medical and scientific sectors and are not subject to the same controls as workers on nuclear sites. I would not hesitate to agree that the medical supervision in nuclear power stations and major nuclear sites adheres very closely to the rules of radiation protection. But this represents a privileged position, because since 1945 the nuclear industry has been fortunate in that radiation protection has been led by established physicists and biologists who have now become masters in the field of radiation protection. But now their positions must be filled by new men, and although I know that there are a number of doctors among you whose competence and ability in radiation protection matters are above reproach, I am not sure that the people who will be taking over the responsibility for radiation protection will all have the same degree of competence and experience. The concept of the approved medical practitioner was introduced in the Basic Safety Standards and we will abide by this. The medical practitioner must obtain his specialized knowledge before or in the course of his work and I would find it quite unacceptable, as a works doctor, if the medical practitioner were unable to play his proper part, as is expected of him, in the multidisciplinary team he will be joining for radiological protection work.The dignity of the medical profession would suffer if he were unable to do this. A doctor responsible for the medical surveillance of workers exposed to radiation must possess at least some basic knowledge of radiation protection, either from university training or from other sources; he must be capable and

worthy of respect, or the medical profession will lose face. Another point has to do with the distinction made between A and B workers. I have already said that this is not a rigid classification and that this was not what the ICRP intended. It is also important to avoid a situation where category B workers, who cost less because there is no individual dosimetry and no specialized medical supervision, are used in preference to A category workers. As for maintenance personnel, I have duly noted the fact that there was no discrimination between the protection guarantees for outside workers and those for personnel permanently employed in the nuclear plant. Indeed, any discrimination in arrangements for radiation protection would be unacceptable, from both the human and the legal points of view. As far as medical records are concerned, it is clear that the use of computers is part of a general trend towards the collection of dosimetric and medical data and the establishment of data banks. This is bound to affect occupational medicine too. Such systems have not yet been perfected but there is no doubting the importance of what Dr Mazaury told us, and the file described just now by himself and his colleague may be taken as a starting point for possible Community action. The main thing is to aim at collection of all available data and to devise economical, efficient systems for storage and subsequent processing of information on exposed workers. This colloquium has touched on the subject, but it will need to be reconsidered in greater detail at a special meeting at a later date.

Friday, 29 November 1974

FOURTH SESSION

NEW EMERGENCY THERAPEUTICS AND
NEW DECONTAMINATION TECHNIQUES

Chairman: Dr. McLEAN

SKIN DECONTAMINATION

G. Möhrle

In the five years since the last SEMINAR ON EXTERNAL AND INTERNAL DECONTAMINATION OF NUCLEAR WORKERS in Munich in November 1969 there have been no important new discoveries in the field of skin decontamination. Today's most welcome exchange of opinions and information should contribute to better knowledge of the principles and methods applied in individual Community countries. The following account therefore attempts to give a general survey of skin decontamination measures, with the emphasis, of necessity, on my own experience.

Whatever measures are taken to remove skin contaminants, care must be taken that the skin is not overtaxed. Most cleaning measures, apart from scrubbing with soap and a brush, which is normally carried out immediately, have some mechanically or chemically abrasive effect and should not therefore be used without careful consideration. Experiments have shown that abrasive thinning of the stratum corneum of the epidermis leads to a number of functional alterations of the skin, such as increased water loss, quicker alkali neutralisation (therefore quicker penetration by solutions) and above all increased roughness of the skin. There occurs in addition mainly with mechanical methods a slight irritation reaching as far as the corium, detectable from an increase in skin temperature even if the corium and epidermis are not injured. In more pronounced cases, a reddening and oedema of the skin can occur, lasting for some hours. A quite superficial injury, such as a skin lesion followed only by discharge of serum and pain (nerve ends of the epidermis), affects only the epidermis from an anatomical point of view and will heal without leaving a scar; but if an injury is accompanied by bleeding, however slight, the stratum papillare of the corium at the very least will be affected. This means that the natural barrier against penetration of radioactive substances into the body formed by the healthy and intact epidermis is broken.

The tissue composition of the skin is not uniform. A distinction is made between the epithelial part, the epidermis, and the fibrous part beneath it, the corium; this gradually merges into the subcutaneous adipose tissue (subcutis). The epidermis is about 0.07–0.17 mm thick excluding the soles of the feet, palms of the hands and parts of the fingers and toes, while the corium is between 1.7 and 2.0 mm thick. The most important task of the corium and more specifically its "papillary layer" is to nourish the avascular epidermis and carry metabolites away from it. By means of its closely spaced dome-shaped papillae which contain the fine-meshed capillaries and their lymph spaces, it reaches up in waves into the lowest layer of the epidermis, the stratum basale of the germ layer (stratum germinativum). The whole epidermis is continuously renewed from this germ layer. Since a great deal of cell division takes place in this layer, it is particularly sensitive to ionizing radiation.

The stratum granulosum adjoins the stratum germinativum and consists of just a few layers of cells. Its name derives from the granules of keratohyalin occurring in the cell protoplasm. These albuminous structures initiate the cornification process. Above the stratum granulosum is a light, refractive stria – the stratum lucidum. Here the keratohyalin granules have liquidized and form a mass saturating the whole layer. The upper visible layer of the epidermis is the stratum corneum which is approximately 0.007 mm thick on average, but can be up to 20 times as thick on the palms of the hands and soles of the feet. It consists of dead but firmly connected epithelial cells. The different cell layers of the epidermis move upwards, are created and die in a process of continual renewal and are continuously shed at the skin surface as horny plates. This process is not usually visible, but occurs as scaling after pathological alterations.

The epidermis has no blood supply. Nutrients are diffused from the corium. It has also been established that, for example, the penetration of radioactive substances through the skin into the body is determined by diffusion, the diffusion speed being proportional to the concentration gradient. The 'diffusion coefficient' depends on the substance diffusing the tissue layer observed and the condition of this layer. Soluble materials can penetrate a sufficiently moist skin much more quickly than a dry one, the rate at which this occurs differing by up to one

order of magnitude. This is also the reason for rubbing talc into the hands or wearing thin cloth gloves under the rubber ones generally used by persons working with exposed radioactive substances. These measures aim to prevent, as far as possible, the formation of a layer of moisture on the skin as a result of perspiration.

It is generally thought today that diffusion through the stratum corneum and stratum lucidum is fairly rapid, while the stratum granulosum has a very low diffusion speed in view of its histological structure and thus forms a natural barrier against penetration into deeper skin layers. Soluble radioactive substances may gradually accumulate in the stratum granulosum and thence perhaps diffuse further down. Diffusion occurs partly into the body and, if the supply from the surface of the skin has diminished sufficiently, also to the outside again. A substance which has once diffused through the stratum granulosum, disappears quickly in the body unless it is adsorbed because of its chemical composition. Skin permeability, moreover, increases considerably if chemical or thermal stresses occur at the same time as contamination. In general, however, it can be said that resorption of the most commonly used radioactive material through the intact skin is certainly low, but not negligible, at least not in the case of substances of high radiotoxicity.

The biological effects of radioactive material on human tissue, including the skin, depends on the type of radiation and its energy. The penetration of, for example, α rays is low (maximum approximately 0.04-0.06 mm), so that the α particles do not reach the radiosensitive germ layer if no diffusion takes place. If there is, however, concentration in the stratum granulosum the stratum germinativum is exposed to a certain dose. Assuming that 10% of an α surface contamination of 1 μCi/cm^2 penetrates the skin and that all the penetrated activity accumulates in the stratum granulosum, a dose rate of 1000 rem/h is calculated for the stratum germinativum. For β emitters, the dose rate calculation is more complicated, since radiation of various energies is emitted and the maximum range is in many cases much greater than with α emitters (up to 1-2 cm). Using the same example as for α emitters, i.e. a

surface contamination of 1 μCi/cm^2 and an assumed 10% penetration of the skin, the dose rate to the germ layer may be calculated in a very simplified manner at about 10 rem/h. Since γ-emitters are known almost always to emit β particles too, calculations were made with various radionuclides which showed that with the assumed surface contamination of 1 μCi/cm^2, γ-radiation is negligible for the dose to the stratum germinativum, compared with β-radiation.

In calculating the internationally accepted maximum permissible values for surface contamination of the skin, allowance was made for the fact that the whole epidermis is renewed in three to four weeks. Furthermore, a skin diffusion of approximately 10% of the contamination was assumed as starting point. The values generally applicable for a maximum permissible α-contamination are 10^{-5} μCi/cm^2, for β-contamination 10^{-4} μCi/cm^2. These values relate only to localized contamination.

In principle, all measurable activity, i.e. a pulse count which registers above zero on a sensitive monitor, should be regarded as contamination which must be eliminated. The intensity of decontamination measures, however, depends largely on the extent of the contamination. It is virtually impossible to define when decontamination should be carried out by the contaminated person himself, done by radiation protection workers or supervised by the doctor, and this is moreover greatly affected by local circumstances and the staff available.

Previous experience shows that it is most frequently the unclothed parts of the body i.e. hands, hair and face, which become contaminated. Extensive skin contamination or whole body contamination are much rarer. Shower equipment is highly unsuitable for these types of partial contamination, since it must be expected that localised activity e.g. on the hair or face, even if it were to some extent diluted, will be distributed over the whole body and really thorough specific decontamination of local radioactivity e.g. on the hands, would be very difficult under a shower and not really advisable. For this reason wash basins which are wider and in particular deeper than normal ones - somewhat similar to those used in laboratories - are much more suitable for the parts of the body where local contamination is most frequent i.e. hands, hair and face.

Since today, lukewarm, i.e. approximately 30 to 32°C, is regarded as the most suitable and least harmful water temperature for decontamination, it is advisable to provide central mixer taps in new installations to avoid unnecessary contamination of individual fittings when used by contaminated persons. This also applies to shower equipment. A ratio of about 4 washbasins to one shower is best, in nuclear plant at least. For shower equipment the following points should be observed. The shower head at the top of the shower should be as wide and flat as possible and provide a predominantly vertical stream of water. In addition, there should be a hand shower at the side with a hose about 1 m long which can be directed at locally concentrated contamination on the trunk or legs. An approximately 6-8 cm high sieve-type perforated plastic platform should be placed on the floor of the shower to prevent the feet remaining in contaminated water, since a build-up of waste water cannot as a rule be avoided. The best type of shower equipment has in addition to the flat shower head and plastic platform mentioned, three to four movable shower heads on both side walls, the lowest about 40 cm from the floor and the others at the same distance above each other.

It has further proved that, except in the case of very slight contamination, the decontamination process - i.e. thorough washing, drying, monitoring - must be repeated several times, and often half an hour to two hours decontamination time is necessary. This, however, also means that there must be enough measuring devices in the decontamination room, since unnecessary journeys and, as far as possible, contact with uncontaminated staff should be avoided. It should suffice to mention merely in passing that containers for contaminated working clothes and shoes must also be provided in the decontamination area plus some temporary clothing which can be worn by the persons concerned until they change into their own clothes.

A toilet should be included in larger decontamination areas. Periods spent in rooms with running water inevitably increase the need to use a toilet and there is no apparent reason why contaminated persons should not be allowed to do so, if necessary, after an initial careful decontamination. Circumstances in no way justify a special separate sewer as sometimes required by the authorities on account of radioactivity

which might be contained in the faeces, since, even in the most serious cases of intake, there is no radioactive elimination in the faeces during the first 6-8 hours and if there is activity in the urine, it is so diluted that special measures are unnecessary. Finally, from the medical point of view it is absolutely necessary to have a first aid post or medical room in every large decontamination area, where first aid and preparations for special transport to hospital, if necessary, can be initiated and carried out both for normal and contaminated casualties and in case of other radiation incidents.

If whole body or hand-foot contamination monitors indicate radioactivity, the first step is to assess its extent and intensity. If the hands are contaminated, special attention must also be paid to the other unclothed parts of the body, i.e. in particular hair and face. If the working clothes are not contaminated, it may be assumed that there is also no activity on the body surface covered by the clothes. If the clothes are contaminated, localized activity must be prevented from spreading to other areas, or the skin, when they are removed. When the outer clothing has been removed, the underwear should be measured for contamination and removed if necessary. Care must be taken to ensure that activity on clothing or skin does not enter the mouth or nose and become incorporated. If the conditions of the workplace give reason to believe that incorporation has also taken place, in particular in the case of dusty or gaseous compounds, the doctor or trained health workers should take nose and throat smears with swabs on stocks as soon as possible; these are then to be measured like swab tests. If no doctor or health worker is present, the radiation protection workers should have the person concerned blow his nose in filter paper and this should then be measured. If measurements confirm that incorporation has taken place, body counter examinations or excretion analyses must be undertaken to assess the uptake, if necessary after decontamination.

The success of every decontamination treatment depends mainly on the speed, but also on the care, with which the action is taken. Radiation protection workers must therefore be specially trained and everyone working in the control zone should know what is or is not to be done if contamination occurs.

The best way to remove the skin contaminants is thorough washing under lukewarm running water with mild soap and a soft brush. The whole of the contaminated skin area should be covered with thick lather and then thoroughly rinsed with water. This washing is to be repeated several times for a period of several minutes. Only light pressure should be applied to the brush, any abrasion of the skin is to be avoided. If the hands are contaminated, for example, skin folds, nail groove and fingernails must be cleaned with particular care. The fingernails may have to be cut short. After this extensive washing process has been carried out several times, the skin should be thoroughly dried, preferably with tear-resistent bonded fibre cloth, then checked with a measuring instrument. In the majority of cases, the greatest decontamination effect occurs after the first thorough washing. Further decontamination until zero reading or at least acceptable residual contamination is reached can, however, be a lengthy process. Washing under lukewarm running water with soap and brush must be patiently repeated, even if the monitoring equipment shows no further decontamination effect. If results are not satisfactory, light duty detergents and wetting agents available commercially may also be used. There are moreover various commercial preparations which are used for more severe conventional soiling of the hands and are also quite suitable for removing contamination. These rely mostly on abrasion.

In addition 3% citric acid has proved effective.

If the skin is highly contaminated, additional measures must be taken, if possible only under medical supervision, since they all attack the skin to some extent. It has been found that a combination of a wetting solution, a complexing agent and a reagent to adjust the pH value has considerable additional effect. This 'complexing solution' is composed as follows : 5 g Titriplex III (bisodium salt of EDTA), 5 g sodium lauryl sulphate, 5 g starch and 35 g sodium carbonate (anhydrous) dissolved in 1000 ml water. This solution will keep for months in plastic bottles and merely needs to be shaken well before use. The hands are thoroughly washed and brushed using this complexing solution and then rinsed under lukewarm running water. This process is repeated 2 to 3 times, then the hands are dried and the decontamination effect is checked on the monitor.

The most practical way of applying this, and the solutions mentioned below, to the contaminated skin is to use plastic spray bottles. Another substance which has proved useful is 4% potassium permanganate solution. For example an equally saturated solution of potassium permanganate and 1% sulphuric acid solution has also proved successful. Since potassium permanganate and 1% sulphuric acid does not keep for longer periods because pyrolusite is precipitated, the potassium permanganate solution of 65 g potassium permanganate and 1 litre 1% sulphuric acid solution can be prepared when required. This mixture, which has a slight acid reaction, is to be poured over the moistened skin, for example the hand, thoroughly covering the nails and cuticles too. The whole surface of the hand including the area between the fingers is rubbed gently with a nailbrush. After about 2 minutes the hands are rinsed under running water. This process can also be repeated 2 to 3 times. As the skin thus acquires a dark brown colour, it is then treated with a 5% sodium bisulphite solution, which has also been freshly prepared and regains its normal colour within 2 minutes, after repeated gentle rubbing and brushing followed by rinsing. It has proved advantageous to have a supply of plastic packs containing 16-20 g sodium pyrosulphite, which is simply dissolved in 400 ml of water to obtain fresh 5% sodium bisulphite solution.

If it is really hard to remove the contamination, 5% soda bleaching lye can also be used. This sodium hypochlorite is available commercially and must be diluted to a concentration of 5%. The skin is severely attacked and if the solution remains on the skin for any length of time slight burning takes place, but the decontamination effect is often very good.

The decontamination solutions are best used in the order given, i.e. when one has no satisfactory decontamination effect, the next one is to be used. If necessary, these agents must be used several times in the stated order as long as this does not involve too much strain for the skin. Most of the solutions, excluding the complexing solution and citric acid, have no specific effect, other than a purely abrasive one like the mechanical means used before. As already mentioned, soluble radioactive substances can reach the stratum granulosum of the epidermis, which first sucks them up like a sponge. Sometimes, therefore, the decisive final decontamination effect does not take place until this

layer is reached. This is, however, also the tolerance limit of the skin if one wishes to avoid the stratum germinativum which is the regenerating layer of the epidermis, and the vascular layers of the corium beneath it, being affected. This would mean rapid incorporation into the subcutis and from there into the whole body.

If, in spite of all these measures, no satisfactory decontamination effect is obtained, or the condition of the skin does not allow of any more treatment, the decontamination process must be interrupted and then continued after some hours or on the following day. This is a quite acceptable procedure, since the contamination is most unlikely to spread after all the decontamination measures taken. In addition the activity which has penetrated the stratum granulosum of the epidermis may partially diffuse to the outside again. At any rate, it is often surprising that when one or another of the decontamination measures is repeated after some hours or on the next day, an effect can often be achieved which was simply impossible beforehand.

To decontaminate the face and hair, 3% citric acid solution and, if necessary, the complexing solution can also be applied in addition to water and soap or shampoo. With particularly sensitive parts of the skin, the solutions mentioned can be applied with slightly absorbent cotton wool after covering the surrounding areas. The hair should always be washed with the head tilted backwards to avoid secondary contamination of the face. If the mucous membranes of the mouth and the teeth are contaminated, the mouth should be thoroughly cleaned with toothbrush, toothpaste and possibly 3% citric acid. - With contamination of the throat, gargling with 3.6% hydrogen peroxide is one possibility. Rinses and gargles must not of course be swallowed.- If the nose is contaminated, a nasal douche using water or physiological sodium chloride solution is recommended; the auditory canal can be syringed. If the eyes are contaminated, the eyelids are to be held wide open by means of the thumb and index finger and the eye rinsed thoroughly under running water, always working from the inner corner of the eye (side next to nose) to the outer to avoid contamination of the tear ducts.

Adhesive plaster, sellotape or something similar is recommended to remove small localized skin contaminations. After careful shaving of any hairs on the skin, these adhesive strips are pressed onto the contaminated spot and then pulled off again. This can be repeated several times if necessary. (Care should be taken to avoid undue skin damage).

All the decontamination measures mentioned refer, of course, to intact healthy skin. After decontamination has been completed, the skin should be treated with a protective cream. With persistent severe contamination, cloth gloves could perhaps be worn in between treatments or a dressing could be attached by means of a gauze bandage.

The attached decontamination regulations contain a summary of both general and specific decontamination measures and should only be applied under supervision of doctors or workers specially trained in radiation protection or industrial hygiene.

DISCUSSION

Dr HUBLET (Belgium)

Having heard Dr Möhrle's well-documented paper, I should like to comment on the following points:

- on the subject of gloves and the use of talc to absorb perspiration, it is better to wear a pair of rubber gloves on top of a pair of thin textile (cotton) gloves than to wear a single pair of textile-lined rubber gloves;

- the water taps for the washbasins should not be hand-operated (foot-operated types, for example, are preferable);

- workers liable to be contaminated (internally that is) must be given prior instruction and information on correct decontamination methods.

Dr RITZL (FRG)

Why did you not mention decontamination by dilution in your paper - for example, washing contaminated areas with non-radioactive sodium iodide in the case of contamination with iodine-131, or washing with phosphate buffers after contamination with phosphorus-32? I have found that washing with these solutions gives very good decontamination in cases of contamination with these nuclides.

Dr MOEHRLE (FRG)

In reply to our Belgian colleague, first of all, I should like to say that I agree completely with his comments.

To answer Dr Ritzl's question, I would say that the use of phosphate buffers for contamination with P-32 is most effective, but I am not sure whether isotopic dilution of iodine is to be recommended.

Dr CARPAY (Netherlands)

1. Where should the first decontamination treatment take place? Should this be on site and if so which chemicals should be made available there?

2. I am surprised that you recommend removal of contaminated clothing in the decontamination building. I think it is better to leave contaminated clothes in the immediate area and to transport people to the central building after they have changed their clothing.

3. Has Dr Möhrle any experience of skin resorption of iodine-131 in the form of potassium iodide?

Dr MOEHRLE

Stronger agents, such as potassium permanganate and soda bleaching lye, are only intended for decontamination of the hands. For the rest of the body, I would use the complexing solution, or I would just scrub the area with soap and water. Of course I agree that contaminated

clothing should if possible be removed in the contamination area or nearby, but time and again we have found that contamination of clothing is only detected when the persons concerned arrive at the central building, and for this reason containers should also be available to deposit clothing there. I cannot give you any more detailed information on resorption of iodine.

Dr CARPAY (Netherlands)

What decontamination agents are provided at the place of work?

Dr MOEHRLE (FRG)

At our centre, where there are some 2,500 occupationally exposed persons; only soap and water, and sometimes citric acid, are available on the spot for self-decontamination and everything else is kept in the central decontamination area.

Dr JOLIVET (CEC)

I think that the various methods proposed by Dr Möhrle for effective decontamination of the skin are the best methods currently available, for they are straightforward and their value has been demonstrated over the years. Some time ago, however, several authors noted that radioactive particles tend to move down the hair follicles and settle in the sweat glands. They observed that these particles could be brought back to the surface by sweating. They therefore proposed decontamination treatment by sweating and showed that when the skin of the body was experimentally subjected to external contamination then made to sweat, part of the radioactivity trapped in the skin appendages returned to the surface. A good deal of this radioactivity could then be removed in the usual way, by washing, or with adhesive textiles, sellotape or plaster. Should this kind of treatment be used, or should it be avoided, as being too time-consuming?

Dr MOEHRLE (FRG)

This would depend on the extent of the contamination. We use this kind of treatment where necessary, but sometimes one can manage

without it. I would only recommend local decontamination with adhesive tape etc. if it cannot be done in the moral way by washing.

W i j k e r (Netherlands)

1) In some plants special attention has to be paid to contamination of the working environment with tritium, especially during shut down periods, as this can lead to internal contamination of the worker by penetration of tritiated water through the skin. The probability of such a contamination is highest were heavy water is used as a moderator. But also in a pressurized light water reactor tritium is produced in appreciable amounts in the primary coolant as a consequence of the addition of boric acid as a burnable poison. The chance of contamination with tritium in a plant with a boiling water reactor is one or two orders of magnitude smaller than with a pressurized water reactor. The tritium problem leads me to the proposal to include as a discussion point during this meeting also the question how fast tritiated water will penetrate the skin. Here the thicknesses of the various skin layers will play a part. The values generally used are obtained from measurements on dead skin samples, as far as I know. Some measurements on living skin however seem to indicate that in situ the layers are somewhat thinner. This difference seems to be caused by the disappearance of stretch when removing the skin from the body for measurements. (Publication in Health Physics?)

2. I want to take the opportunity to put right a mistake that has occured in my paper on decontamination read at the Euratom symposium at Munich in 1962 and to stress the necessity of reading the last version of your article where possible. I have noticed that some translators make mistakes. For instance in my paper the translater changed my right English text "eye-washing in a direction from the nose" into "eye-washing in the direction of the nose" on his own account and without notice. Away from the nose is the correct treatment.

Dr MOEHRLE (FRG)

I do not have any precise information on the diffusion of tritium-contaminated water into the skin with time; I do know that tritium can be detected in the urine as little as 5-10 minutes later. In reply to the question on skin diseases, I am afraid I cannot give you any details; I am acquainted with the paper you mentioned, and it is true that in part the experiments were only carried out on dead skin. I would imagine that the results would be much more favorable with living skin.

Dr LALU (France)

1. Which of the methods mentioned by Dr. Möhrle in his paper are in fact new, and what advantages do they have over older methods?

2. Where there is resistance to decontamination, might it be useful to apply Vaseline and leave for 24-48 hours?

Dr MOEHRLE (FRG)

In my paper I made a point of saying that there have been no important new discoveries in this field in the past five years. However, having been asked to give a report on this subject, I decided to give a general survey of what is known now, and that is unchanged. I do not know of any more recent methods of decontamination. The reply to your second question is that we avoid using Vaseline because of its high fat content, and use lanoline or similar cream for skin care.

Dr ZUIDEMA (Netherlands)

In general occupational medicine we have observed that some rubber and plastic gloves are surprisingly permeable to hydrocarbon solutions and sometimes even aqueous solutions.

It is therefore recommended that before use, the various types of gloves are tested in the laboratory with the solutions used in radiological work.

Dr MOEHRLE (FRG)

This is a very interesting piece of information. We have no experience of this type of thing, as most of the work at our centre is carried out with large rubber gloves in hot laboratories and in glove boxes, and there are very frequent cases of allergic skin reactions to the rubber.

Dr CARMICHAEL (U.K.)

My question perhaps extends, in part, to yesterday's discussions in respect to unfitness for radiation work, this involves the compulsive finger nail biter. Because of the great difficulties, even after cutting the nails short, of decontamination under the nails, should these people be excluded from the risk of hand contamination?

Dr MOEHRLE (FRG)

Yes, I would agree with you. One of the most important contra tions for contamination is acute or chronic skin disease and at the preliminary examination affected persons are, from the outset, barred from work with unsealed sources of radioactivity, although there is still a possibility of employing them in other controlled areas where there is no danger of contamination. When reservations are expressed on health grounds, we distinguish between reservations about suitability for work involving unsealed radioactive substances and more general reservations about unsuitability for any kind of work in controlled areas.

Dr LE GUEN (

Skin contamination is rarely straightforward and is often accompanied by internal contamination. I think that the latter is just as important, if not more so, because of the risk of contaminants migrating through the lungs or the blood to the critical organs.

In view of this danger, immediate action is often called for on the spot. For this reason we have recommended immediate inhalation of "DTPA-Ca" aerosol in cases involving atmospheric and/or skin contamination by plutonium-238 and 239. The sooner this treatment is applied, the more effective it will be.

At CEA and Fontenay-aux-Roses, we are now planning to provide persons exposed to these hazards with a portable "Spinhaler"-type aerosol for inhalation of a dose of 500 mg of micronized DTPA-Ca in a snap-top ampoule (treatment based on the findings of Ducousso-Pasquier et al. Den/CREJSA - to be published in "Radioprotection").

Dr MOEHRLE (FRG)

I quite agree that roughly speaking 30% of all contamination is accompanied by intake resulting from inhalation. We try to monitor this by nose and throat smears, or by asking the subject to blow his nose into filter paper, and analysing the result so that appropriate measures can be taken. However, this is done in the central decontamination area, not at the place of the accident.

Dr JAMMET (France)

I think it is wrong to treat radioactive contamination of the skin in such a dramatic way. In the vast majority of cases it is a run-of-the-mill occurrence and it would be a pity to apply measures which are out of all proportion to the actual risks involved, both from the economic point of view and from the psychological point of view, so far as workers are concerned.

Dr MOEHRLE (FRG)

On the whole I would agree entirely. I was not at all happy about being given this rather barren subject and would have much preferred to give a paper on internal decontamination measures. Anyway external decontamination is virtually everyday practice in radiation protection. At our centre we have had more than 2,500 cases of contamination, of which some 70% were very minor cases where it would not be worth

applying these methods. Of course this was untrue for the remainder, and in the case of skin diseases such as psoriasis or eczema of the hands. In these cases the person concerned must be barred from work with radioactive substances, as there are difficulties with decontamination.

Dr JAMMET (France)

I agree with Dr Moehrle, especially with the point about radioactive decontamination being a daily routine. No such concern is expressed about garage mechanics who have to wash their hands before meals because they work with dirty oil and grease. If atomic power had been in use for a thousand years and the motor car had just been invented, special precautions would be taken - mechanics would have to work with glove boxes and would be barred from work if they had sensitive skin. But this is not the case, even though some of the products used in garages can cause skin cancer.

Dr ERSKINE (U.K.)

I would like to speak in support of previous two speakers. As the responsible officer for 2000 radiation workers I know the occupational physician cannot be present when the accident happens. He must train the team which starts with the workers and moves up through stages of capability. The man on the job must cover the first two hours. Then a skilled nurse and health physicist will be available. An occupational physician may be available after 4 hours. It is therefore essential that the immediate measures are simple.

Dr BOWKER (U.K.)

I agree with the last speaker. In our experience most decontamination of the intact skin is done in the main changeroom and never reaches the medical services. I wonder whether Dr Moehrle would care to widen the subject a little and say a few words about wound decontamination. As Dr Erskine said on CEGB stations initial treatment is carried out by first-aiders and must therefore be simple. However, even superficial wounds can present problems particularly of detection

and measurement. To help to overcome this difficulty our normal pro-..edure is to monitor the cause as well as the effect. If contamination is detected, simple techniques as tourniquets, washing with light scrubbing, etc. are carried out by trained first aiders under the supervision of Health Physics staff. If necessary further measures are carried out on the arrival of nursing and medical staff.

Dr MOEHRLE (FRG)

I do not have anything particular to say in answer to your question, but on the whole I agree with you. If I have put more emphasis on certain aspects, it is because at our centre in Karlsruhe, we have some 600 persons working with unsealed plutonium. The whole subject of contamination appears in a different light when one is dealing with other radioactive substances.

PULMONARY LAVAGE

J. Lafuma

Several experimental studies have been carried out to remove insoluble radioactive particles from lungs in which they had settled. The only method which has proved effective up to the present is pulmonary lavage, generally carried out with a physiological solution of sodium chloride.

The research was carried out on several animal species: dogs, rats and baboons (1), and approximately 50% of the particles in the lungs were removed by this method. Only one human contaminated with plutonium-239 oxide has been treated by this method, which enabled a fraction of the contaminant (2) to be removed.

For several years the C.E.A. has been carrying on research to develop a pulmonary lavage technique for use on humans.

So far the experiments have been conducted on 80 baboons (3 & 4). They can be summed up as follows:

- 13 animals free of Pu were subjected to lavage for histopathological studies of the method itself;

- 67 apes underwent lavage after inhaling Pu-239 oxide.

Of these 67 apes, 47 were used to perfect the method and 10 were put down for a histopathological comparison of the treated animals with similarly contaminated untreated animals.

The last 10 animals were kept for studies on the effectiveness of lavage with regard to the animals' life expectancy.

During these studies no injuries due to the lavage itself were observed, but 5 apes died as a result of the anaesthetic, no facilities for resuscitation being available.

I. Method of pulmonary lavage

I.1 - Both lungs are lavaged with an interval of one hour and respiration is assured each time by the lower lobe of the opposite lung.

- oxygenation and degasification times were reduced to a few minutes.

- lavages were begun at the earliest 24 hours after contamination, since this is the time necessary for, on the one hand, the particles deposited in the respiratory passages to be eliminated and, on the other hand, the particles deposited in the alveoli to be phagocytized by the macrophages:

- thus the problem is one of eliminating as much as possible from these cells

- the liquid chosen for the lavage is a 9% solution of NaCl

- the experiment showed that preliminary oxygenation and degasification increase the method's effectiveness.

I.2 - Recovery of lavage liquid

- 95% at each lavage with the exception of the first, where less liquid is recovered.

I.3 - Elimination of the activity and number of macrophages

- Results show that the first lavage gives distinctly better results, since it is this operation which eliminates the ascending macrophages.

- If the proportion of macrophages eliminated during each successive lavage is studied, it can be seen that there is no useful purpose served in conducting more than eight.

II. Effectiveness of pulmonary lavage

II/1. Effect of repeated lavages

The following results were obtained from lavages repeated at weekly intervals :

- Lavage 1 (D + 4) = 12%
- " 2 (D + 11) = 19%
- " 3 (D + 18) = 34%
- " 4 (D + 25) = 40%
- " 5 (D + 32) = 52%

II/2. Determination of a set procedure

- The experiments show that the yield decreases during the first three days and becomes constant at approximately 10% elimination per lavage.

- In addition, the yield does not depend on the pulmonary burden.

- The laboratory's current procedure is to administer the first lavage at D + 1, a further lavage at D + 4, then one lavage per week.

- In a total of 10 lavages, 50% of the deposited material was recovered.

- In practice, the number of lavages must be modified according to the effectiveness of lavages already carried out, since individual variations are considerable.

- In addition, it can be observed that pulmonary lavage is conducive to the passage of active particles into the interstitium, which has a decontaminating effect but at the same time increases the burden of the lymphatic nodes. After some months, decontamination of the alveoli of certain animals reaches 90%.

III. Physiopathology

- Checks showed that variations in cardiac and respiratory rhythm, blood pressure and composition of the gases in the blood were temporary and that recovery was complete.

- The anatomopathological examination revealed :

- slight swelling, inflammation and some haemorragic areas. In 4 days the lungs returned to normal.

- The pneumocytes I disappear and changes in the pneumocytes II are observed in the first 6 hours.

- Between 6 and 12 hours afterwards, polynuclear leucocytes and megacaryocytes are seen to appear in the alveoli.

- After 12 hours the epithelial membrane is restored and after 48 hours the lung is normal.

- No lesions were observed 3, 6 and 12 months after such courses of treatment.

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TRITIUM CONTAMINATION AND EXTRARENAL CLEARANCE

Ph. Henry

Summary

In cases of significant internal contamination by tritium, a therapy aimed at accelerating the turnover rate of tritium in the body should be applied.

The purpose of this study is to determine the effectiveness of extrarenal clearance methods in hastening the elimination of tritiated water. The results of our experiments show that the biological half life in man can be reduced to 13 hours by peritoneal dialysis and to less than 4 hours by hemodialysis.

The type of treatment and its duration should be based on the calculation of the dose commitment; in practice, this can probably be reduced to 5% of the initial concentration.

I - RISKS ARISING FROM TRITIUM

Tritium, classified as a low toxicity radionuclide, is handled in industry although its potential danger is considerable because of its high specific activity (app. 10^4 Ci/g for T_2 and 1.5×10^3 Ci/g for HTO), its marked volatility and its capacity to diffuse through a very wide range of materials. Tritium most usually finds its way into the body in the form of tritiated water, which is absorbed rapidly through the skin and the lungs. The partial conversion of tritium gas into HTO is the result of biological or spontaneous oxidation and of isotopic exchange with H atoms in water vapour. In whatever way it is introduced, tritiated water diffuses and spreads through all the water in the organism, extra- and intra-cellular. Within three to four hours,

This study was carried out in cooperation with the Clinique des Maladies Metaboliques et Endocriniennes, Clinique Saint-Eloi in Montpellier.

a state of equilibrium is reached in all the aqueous compartments of the organism, which is thus completely irradiated.

After a single contamination, the tritium concentration in the body water is progressively reduced as the water in the organism is replaced. The biological or effective half life of the tritiated water ranges from 7 to 14 days with extremes of 4 and 18 days. The average is between 9 and 10 days.

The CIPR, in its publication No 10, reduced the half life recommended for calculating the dose received by a standard man from 12 to 10 days. (1)

A fraction of the tritium contained in the tritiated water is exchanged with the hydrogen atoms of organic molecules. This organic component has a much longer half life, of the order of 1 to 3 months. However, its share of the total dose is so slight as to be negligible (2, 3).

II - METHODS USED IN TREATING CONTAMINATION BY TRITIATED WATER (4)

In order to eliminate the tritiated water more rapidly, it is clearly necessary to use therapy which will shorten the average life of the water in the organism.

II - 1. Renal Clearance, Osmotic Diuresis

The first therapy, the least aggressive in a healthy subject, is hydrotic diuresis, which consists of having the subject ingest large quantities of water each day; but this very soon becomes intolerable.

The perfusion by molecules with a strong osmotic effect, which can be filtered by the kidney and are not reabsorbed, promotes a marked degree of diuresis; this is known as osmotic diuresis. It can be simply achieved by perfusion with mannitol or urea. This treatment producing diureses of from 5 to 8 litres per day, can reduce the biological half life of the tritiated water to less than 4 days.

For more intensive osmotic diuresis, it is necessary to monitor the central venous pressure, insert a catheter into the bladder, measure the hourly flow and ensure hourly clinical supervision and frequent biological monitoring.

II - 2 - Extrarenal Clearance

The purpose of extrarenal clearance methods is usually to maintain or to restore satisfactory biological equilibrium in patients with acute or chronic renal insufficiency, by eliminating toxic molecules and waste substances contained in biological fluids.

Two methods are used: peritoneal dialysis and hemodialysis.

II - 2a - Peritoneal Dialysis

This treatment consists of injecting into the peritoneal cavity a given volume, usually approximately two litres, of isotonic or hypertonic fluid which absorbs the substances to be eliminated by exchange with the blood through the serous membrane of the peritoneum.

After a residence of variable duration, the fluid is drained off and replaced with fresh fluid.

The time between the beginning of the injection and the end of the drainage constitutes one dialytic cycle.

The cycles are repeated until the desired result is obtained; a session normally lasts 24 hours, but may be extended if necessary.

II - 2b - Hemodialysis

Hemodialysis is based on exactly the same principle as peritoneal dialysis, but exchanges between the blood and the dialyzing solution take place not through the serous membrane of the peritoneum but through a semi-permeable membrane in a machine known as an artificial kidney.

The patient's blood circulates in a cellophane pocket around which the dialyzing solution flows in the opposite direction. A cannula or arteriovenous fistula must be used for the circulation of the blood outside the body.

II -2c - Exchange mechanisms in extrarenal clearance

The peritoneum behaves in practically the same way as an inert semi-permeable membrane; exchanges through this serous membrane obey the traditional laws of osmosis and diffusion and are of the same nature as the exchanges which occur during hemodialysis. The difference between the two methods lies in the kinetics of the exchanges.

In both cases the effectiveness of the clearance is due mainly to the diffusion of molecules through the membrane.

III - CLEARANCE OF THE TRITIATED WATER BY PERITONEAL DIALYSIS

III - 1 - Theoretical study of the kinetics of the clearance process

In the interests of simplicity, we have supposed that only one substance was on either side of the serous membrane of the peritoneum: the body water and the dialysing solution.

III - 1a - Kinetics of diffusion during a cycle

Diffusion obeys Fick's law: 'the rate of diffusion of one material in another is proportional to the negative of the gradient of the concentration of the first material'.

Let K be the proportionality or permeability constant of the membrane for the substance under examination.

let :

1 refer to the body water
2 refer to the dialysing solution

V_1 and V_2 be the volumes
C_1 and C_2 be the concentrations at time t
$C_{1.0}$ and $C_{2.0}$ the volumes at time t = 0
At time t = 0 all the molecules are in substance 1

When the concentrations on both sides of the membrane are equalized, the situation is :

$$C_1 = C_2 = C_{eq} \text{ (equilibrium)}$$

and

$$\boxed{C_{eq} = C_{1.0} \frac{V_1}{V_1 + V_2}}$$

The calculation of the concentration at time t in the dialyzing solution gives the following formula :

$$C_2 = C_{eq} (1 - e^{-\lambda_D t})$$

in which

$$\lambda_D = K \frac{V_1 + V_2}{V_1 V_2} = \text{the diffusion constant}$$

III -1b - Kinetics of clearance during dialysis

t, the total length of a cycle, is taken, as a first hypothesis, to be equal to the time taken for the diffusion.

Let $C_{1.0}$ be the concentration in the body water at the beginning of each cycle.

The proportion cleared in each cycle is equal to :

$$\frac{C_{1.0} V_1}{C_2 V_2} = \frac{C_{1.0} \frac{V_1}{V_1 + V_2} \cdot V_2 (1 - e^{-\lambda_D t})}{C_{1.0} V_1} = \frac{V_2}{V_1 + V_2} (1 - e^{-\lambda_D t})$$

The mean cleared fraction per unit of time λ_E is therefore given by :

$$\lambda_E = \frac{V_2}{V_1 + V_2} \cdot \frac{I - e^{-\lambda_D t}}{t}$$

The proportion λ_E represents the clearance constant or relative clearance and $T_E = \frac{0.693}{\lambda_E}$, the clearance period.

At the end of the Nth cycle, after a dialyzing time D = Nt, the concentration in the body water is given by the equation :

$$C_1 = C_i e^{-\lambda_E D}$$

in which C_i represents the initial value of C_1 before the test ($C_{1.0}$ of the first cycle).

The absolute clearance CL is obtained by multiplying the relative clearance by the volume to be cleared, viz.:

$$CL = \lambda_E V_1 = \frac{C_2 V_2}{C_{1.0} t} = \frac{V_1 V_2}{V_1 + V_2} \cdot \frac{1 - e^{-\lambda_D t}}{t}$$

According to this formula, the clearance should increase with the flow of dialysate and move eventually towards K, the peritoneal permeability constant.

Experience shows that the clearance reaches a peak, then falls when the flow of dialysate is increased. There is a simple explanation for this phenomenon.

Only part of the peritoneum is involved in the exchanges which take place while the peritoneal cavity is being filled and drained, as if part of the time t were lost in a resting phase during which no diffusion takes place.

In these circumstances :

- let m be the length of the resting phase
  and $\theta = t - m$ the effective diffusion time.

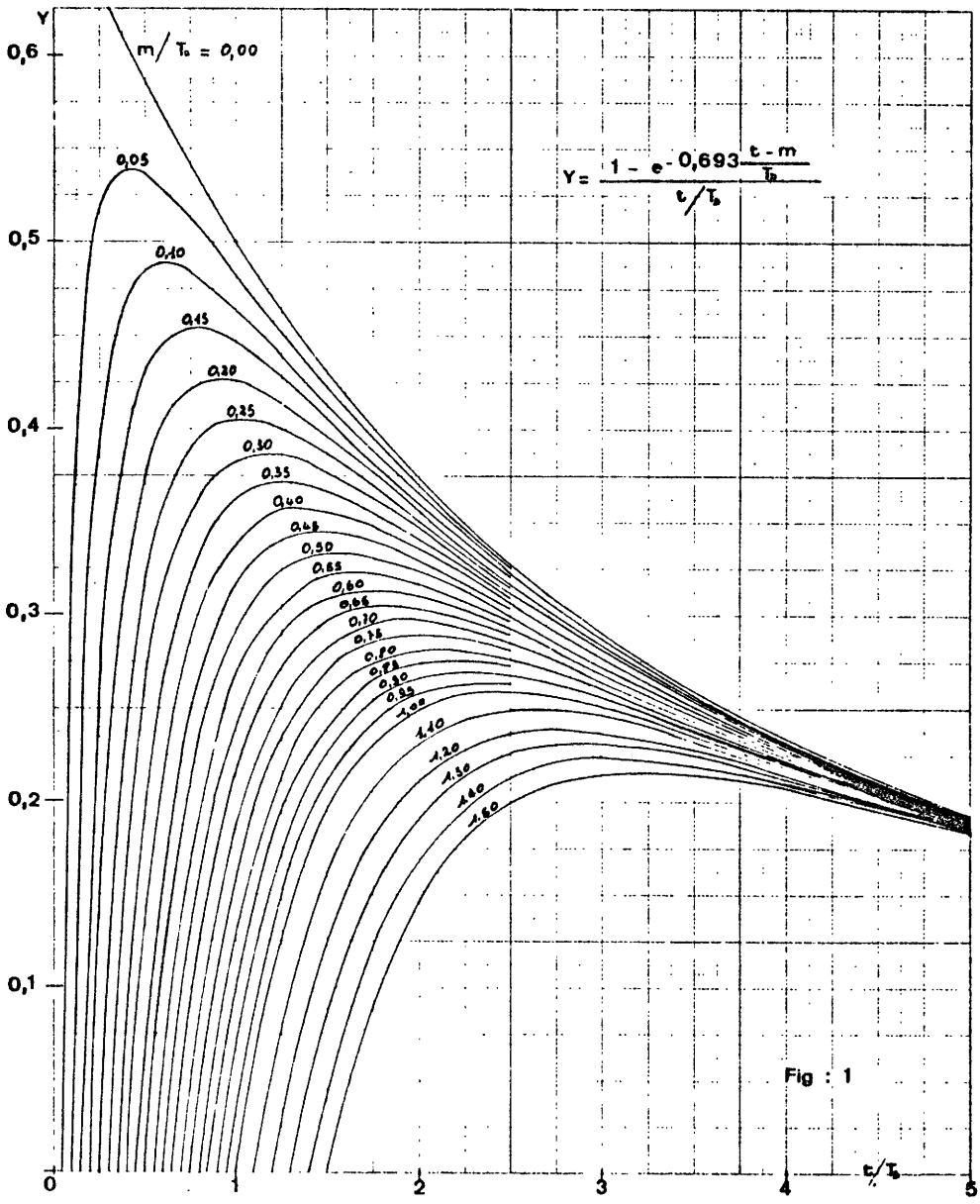
Y
0,6
0,5
0,4
0,3
0,2
0,1
0
1
2
3
4
5
t/T₀
m/T₀ = 0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
0,40
0,45
0,50
0,55
0,60
0,65
0,70
0,75
0,80
0,85
0,90
0,95
1,00
1,10
1,20
1,30
1,40
1,50
Y = (1 - e^-0,693 (t-m)/T₀) / t/T₀

Fig : 1

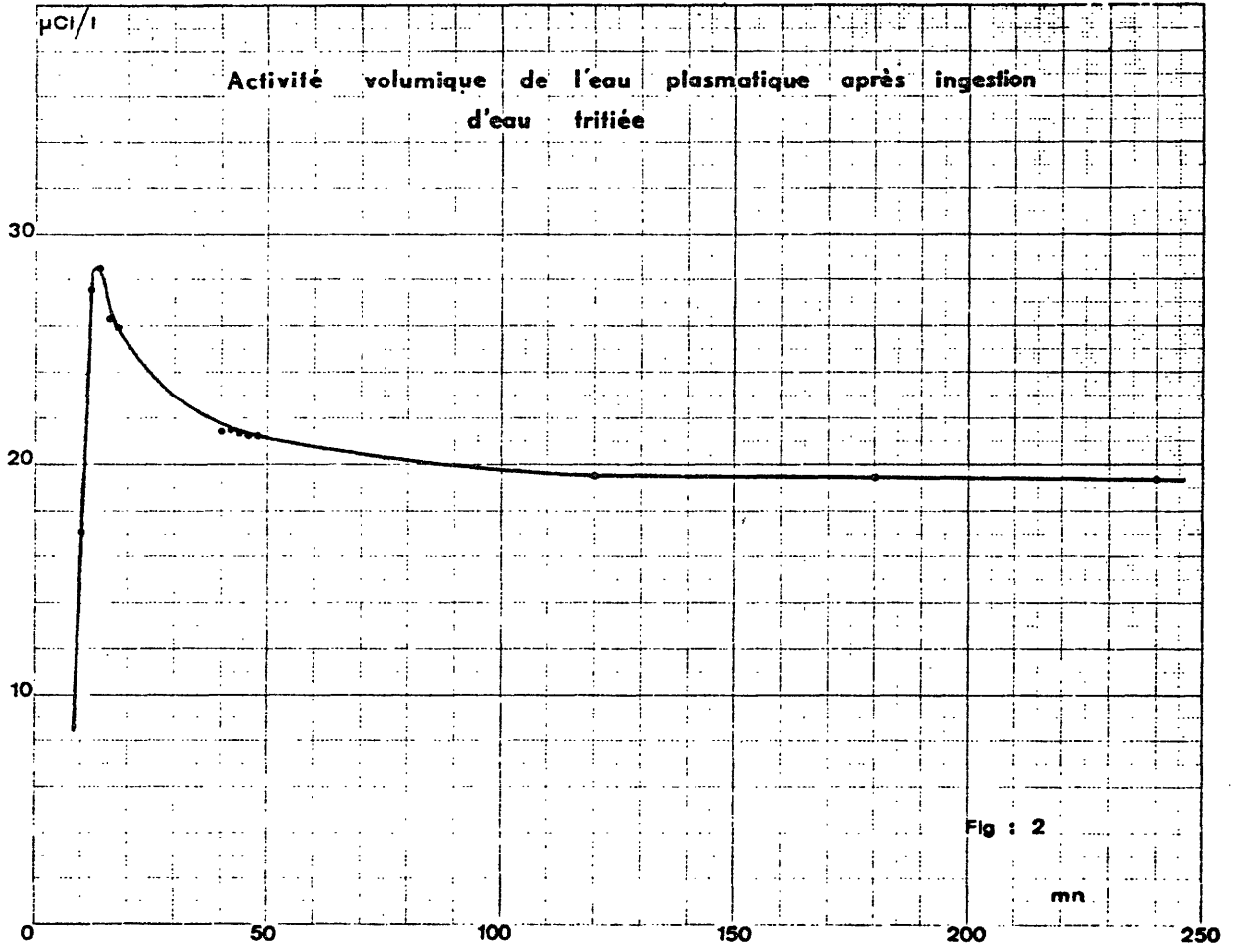
µCi/l
Activité volumique de l'eau plasmatique après ingestion d'eau tritiée
30
20
10
0
50
100
150
200
250
mn

Fig : 2

The constant λ_E is then obtained by the formula :

$$\lambda_E = \frac{V_2}{V_1 + V_2} \cdot \frac{1 - e^{-0.693 \frac{t-m}{T_D}}}{t}$$

The calculation shows that, for a given value of m/T_D, there is an optimal value of t which corresponds to a maximum clearance λ_E.

By giving the relative value of the unit of time t in terms of T_D, it is possible to calculate the numerical values for $\frac{1 - e^{-0.693 \frac{t-m}{T_D}}}{t/T_D}$ when the ratio t/T_D is varied.

The graphs thus obtained are shown in figure 1. The duration of the cycle and consequently the flow giving the best clearance can be selected by reference to the graphs when m and T_D are known.

III - 2 - Experimental work

The subjects tested in the experimental work were anuretic patients suffering from acute or chronic renal deficiency and who were being treated by peritoneal dialysis.

III -2a - Protocol of the experiment

Labelling the water with tritiated water

- Ingestion when fasting of 50 cm^3 of tritiated water containing approximately 1 millicurie and twice 50 cm^3 of rinsing water (activity evaluated before ingestion).

- Three hours later a sample of blood is taken in order to measure the activity of the water in the plasma in equilibrium with the body water. It is clear from the available data that this provides ample time. A test carried out on a healthy subject has provided confirmation of this.

Figure 2 shows that the peak of the activity of the water in the plasma is reached 14 minutes after ingestion and is stabilized at its equilibrium concentration in less than two hours.

Peritoneal dialysis process

The dialysing circuit consists of an injection vessel and a drainage vessel both connected to the intraperitoneal catheter by a simple Y joint. The two tubes are clamped alternately during the injection and drainage processes which are effected by gravity flow.

The fluid is drained off into a measuring jar to determine the distribution and quantity of the substances being examined.

Throughout the experiment, the volume injected per cycle is fixed at approximately two litres of a solution containing: 15 g of glucose, 100 meq of sodium chloride, 35 meq of sodium acetate and 3 meq/litre of calcium chloride.

However, the length of the cycle is varied according to the purpose of the test.

To simplify the description of the test, we shall call :

- t_1 the injection time for the dialysing solution,
- t_2 the residence time in the peritoneal cavity between the end of the injection and the beginning of the drainage,
- t_3 drainage time,
- $t = t_1 + t_2 + t_3$ the total time taken by each cycle.

The duration of t_2 varies from one test to another and, in some cases, two different times are used during the same session of dialysis in order to observe their influence on the effectiveness of the clearance.

At the beginning or end of each session, some cycles were expressly used for studying the characteristics of diffusion using methods described below.

Samples taken during dialysis

These comprise :

- blood samples taken at regular intervals, every three or four hours, the first being taken after ingestion and just before the beginning of the dialysis (D = 0). In some cases a monitoring sample was taken two hours after the end of the dialysis session to detect any "rebound" in plasma activity,

- varying numbers of samples of dialysate taken during the dialysis after drainage or taken during cycles used for studying the diffusion.

III -2b - Presentation of the results

The results of the measurements were shown in volume concentrations or activities expressed as /uCi per litre of water contained in the plasmas (C_1) or the dialysates (C_2).

Calculation of the volume V_1 of the water compartment

The water compartment is calculated according to the formula :

$$V_1 = \frac{\text{Activity ingested - Activity eliminated}}{\text{Per unit volume activity of the water in the plasma}}$$

The plasma activity is that of the sample taken three hours after ingestion.

In the case of anuretic patients, the activity excreted through the skin or the lungs in these three hours is considered to be negligible.

Calculation of the constant λ_E and of the clearance period T_E

Rather than show the function $C_1 = C_i e^{-\lambda_E D}$ on semi-logarithmic paper, we preferred to take napierian logarithms of the C_1 values and show on paper with linear coordinates the straight line describing the function :

$$\ln C_1 = \ln C_i - \lambda_E D$$

The straight line graph gives the values of the constant λ_E, viz.:

$$\lambda_E = \frac{\ln C_i - \ln C_1}{D}$$

Calculation of the diffusion parameters

a) Calculation of diffusion time T_D

Two methods were used.

- Method using a dialysing cycle

After injecting the dialysing fluid, samples of approximately 5 ml were drawn off every five, then every ten minutes by the evacuation catheter, after the solution lying in the catheter had been removed.

The first sample was taken immediately after t_1. The concentration C_2 of the tritiated water in each sample was determined, and C_{eq} was calculated using the formula $C_{eq} = C_{1.0} \cdot \frac{V_1}{V_1 + V_2}$.

The value $C_{1.0}$ at the beginning of the cycle, hereafter C_1, was read off the straight line graph of plasma activity. It was then possible to draw the ascending exponential $C_2/C_{eq} = 1 - e^{-\lambda_D t}$ and the descending exponential.

$$1 - C_2/C_{eq} = e^{-\lambda_D t}$$

The negative part of the straight line representing the linear function $\ln (1 - C_2/C_{eq}) = - \lambda_D t$ is the constant λ_D, from which the diffusion time T_D is deduced in accordance with the usual formula $T_D = 0.693/\lambda_D$.

- Method using several complete cycles

Several complete cycles, including drainage, were carried out successively keeping t_1 and t_3 as constant as possible and gradually increasing t_2. The same calculations were made as in the previous method, using the appropriate C_{eq} value for each cycle.

A straight-line graph was plotted, taking for each value of $\ln (1 - C_2/C_{eq})$ the abscissa corresponding to the complete time of the cycle ($t = t_1 + t_2 + t_3$). This straight line passes through the ordinate 0 (on which $4.6 = \ln 100$, if C_2/C_{eq} is expressed as a percentage) for a value of t greater than 0, equal to the value m of the resting phase in each cycle.

b) Calculation of the dead time m and of the effective diffusion time θ

- When diffusion had been studied over several complete cycles, the value of the dead time was obtained directly by using the graph described above.

- If diffusion is studied over a single cycle which does not include drainage time t_3, the graph cannot be used to calculate the dead time.

It can, however, be calculated indirectly by using the measurements taken of the dialysates recovered during the session from cycles for which t_1, t_2 and t_3 were standardized.

θ can then be calculated by using the formula $C_2/C_{eq} = I - e^{-\lambda_D \theta}$. The dead time m is then obtained from the equation $m = t - \theta$.

Calculation of absolute clearance :

Taking a minute as the unit of time and a millilitre as the unit of volume, three formulas can be used to calculate the clearance expressed in millilitre/minute.

1) $CL = \lambda_E \cdot V_1$. This formula gives the clearance based on the development of the plasma activity. It measures the total clearance, peritoneal and extraperitoneal (sweat and expelled air); this latter form, in normal conditions and excluding any perfusion, represents only a negligible proportion of the total clearance.

2) $CL = \frac{C_2 \cdot V_2}{C_1 \cdot t}$. It is possible with this formula to calculate the clearance, cycle by cycle, using real and measured values of C_2, V_2 and t, the value C_1 being read off the plasma activity graph. The clearances thus calculated measure only the peritoneal clearance.

Naturally, they fluctuate from one cycle to another. In any case, an average clearance can be established, the value of which depends mainly on the number of cycles examined.

3) $CL = \frac{V_1 \cdot V_2}{V_1 + V_2} \cdot \frac{1 - e^{-\lambda_D \theta}}{t}$. It is possible with this formula to base a forecast of the peritoneal clearance on the diffusion parameters alone. The same formula, using the curves in Figure 1, may be used especially to calculate the optimal residence time in the peritoneum required to obtain the maximum clearance in operating conditions.

III - 2c - Experimental Results

Six sessions of dialysis were performed for five patients. Details on the methods used in each session have already been published [4]. The graphs showing the stages of diffusion and clearance are given, two per session, in Figures 3 to 14.* The first shows the stages of diffusion in the peritoneal fluid, the second describes the clearance of the body (water in the plasma) during the peritoneal dialysis.

A summary of the values obtained is given below.

* See figures 3 to 14 pp 153-164

III -2d - Summary of the experimental study of peritoneal dialysis

Diffusion times - Table I

TABLE I

Diffusion times

Patient No 1	T_D = 12.4 mn
Patient No 2	T_D = 28.0 mn
Patient No 3 - Session 1	T_D = 31.5 mn
Patient No 3 - Session 2	T_D = 23.5 mn
Patient No 4	T_D = 18.3 mn
Patient No 5	T_D = 20.4 mn
Average :	T_D = 22.3 mn

There is a significant variation in the diffusion periods between subjects. It seems to be shorter in those suffering from chronic renal insufficiency, repeatedly subjected to dialysis, but this requires corroboration.

TABLE II

Dead Time (mn)

Patient	Direct calculation	Indirect calculation	(t_1+t_3) average	$m/(t_1+t_2)$
1	-	13.6	26.2	0.52
2	-	8.3	24,7	0,34
	-	0.0	17.3	0.00
3 I	-	5.3	20.5	0.26
	-	3.7	18.4	0.20
3 II	6.0	-	18.0	0.33
4	4.6	-	18.0	0.25
5	3.0	-	18.0	0.17

This table shows that the dead time represents approximately 25 %, or 1/4 on average, of the sum of $t_1 + t_3$, when it falls between 18 and 20 minutes, which is the normal time taken for an incident-free cycle of dialysis.

Clearances

The cases studied show a good measure of agreement between the clearances calculated by different methods; the few discrepancies noted can be explained.

The table below shows the experimental peritoneal clearances and the maximum clearances calculated on the basis of the average injection and drainage times noted during the sessions.

TABLE III

Patient	CL (ml/mn)	CL_{max} (ml/mn)
1	35.5	36.0
2	31.6	36.5
3 I	27.3	28.5
3 II	28.0	31.0
4	36.8	41.0
5	34.9	41.0
Averages	32.3	36.0

Note: When sessions of dialysis included two stages, we have retained only the stage best suited to the elimination of tritiated water.

Conclusion

What results can be expected when a person contaminated by tritiated water is treated by peritoneal dialysis?

The clearances achieved during experiments reached an average of 32.3 ml/mn and they could have been improved to 36 in optimal dialysing conditions.

It is also possible to estimate the probable clearance on the basis of the average values adopted for the diffusion parameters.

If

V_1 = $4.3.10^4$ ml (standard man)
V_2 = 2.10^3 ml
t_1 t_3 = 20 mn
T_D = 22 mn
λ_D = $3.15.10^{-2} mn^{-1}$
m = 5 mn (25% of $t_1 + t_3$)

Then : $m/T_D = 5/22 = 0.23$.

The best clearance is obtained for $t/T_D \approx 1$, viz $t \approx 22$ mn. In these conditions :

$$\theta = 22 - 5 = 17 \text{ mn and } CL = \frac{V_1 \cdot V_2}{V_1 + V_2} \cdot \frac{1 - e^{-\lambda_D \theta}}{t} = 36 \text{ ml/mn}$$

To this value can be added the normal clearance which, in a healthy subject, amounts to approximately 2 ml/mn for a daily balance between 2.5 and 3 litres. This therefore results in a clearance of 38 cm^3/mn.

The clearance constant is deducted

$$\lambda_E = \frac{CL}{V_1} = \frac{38 \times 60}{4.3.10^4} = 5.3.10^{-2} h^{-1}$$

and the clearance period $T_E = 0.693/\lambda_E = 13$ hours.

IV - Clearance of tritiated water by hemodialysis

IV - 1 - Summing up of basic principles

The theory of the artificial kidney is sufficiently well known for a detailed explanation to be unnecessary here. We shall therefore merely refer to a few basic principles.

The mechanics of hemodialysis are the same as those for peritoneal dialysis but it is a continuous process, without a dead time and depending basically on the quality of the membrane, the geometry of the kidney and the flow speed.

The cleansing power of an artificial kidney is expressed in terms of dialysance, which are identical to those for clearance used in reference to natural clearance.

If :

Q_1 is the blood flow in ml/mn
Q_2 the flow of the dialysing medium
C_{1E} the concentration of the substance in the blood on entering the dialyser
C_{1S} the concentration of the substance in the blood on leaving the dialyser
C_{2E} the concentration in the dialysing medium on entering the dialyser
C_{2S} the concentration in the dialysing medium on leaving the dialyser

The dialysance D is obtained by using the formula :

$$D = Q_1 \cdot \frac{C_{1E} - C_{1S}}{C_{1E} - C_{2E}} = Q_2 \cdot \frac{C_{2S} - C_{2E}}{C_{1E} - C_{2E}}$$

When $C_{2E} = 0$, which is the most frequent situation, the formula becomes :

$$D = Q_1 \left(1 - \frac{C_{1S}}{C_{1E}}\right) = Q_2 \cdot \frac{C_{2S}}{C_{1E}}$$

When the streams of blood and the dialysate are flowing in the same direction, the best result is obtained from the dialyser when both fluids have the same concentration on leaving it:

The calculations then show that :

$$D_{max} = \frac{Q_1 \cdot Q_2}{Q_1 + Q_2} \quad \text{or} \quad \frac{1}{D_{max}} = \frac{1}{Q_1} + \frac{1}{Q_2}$$

When the dialysate and the blood flow in opposite directions, theoretical equilibrium is reached when $C_{2S} = C_{1E}$. The maximum dialysance is then equal to Q_2.

In practice, commercial dialysers, in which the two fluids flow in opposite directions, do not achieve a real counter-current extraction such as would enable ideal conditions of equilibrium to be achieved with the rates of blood flow used.

The limited extractive power of all dialysers is not generally due to the quality of the membranes, but to flow characteristics and to geometrical conditions governing the distribution of the blood and the dialysate.

The best dialysing conditions are generally obtained with a flow of dialysing medium four times as great as that of the blood.

IV - Experimental work

IV -2a - Protocol of the experiment

The two patients subjected to tests had multiple injuries and were suffering from acute renal insufficiency. The conditions in which the water was labelled with tritium and the activity of the biological fluids measured were the same as for peritoneal dialysis.

The hemodialysis process

In the clinic St Eloi in Montpellier for metabolic and endocrinal diseases, extracorporeal flow of the blood is ensured by a surgical operation, under local anesthetic, during which a Scribner type arterio-veinous circuit is inserted between a distal artery and a vein in an upper or lower limb.

Disc kidneys of the KIIL type and "P.T. 150 cuprophane" membranes are used. The "heparinisation" of the patient is general and continuous.

The rate at which the dialysing medium flows through the kidney usually varies between 500 and 600 ml/mn. The dialysing medium consists of : 100 meq of sodium chloride; 35 meq of sodium acetate; 3 meq of calcium chloride; 1.5 meq of magnesium chloride and 1.5 meq per litre of potassium chloride.

The following samples were taken during the session :

- blood entering the kidney : one sample per hour;
- blood leaving the kidney : two or three samples;
- dialysing effluent : one sample every half hour.

Analysis of the results :

The results were used to :

- calculate the volume of the water compartment
- plot the clearance exponential, log C_{1E} as a function of time.

The straight line representing the development of the activity of the dialysates, ln C_{2S} as a function of time, was plotted on the same graph.

- Calculation of the dialysance by the two formulas :

$$D = Q_1 \cdot \left(1 - \frac{C_{1S}}{C_{1E}}\right) \text{ and } D = Q_2 \frac{C_{2S}}{C_{1E}}$$

Since the voluminal activities C_{1S} and C_{1E} were the same as those of the water in the plasma, the calculations of the flow Q_1 (and the dialysance) were based on the water, allowance being made for hematocrit, and on the average volume of water in the plasma (94%) and in the globules (66%).

- Comparison of the dialysance achieved and of the clearance deduced from the plasma clearance graph.

IV -2b - Experimental results

Patient No 1 - Miss MES

Volume of the body water V = 904/37.1 = ... 24.3 litres

Hemodialysis Conditions

Because of the low hematocrit reading in this patient, we used only one sector of the kidney, since a two-stage dialysis might have resulted in serious resuscitation problems.

Blood flow ..... Q_1 = 128 ml/mn

= 115 ml of water/mn

Dialysate flow ..... $Q_2 \approx$ 600 ml/mn

Interpretation of the results

Clearance constant (see Figure 15, p. 165) $\lambda_E = 1.64.10^{-1}h^{-1}$

Clearance period ..... T_E = 4.2 h

Clearance $\lambda_E \cdot V = (0.164/60) \cdot 24.4.10^3$ = ... 66.5 ml/mn

Dialysance $D = Q_1 \left(\frac{1 - C_{1S}}{C_{1E}}\right) = 115\ (1 - 0.44) = 64.5$ ml/mn

$$D = Q_2 \times \frac{C_{1S}}{C_{1E}} = 600 \times 0.11 = 66 \text{ ml/mn}$$

The correlation between these values is satisfactory.

Patient No 2 - Mrs DES

Volume of body water V = 890/36.05 = ... 24.6 litres.

Conditions of the hemodialysis

Because of the clotting of an upper stage of the kidney at the beginning of the session, which put that stage out of operation, the hemodialysis was carried out on one sector only.

Blood flow Q_1 = 160 ml/mn = 138 ml of water/mn (hematocrite = 29)

Dialysate flow Q_2 between 650 and 580 ml/mn (average 615 ml/mn).

Interpretation of the results

Clearance constant (see Figure 16, p. 166) $\lambda_E = 1.99.10^{-1}h^{-1}$

Clearance period ..... $T_E = 3.5$ h

Clearance $\lambda_E \cdot V = \frac{0.199}{60} \times 24.6 = 81.6$ ml/mn

Dialysance $D = Q_1 \left(1 - \frac{C_{1S}}{C_{1E}}\right) = 138(1 - 0.424) = 79.5$ ml/mn

$$D = Q_2 \cdot \frac{C_{2S}}{C_{1E}} = 615 \times 0.133 = 81.8 \text{ ml/mn}$$

In view of the precision of the flow figures, the correlation between the values is satisfactory.

IV -2c - Conclusions on the study of hemodialysis

In this very brief study of hemodialysis, the modest results we have obtained are due to the fact that, for various reasons, it was possible to use only one sector of the kidney for clearance. In both cases, the dialysances obtained for tritiated water (66 and 80 ml/mn) came to approximately 58% of the maximum theoretical dialysis represented by the flows Q_1 (115 and 138 ml/mn) of the water in the blood.

There is good reason to think that this performance could be considerably improved if a complete kidney were being used and that it is possible to obtain a dialysance approaching 90% of Q_1.

Assuming an average blood flow of 180 ml/mn, viz 145 ml of water/mn, in a healthy subject weighing 70 kg, a dialysance in the region of 130 ml/mn might be expected.

The following average values can therefore be taken for the standard subject :

$$CL = 130 \text{ ml/mn}$$

$$\lambda_E = \frac{130 \times 60}{43.10^3} = 1.81.10^{-1}h^{-1}$$

$$T_E = 0{,}693/\lambda_E = 3.8 \text{ h.}$$

IV - 3 - Comparison of peritoneal dialysis and hemodialysis

The incontestable advantage of hemodialysis lies in its effectiveness, which is noticeably greater than that of peritoneal dialysis. The use of an artificial kidney for clearance does, however, present certain disadvantages, in particular:

- the need to use an artery and a vein
- the time required for the process
- the risks involved in the use of the artificial kidney.

The main disadvantage of peritoneal dialysis is the danger of infection which can be minimised by proper asepsis.

On the other hand, this method of clearance has considerable advantages :

- the short time required for preparations;
- the patient's arterio-venous system is left intact;
- an extensive deployment of staff and equipment is not required for supervising the patient's equilibrium;

- the process can, if necessary, be extended over several days and the dialysing cycles may be controlled automatically.

In conclusion, peritoneal dialysis is the therapy to be preferred; hemodialysis is only advisable in exceptional cases.

This leads us to consider what procedure should be followed for different levels of contamination.

V - Procedure to be followed for different levels of contamination

The level of accidental contamination by tritium is evaluated by calculating the dose (dose equivalent) received.

General formula

$$D = 51.2\, \epsilon\, m^{-1}\, Q$$

where :

D = the dose in rems to the critical organ
ϵ = effective energy in MeV absorbed by disintegration
m = mass of the critical organ (in grammes)
Q = the total burden of the activity in the crital organ in /uCi-days.

Contamination by tritiated water

• $\epsilon = 5.7.10^{-3}$ (F.Q = 1 [5])

. Critical organ (in whole body). The highest concentration of water, approximately 80%, is in the gonads and the bone marrow. In these conditions, the activity of the critical organ is evaluated by multiplying c, the concentration of tritiated water in the body water or the urine, by 0.8.

Taking C to be the integral of the concentration in the urine, the general formula becomes :

$$D = 51.2 \times 5.7.10^{-3} \times 0.8 \times C$$

$$\boxed{D = 0.233\ C}$$

The dose is expressed in rems or in millirems, depending on whether the integral is given in $\mu Ci\ ml^{-1}\ j^{-1}$ or in $\mu Ci\ l^{-1}\ j^{-1}$. If we assume a single exponential retention function then :

$$C = \int_0^t c_t \cdot dt$$

$$= c_0\ ^{\lambda-1}\ (1 - e^{-\lambda t})$$

and for $t \gg T$,

$$C = c_0\ ^{\lambda-1}$$

$$D \doteq 0.23\ ^{\lambda-1} c_0$$

If we attribute to T an average value of 10 days ($\lambda = 6.93.10^{-2}$) the following formula can be used to evaluate the dose received:

$$\boxed{D = 3.37\ c_0}$$

The value c_0 is the initial concentration of the tritium in the body water, when the status of equilibrium is reached.

As a guide, we shall give the burden in the body Q_0 which corresponds for a standard man to the value c_0

1st patient

D less than 10 rems
c_0 less than 3 $\mu Ci\ cm^{-3}$
Q_0 less than 130 mCi

No intensive therapy seems justified. The only recommendation would be to increase the daily ingestion of liquids.

2nd patient

D between 10 and 100 rems
c_0 between 3 and 30 $\mu Ci\text{-}cm^{-3}$
Q_0 between 130 mCi and 1.3 Ci

It seems to us that this patient should be hospitalized and treated by osmotic diuresis which, if applied for some days, should reduce the dose received by half.

3rd patient

D in excess of 100 rems
c_0 in excess of 30 $Ci\text{-}cm^3$
Q_0 in excess of 1.3 Ci

When the dose equivalent is higher than 100 rems, we think that intensive treatment is required. The choice of therapy, osmotic diuresis, peritoneal dialysis or hemodialysis will depend basically on the dose received. In most cases it will be possible to use peritoneal dialysis, a moderately aggressive process which can be carried out promptly in a hospital environment.

The length of time selected for the treatment and any decision to use hemodialysis will be based on careful calculations of the dose which, depending on the treatment, will actually be delivered.

We shall take as an example the case of a standard man who has accidentally absorbed 10 Ci of tritium, which, roughly, corresponds to an initial volume activity of 230 $\mu Ci/cm^3$ and to a dose of 800 rems.

The total dose D received by the contaminated person can be divided into three components.

1. D_1 = dose received during the time between the incident and the beginning of the treatment. We shall assume this time to be equal to 4 hours.

2. D_2= dose received during the treatment with a half life of 13 hours.

3. D_R = dose to be received after the dialysis, with a half life of 10 days.

The total dose received D will be equal to the sum of $D_1+D_2+D_R$.

The following table sets out the doses received depending on the length of the dialysis.

TABLE IV

Dose in rems delivered by 10 Ci of HTO in standard man

Dose received ≈ 800 rems

Treatment by peritoneal dialysis

Duration of the Dialysis	D_1	D_2	D_R	D_T	D/D_E
12 hours	9	20	410	439	55%
24 hours	9	30	216	255	32%
36 hours	9	36	113	158	20%
48 hours	9	39	60	108	14%

This table provides a simple forecast of the effectiveness of the treatment depending on its duration.

If we take 48 hours as the maximum reasonable duration for the dialysis, a dose approximately seven times less than the received dose can be attained. If this reduction is thought to be inadequate, it would be necessary to consider beginning hemodialysis as soon as possible in addition to the peritoneal dialysis. Such a decision could be taken if calculations show that 48 hours' dialysis will not be enough to bring the dose below 100 rems.

A therapy combining the two methods of clearance can give a half life equal to

$$\frac{13 \times 3.8}{13 + 3.8}$$ hours, viz. approximately 3 hours.

Let us suppose for the sake of example that, in the case studied above (absorption of 10 Ci by a standard man) the hemodialysis begins 12 hours after the beginning of the peritoneal dialysis, other factors remaining unchanged.

Depending on the duration of the hemodialysis, the following results are obtained :

TABLE V

Peritoneal Dialysis (12 hours) + Hemodialysis

Duration of the Hemodialysis	$D_1 + D_2$	D_3	D_R	D_T	D/D_E
12 hours	29	4.8	25.5	59	7.5%
24 hours	29	5.1	1.6	36	4.5%

D_1 = Dose before treatment
D_2 = Dose during the peritoneal dialysis
D_3 = Dose during dialysis + hemodialysis
D_R = Residual dose received after treatment
D_N = Total dose

This table shows that one can hope to reduce the dose received by a factor of 20.

A greater reduction of the dose could only be obtained by reducing the delay in beginning treatment.

CONCLUSION

Extrarenal clearance is an ideal treatment for accelerating the elimination of tritiated water in the case of serious accidental contamination. The procedure which we recommend should not be regarded as inflexible; it may be modified in the light of the clinical features of each case. Nonetheless, we think that it can serve as a guide in making the necessary decisions when incidents occur.

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(4) Mirouze J., Mion C., Fabre J.L., Mazaury E., Henry Ph., Mercier J.: Utilisation des méthodes d'épuration dans le traitement de la contamination par l'eau tritiée. Rapport CEA/R/3974 (1970).

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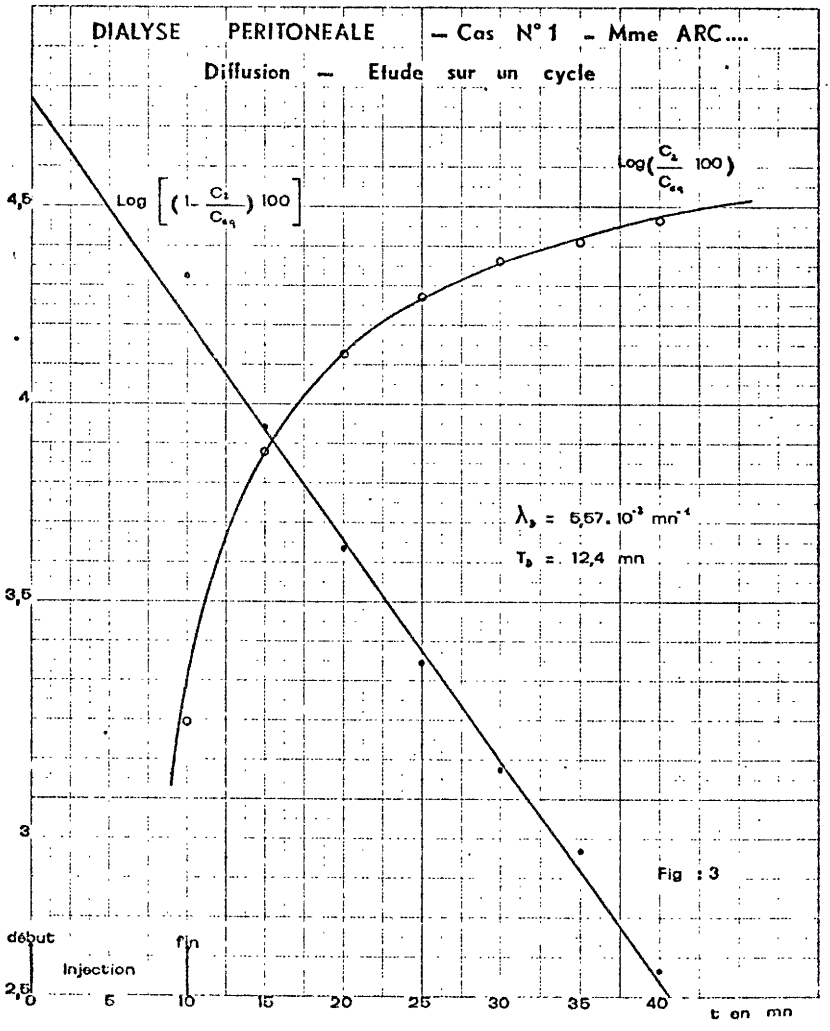

DIALYSE PERITONEALE – Cas N° 1 – Mme ARC....
Diffusion – Etude sur un cycle
Log [(1- C2/Ceq) 100]
Log (C2/Ceq 100)
λb = 5,57. 10-3 mn-1
Tb = 12,4 mn
Fig : 3
début
fin
Injection
4,5
4
3,5
3
2,5
0
5
10
15
20
25
30
35
40
t en mn

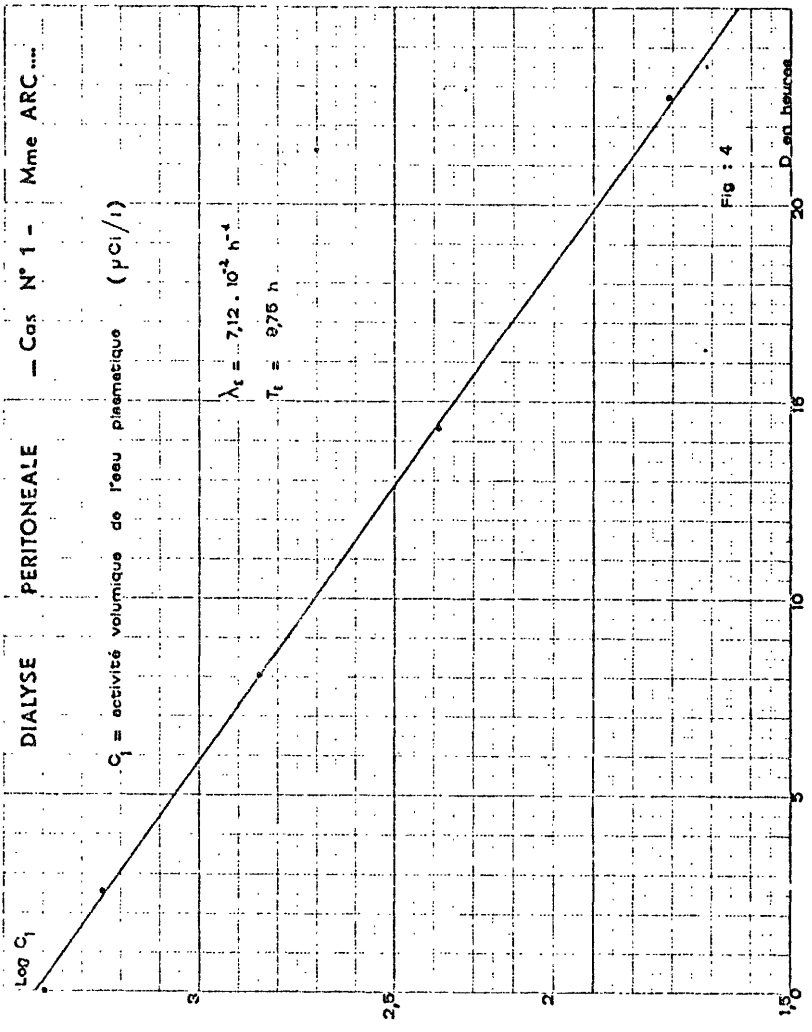
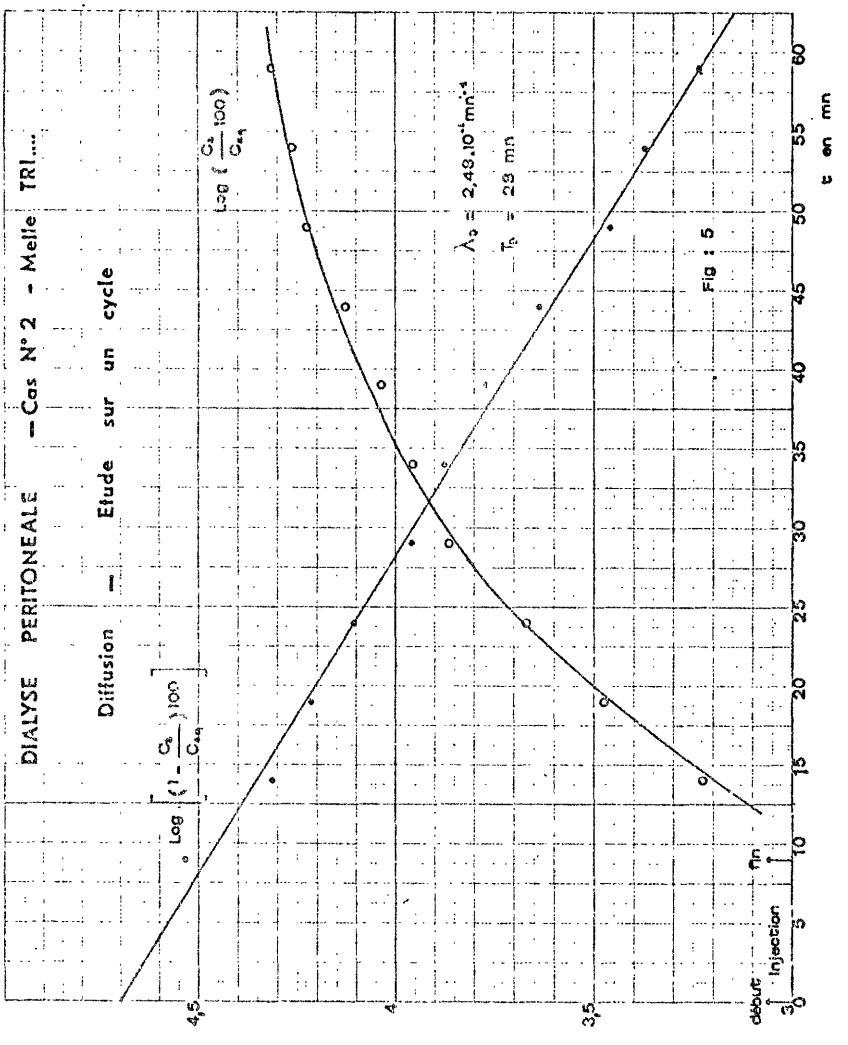

DIALYSE PERITONEALE — Cas N° 1 - Mme ARC....
C_1 = activité volumique de l'eau plasmatique (µCi/l)
$\lambda_t = 7{,}12 \cdot 10^{-2}\ h^{-1}$
$T_t = 9{,}75\ h$
Log C_1
3
2,5
2
1,5
0
5
10
15
20
D en heures

Fig : 4


DIALYSE PERITONEALE - Cas N° 2 - Melle TRI....
Diffusion - Etude sur un cycle
Log [(1 - Ce/Ceq) 100]
Log (Cs/Ceq 100)
λb = 2,48.10⁻¹ mn⁻¹
Tb = 28 mn
Fig : 5
4,5
4
3,5
3
début Injection
fin
0
5
10
15
20
25
30
35
40
45
50
55
60
t en mn

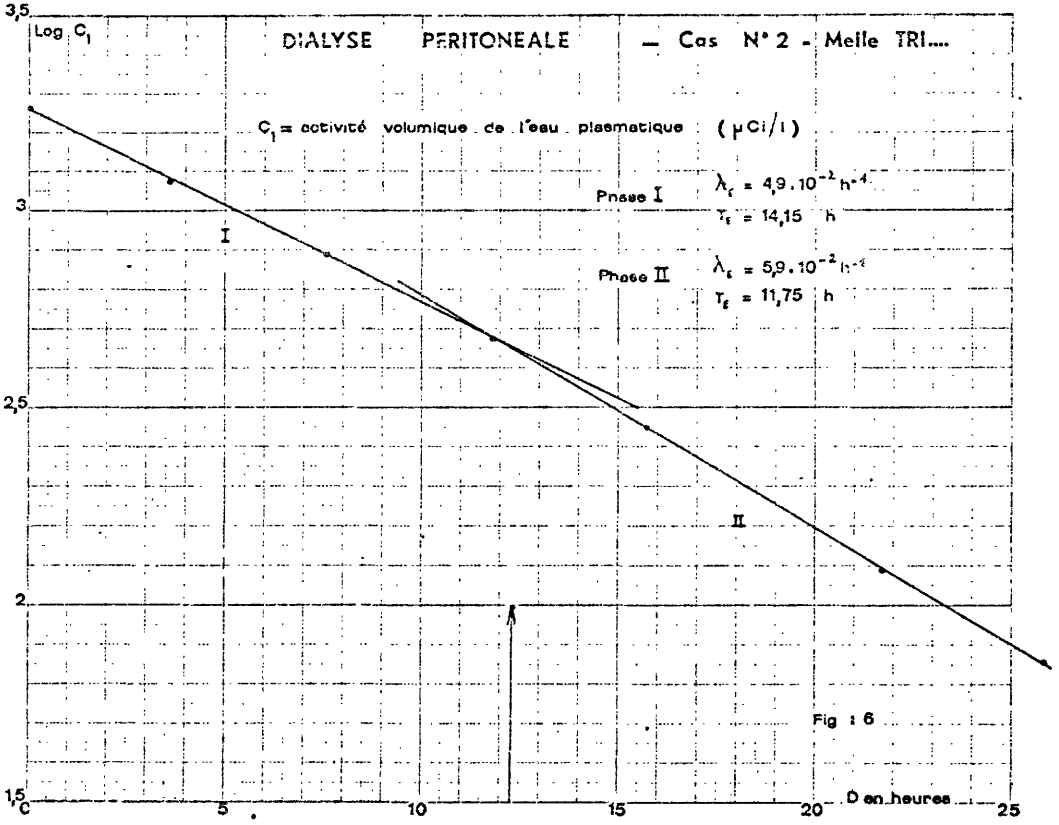
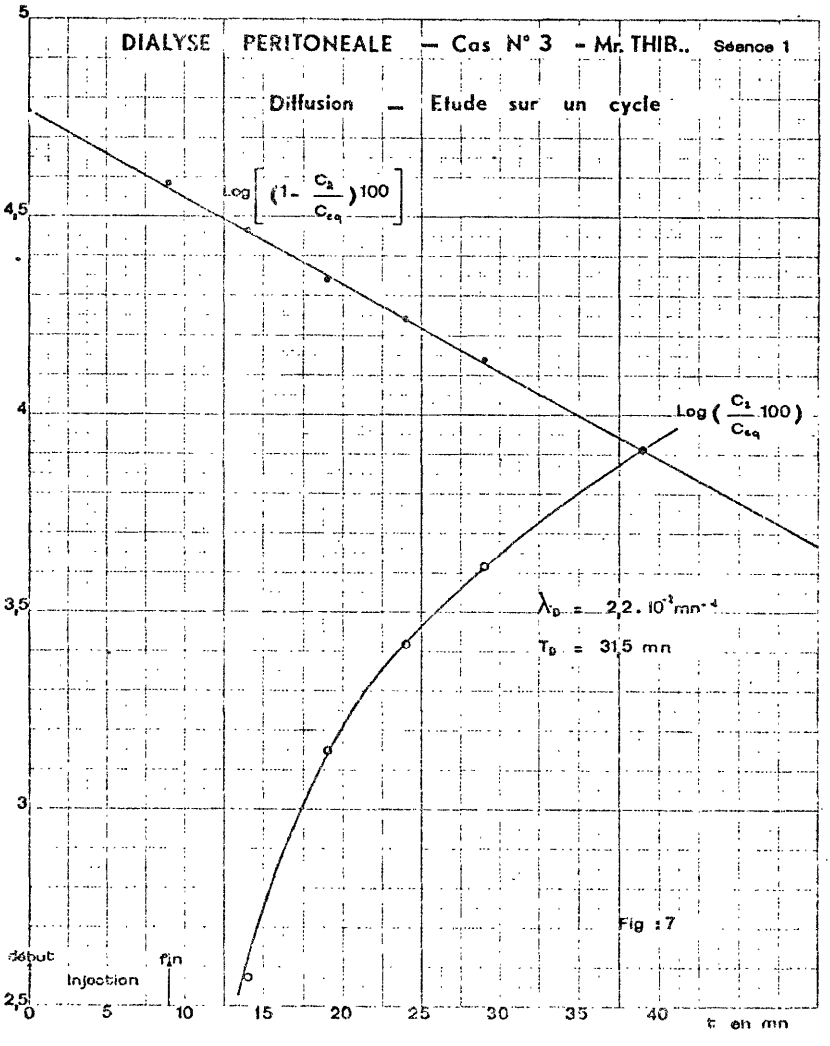

DIALYSE PERITONEALE — Cas N° 2 - Melle TRI....
Log C_1
C_1 = activité volumique de l'eau plasmatique (µCi/l)
Phase I
$\lambda_E = 4,9.10^{-2}\ h^{-1}$
$T_E = 14,15$ h
Phase II
$\lambda_E = 5,9.10^{-2}\ h^{-1}$
$T_E = 11,75$ h
I
II
3,5
3
2,5
2
1,5
0
5
10
15
20
25
D en heures

Fig : 6


DIALYSE PERITONEALE — Cas N° 3 - Mr. THIB.. Séance 1
Diffusion — Etude sur un cycle
Log [(1- C2/Ceq) 100]
Log (C2/Ceq 100)
λD = 2,2. 10⁻² mn⁻¹
TD = 31,5 mn
Fig : 7
début
Injection
fin
5
4,5
4
3,5
3
2,5
0
5
10
15
20
25
30
35
40
t en mn

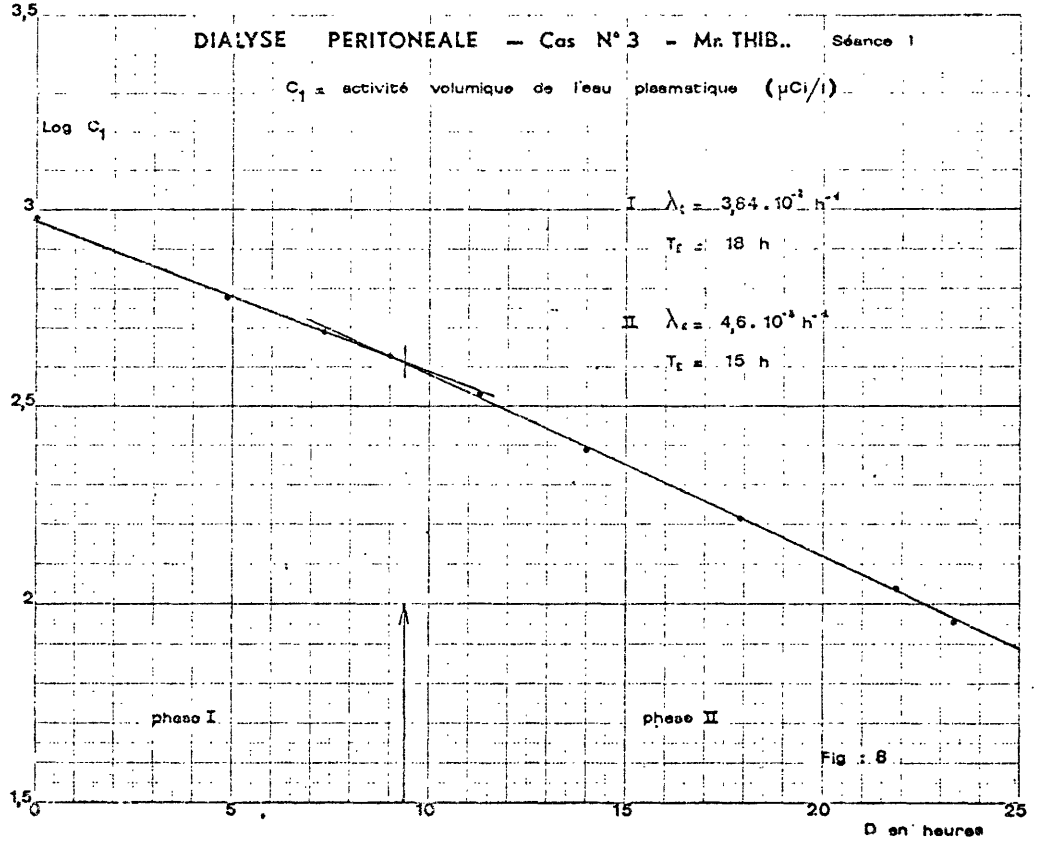

DIALYSE PERITONEALE — Cas N° 3 - Mr. THIB.. Séance 1
C_1 = activité volumique de l'eau plasmatique (µCi/l)
Log C_1
3,5
3
2,5
2
1,5
I $\lambda_1 = 3{,}64 \cdot 10^{-2}\ h^{-1}$
$T_1 = 18$ h
II $\lambda_2 = 4{,}6 \cdot 10^{-2}\ h^{-1}$
$T_2 = 15$ h
phase I
phase II
0
5
10
15
20
25
D en heures

Fig : 8

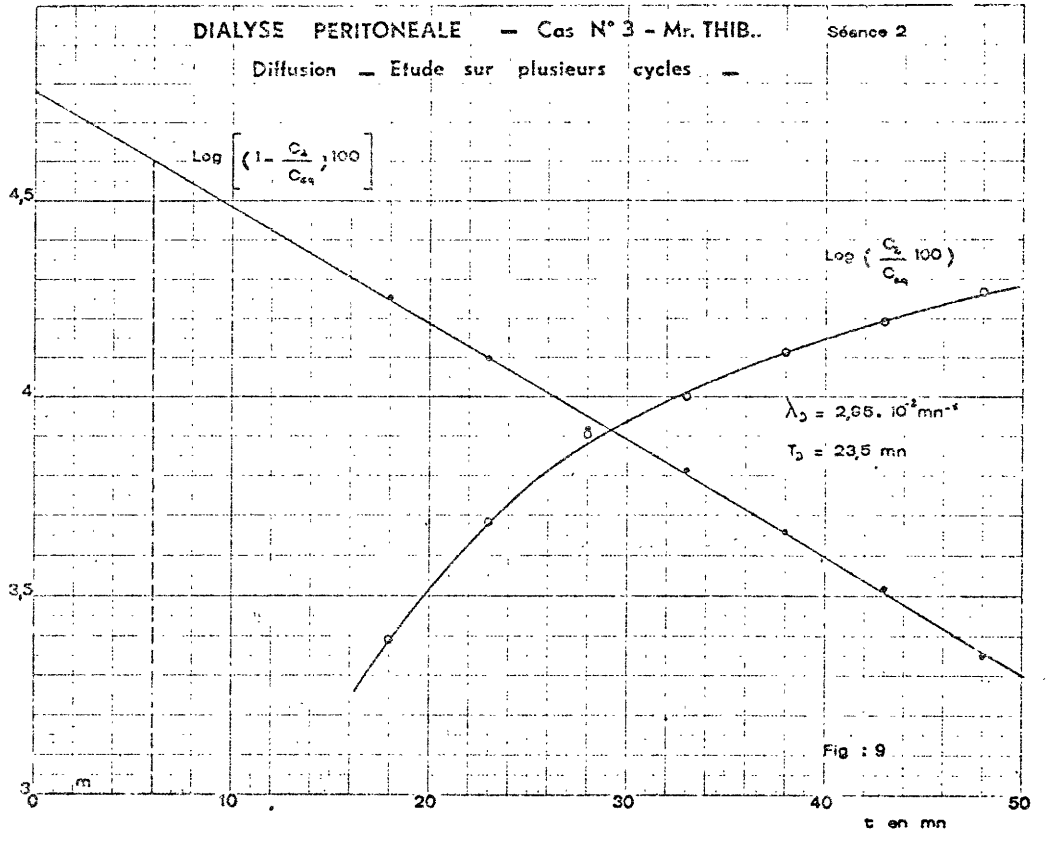

DIALYSE PERITONEALE — Cas N° 3 - Mr. THIB..
Séance 2
Diffusion — Etude sur plusieurs cycles —
Log [(1 - C1/Ceq) 100]
Log (C2/Ceq 100)
λD = 2,65. 10⁻²mn⁻¹
TD = 23,5 mn
4,5
4
3,5
3
0
10
20
30
40
50
m
t en mn

Fig : 9

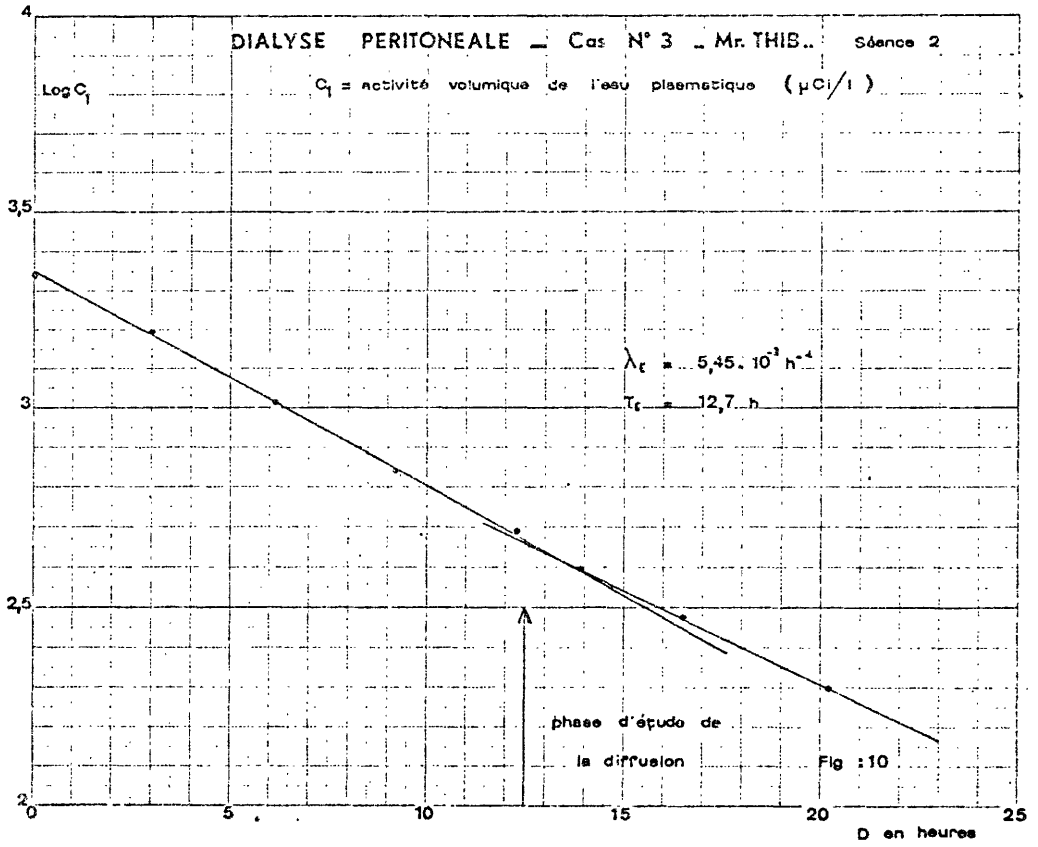
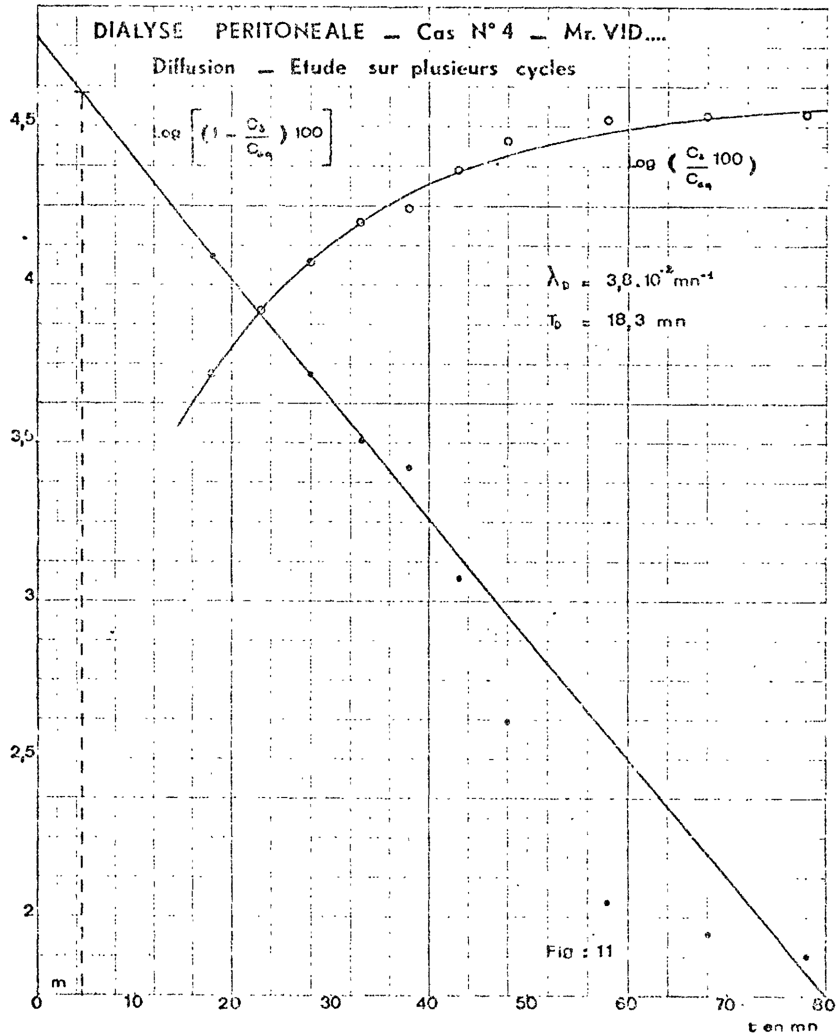

DIALYSE PERITONEALE – Cas N° 3 – Mr. THIB.. Séance 2
C_1 = activité volumique de l'eau plasmatique (µCi/l)
Log C_1
λ_E = 5,45 . 10^{-3} h^{-1}
T_E = 12,7 h
phase d'étude de la diffusion
4
3,5
3
2,5
2
0
5
10
15
20
25
D en heures

Fig : 10


DIALYSE PERITONEALE _ Cas N° 4 _ Mr. VID....
Diffusion _ Etude sur plusieurs cycles
Log [(1 - Cs/Ceq) 100]
Log (Cs/Ceq 100)
λD = 3,8.10⁻² mn⁻¹
TD = 18,3 mn
4,5
4
3,5
3
2,5
2
m
0
10
20
30
40
50
60
70
80
t en mn
Fig : 11

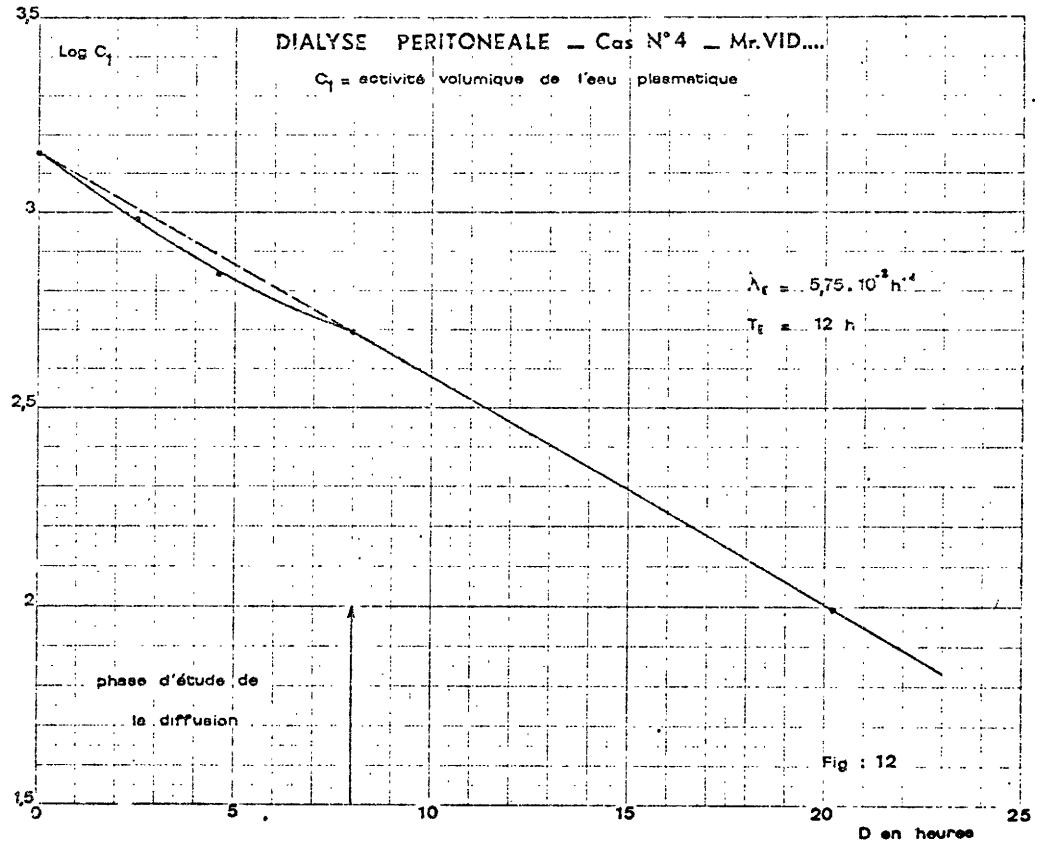
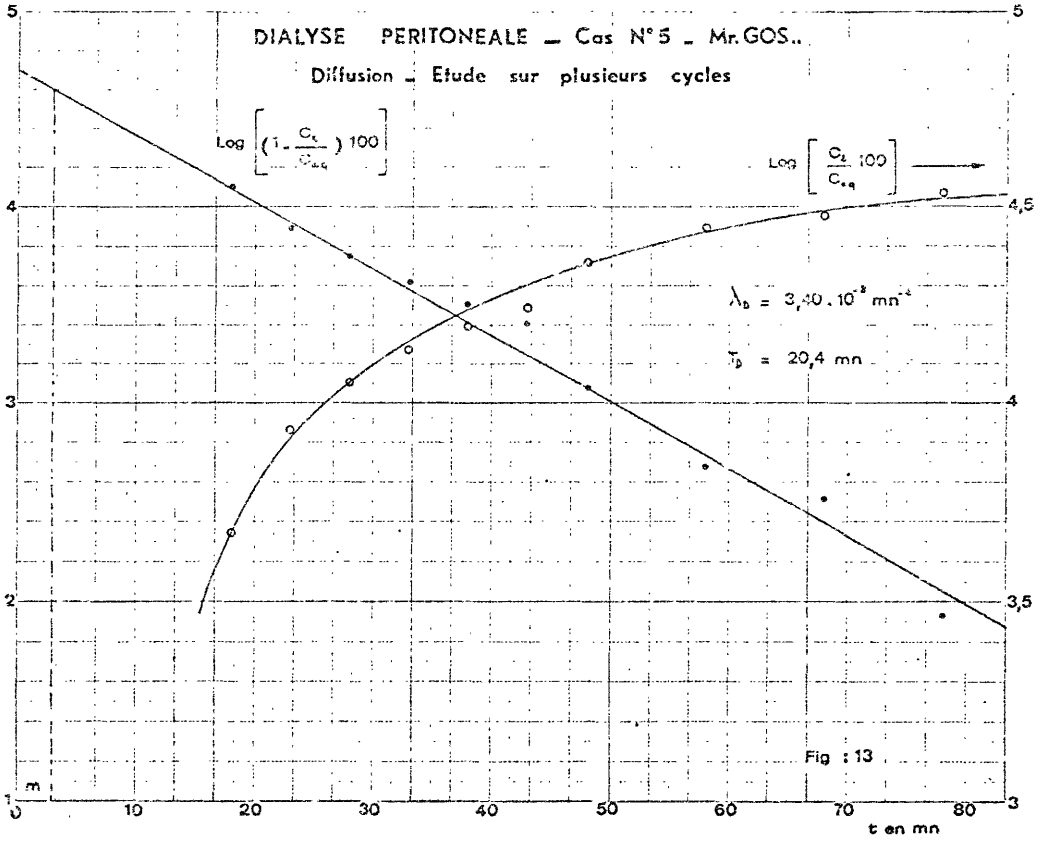
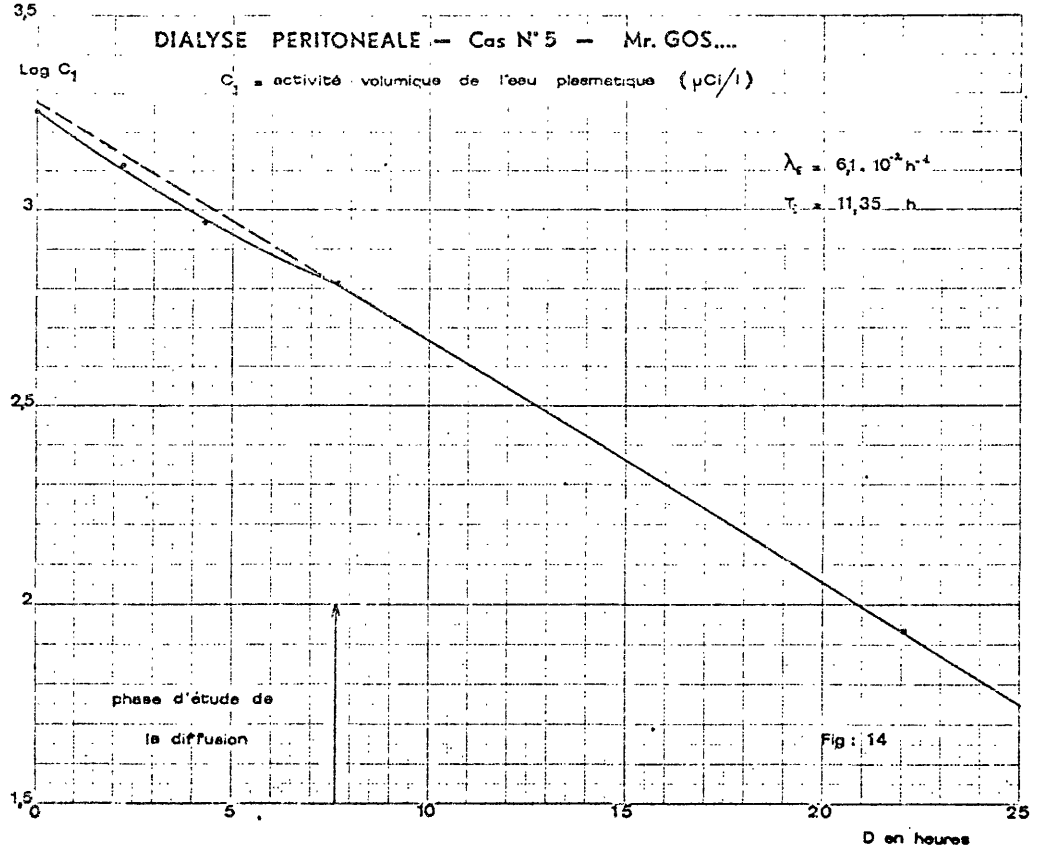

DIALYSE PERITONEALE _ Cas N°4 _ Mr.VID....
C_1 = activité volumique de l'eau plasmatique
Log C_1
3,5
3
2,5
2
1,5
0
5
10
15
20
25
D en heures
λ_E = 5,75.10^{-2} h^{-1}
T_E = 12 h
phase d'étude de
la diffusion

Fig : 12


DIALYSE PERITONEALE – Cas N° 5 – Mr. GOS..
Diffusion – Etude sur plusieurs cycles
Log [(1 - Ct/Ceq) 100]
Log [Ct/Ceq 100]
λb = 3,40 . 10⁻² mn⁻¹
τb = 20,4 mn
Fig : 13
t en mn


DIALYSE PERITONEALE — Cas N° 5 — Mr. GOS....
Log C_1
C_1 = activité volumique de l'eau plasmatique (µCi/l)
$\lambda_\varepsilon = 6{,}1 \cdot 10^{-2}\ h^{-1}$
$T_\varepsilon = 11{,}35$ h
3,5
3
2,5
2
1,5
0
5
10
15
20
25
D en heures
phase d'étude de
la diffusion
Fig : 14

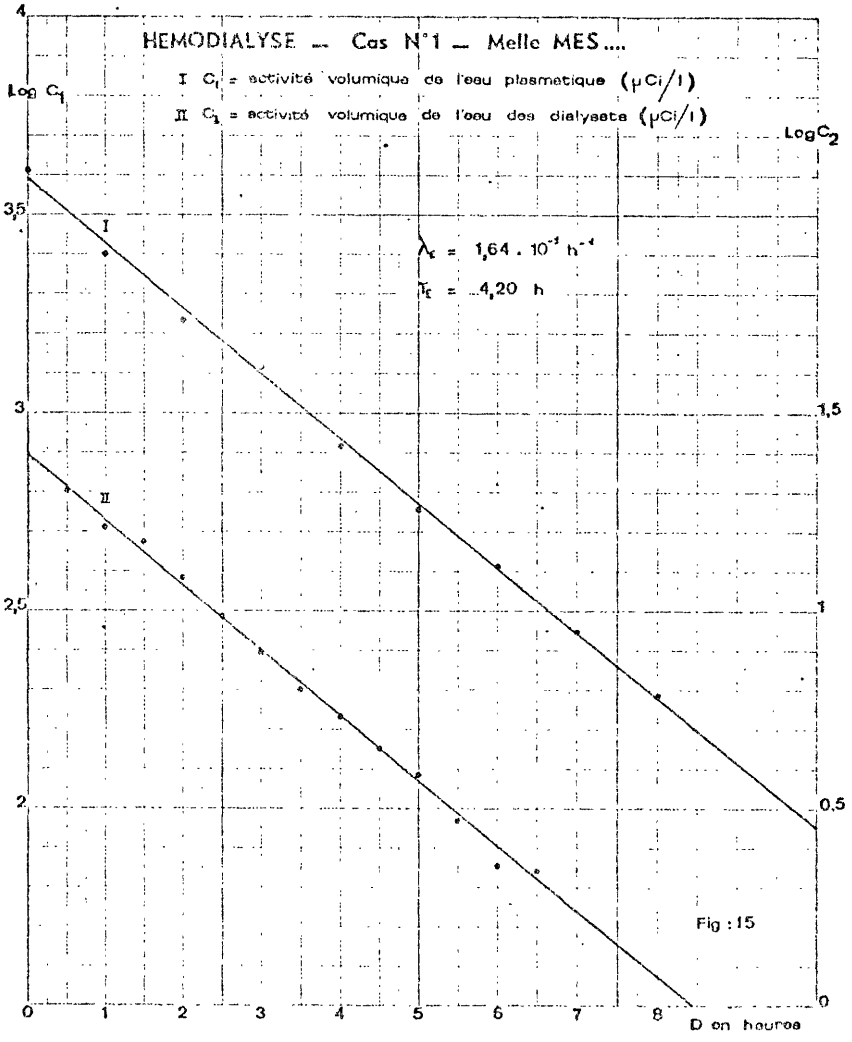

HEMODIALYSE — Cas N°1 — Melle MES....
I C_1 = activité volumique de l'eau plasmatique (µCi/l)
II C_2 = activité volumique de l'eau des dialysats (µCi/l)
Log C_1
Log C_2
λ_t = 1,64 . 10^{-1} h^{-1}
T_t = 4,20 h
I
II
4
3,5
3
2,5
2
1,5
1
0,5
0
0 1 2 3 4 5 6 7 8
D en heures

Fig : 15

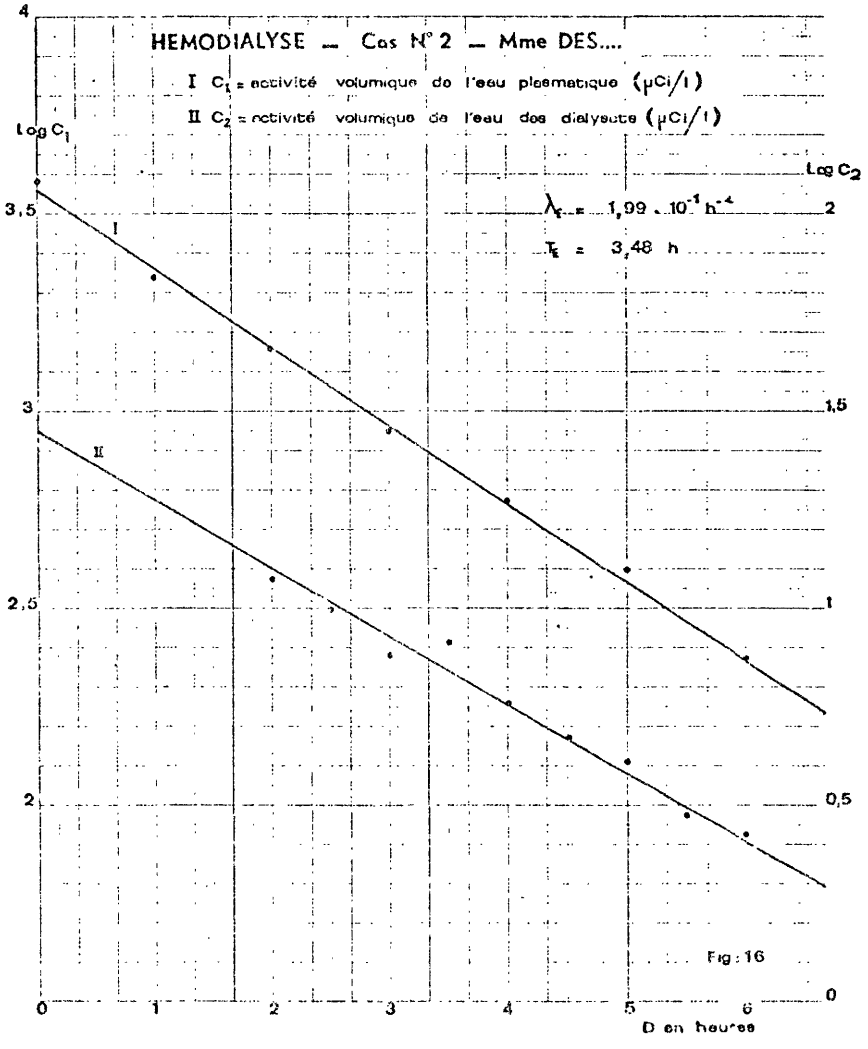

HEMODIALYSE — Cas N° 2 — Mme DES....
I C_1 = activité volumique de l'eau plasmatique (µCi/l)
II C_2 = activité volumique de l'eau des dialysats (µCi/l)
Log C_1
Log C_2
λ_E = 1,99 . 10^{-1} h^{-1}
T_E = 3,48 h
I
II
4
3,5
3
2,5
2
2
1,5
1
0,5
0
0
1
2
3
4
5
6
D en heures

Fig : 16

DISCUSSION

RAE (U.K.)

1. Is Mr Lafuma satisfied that all aspects of lung function are unaffected and remain unaffected by repeated lung lavage? In particular transfer factor to the resistance to infection.

2. Was there a wide range of reactions to lavage in the animals? Did any single animal show severe immediate reaction to the procedure?

Dr LAFUMA (France)

I have only mentioned four points in connection with lung functions, but we did in fact study some other points, including ion transfer factors, which return to normal in just under 48 hours. All the tests we carried out on the lungs indicated that all the lung functions studied returned to normal. As far as infection is concerned, we do use sterile material, although without taking extensive precautions, but we have never observed any infection in dogs. As for the animals' reactions, we have never noted severe reactions in any single animal following pulmonary lavage. Some of them were lavaged more than 15 times, once and sometimes twice a week, when we were trying to establish the best treatment schedule. The treatment appears to be tolerated very well. In any case, this type of treatment would only be used in cases where it is felt that the risk from contamination is high. Bearing this in mind, I think that the findings are very positively in favour of this method.

Dr FABRY (Belgium)

Can Dr Lafuma tell us whether his experiments have gone far enough, and if he has a hospital infrastructure capable of carrying out pulmonary lavage on human beings contaminated with radioactivity? In other words, if today he was informed of a case of lung contamination exceeding 10 µCi, would he give pulmonary lavage tomorrow?

Dr LAFUMA (France)

There is a hospital in Paris where pulmonary lavage has been performed on occasion, and we are currently developing an infrastructure for carrying out lavages in the case of an accident. If tomorrow you sent a subject contaminated with 40 or 50 µCi of plutonium-239, I think that a pulmonary lavage could be carried out with a good resuscitator and by a good lung surgeon.

Dr ECONELL (U.K.)

Could I ask Dr Lafuma one question and make one comment?

1. In what chemical and physical form were the radioactive materials administered to the animals before pulmonary lavage?

2. The comment refers to the treatment of ingested radioactive materials. Alginate has been shown to reduce the absorption of strontium-90 from the gut by a factor of 4. Potassium iodide and iodate can be used for treatment of thyroid irradiation by radioactive iodine, in severe acute cases, antithyroid drugs such as Thiouracil and Carbimazole would also be effective.

Dr LAFUMA (France)

The radioactive substance administered was plutonium-239 calcinated at a high temperature to make it completely insoluble. Solubility must be below one part per million. Alginate is extremely effective for oral absorption of strontium, but in the nuclear industry strontium contamination usually results from inhalation, followed by very rapid diffusion. Your point about iodine is correct, and we still use stable iodine, but this is not a new technique. I was asked to speak about recent findings, and I do not know of any new methods of thyroid decontamination following contamination with iodine.

Dr STOTT (U.K.)

I have three points to make.

Firstly I congratulate Dr Lafuma on his excellent work and also on his courage. During discussions in the U.K. on this subject none of our national experts could decide on a lung burden of insoluble α-emitters at which this treatment should be started. Lafuma has spoken of 10 μCi which is in fact almost 1000 maximum permissible lung burdens. I am sure he will agree that this is the sort of accident which hopefully is very rare. He also said that the treatment must not be started before 24 hours and should be started within four days. This means that there is little time to make accurate estimates of lung burden. So we have a situation where a rare type of accident must be dealt with quickly and the trouble is that unless hospital arrangements are frequently tested they fail to respond when needed.

Secondly, with lung lavage you can apparently remove 50% of the initial deposited activity. If you start at 1000 maximum permissible lung burdens you are then left with 500 maximum permissible lung burdens. Does he consider that DTPA therapy should also be given and if so, should it be given simultaneously or after the lavage.

Lastly, his experiments were conducted with healthy young monkeys. Does he think the response would be equally good in the typical worker we have in the U.K. - a middle-aged smoking bronchitic?

Dr LAFUMA (France)

It is effectively above 10 microcuries that treatment should be started. I should like to add that I think it would be quite unusual to actually obtain such a high lung burden with plutonium-239 oxide. The conditions of the accident would have to be very unusual for the lungs to absorb a mass of material representing 10 microcuries of radioactivity. On the other hand, our experience with plutonium-238, and plutonium-253 oxide in particular, indicates that this type of accident

could very well happen. The mass of material required is very small and the diffusibility of plutonium-238 is very high. And basically this method, if and when it is applied, will be used mainly in the case of contamination with plutonium-238 oxide. In such a case, with a completely insoluble oxide like the plutonium oxides, DTPA would add nothing to the decontamination effect. But with americium and curium oxides inhaled in the form of insoluble particles, we often observe extremely rapid solubilisation in the lungs and pulmonary lavage would therefore not be worthwhile. DTPA alone is much more effective. That is why it is important to check that the substance to be eliminated is insoluble before commencing treatment involving lung lavage; otherwise there is no point in doing the lavage. As for your comment on extrapolation from primates to workers, it is rather difficult to give you an answer on this, as we do have little opportunity to test the treatment on human beings. It is to be hoped that workers would respond at least as well as primates to lavage treatment.

Dr MIRC (France)

In the course of the discussion we have touched on one problem relating to iodine contamination which I do not quite understand. It is quite normal in nuclear medicine to block iodine metabolism not only in the thyroid gland but in all cells with an iodine metabolism, especially gastric cells, by ingestion of potassium perchlorate or injection of sodium thiocyanate (or sodium rhodanate). In view of this I do not see why the same method should not be used in cases of accidental iodine contamination.

Dr LAFUMA (France)

In nuclear medicine these products are administered before administration of iodine. It should be noted that administration of stable iodine by ingestion is very easy and effectively blocks the thyroid gland, which is the only problem from the point of view of protection.

Dr WIJKER (Netherlands)

Insoluble PuO_2 concentrates in the lymph nodes and gives a more concentrated irradiation there than spread in the lung. Is this incorporated in setting a value as indication for lavage?

Dr LAFUMA (France)

In the case of alpha emitters I spoke of activity levels, not rads - the figures represent levels of microcuries and nanocuries in the alveoli. Given the differences in dispersion, calculating in rads would be of little use. On the other hand, for beta emitters, which have a longer range, I have given the figures in rads because the energy of beta particles can vary very widely and it would be of little use to give values in terms of activity. That was why I mentioned the figure of 1,000 rads as the level above which lavage treatment may be considered for beta emitters. We cannot calculate in rads for alpha emitters.

Dr HEUSE (Belgium)

Your tests and measurements were on anuric subjects. With healthy subjects, where renal function is perfectly maintained with peritoneal dialysis, what effect will this diuresis have on the P.D.? (IP instillation of 2l of liquid will affect diuresis). In this case what relationship is there between the two types of purge (peritoneal and renal) in healthy androids? And is there any advantage in using the peritoneal technique with healthy subjects in preference to osmotic diuresis, which can be carried out without any special equipment, even that which is normally available?

Dr HENRI (France)

I do not think there would be the slightest interference between normal filtration by the kidneys and hemodialysis, I just think that normal kidney filtration is roughly 2,000 litres per minute and would therefore add to the filtration effect of the extra-renal method. I do not see why there should be any interference as long as the individual

eats or drinks,

Dr. RITZL (FRG)

What diseases or conditions would, in your opinion, represent a contra-indication for pulmonary lavage?

Dr LAFUMA (France)

I do not know . I think you would have to ask a specialist in pulmonary pathology; I admit that I have not thought about this.

Dr FARULLA (Italy)

At which level of contamination of the lung by insoluble beta emitters do you suggest to recommend pulmonary lavage; considering that the event of pulmonary fibrosis must reasonably be excluded?

Dr LAFUMA (France)

I gave the figure of 1,000 rads in a normal individual contaminated with a very pure beta emitter produced by fission and without any other additional toxicity. This is a basic figure, not an absolute value; it is the limit above which one can seriously consider the possibility of treatment by lung lavage. Obviously the figure would be lower in the case of radioactive substances in a form having a very high level of chemical toxicity.

FIFTH SESSION

MEDICAL SUPERVISION OF WORKERS EXPOSED TO CERTAIN ELECTROMAGNETIC RADIATIONS (LASERS, MICROWAVES) REPRESENTING RISKS SIMILAR TO THOSE FROM IONISING RADIATION

Chairman : Prof. FABER

BIOLOGICAL HAZARDS OF EXPOSURE TO MICROWAVE RADIATION

E.H. Grant

In this brief communication the facts concerning the effects of microwave radiation on biological tissue will be reviewed and interpreted in practical terms. Areas where controversy still exists will be discussed and mention will be made of some of the outstanding problems yet to be solved.

More than 15 years ago the maximum permissible recommended power level for microwave workers in the United Kingdom[1] was proposed as 10 $mW.cm.^{-2}$. This was in line with the American recommendation which was based on observations made [2] on rabbits that cataract could be produced by microwaves at power levels of about 100$mW.cm^{-2}$. Bearing in mind the possible errors in dosimetry and the fact that different species might react differently a figure of ten seemed to be an appropriate scaling factor for the purpose of producing a maximum permissible intensity for personnel working with microwaves. This figure of 10 $mW.\ cm^{-2}$ also appeared to be of the correct order of magnitude in that it is only about twice the amount of heat given out by the human body under normal conditions. A typical human has a surface area of about 2 square metres and loses heat at a rate of 100 watts, i.e. 5 $mW.\ cm^{-2}$. In the past few years the American Standard[3] for the emission of radiation from microwave ovens has been lowered to 1 $mW.cm^{-2}$ at 5 cm distance from the oven at the time of its sale and not more than 5 $mW.cm^{-2}$ during the working life of the oven. The maximum permitted levels in the USSR and other Eastern European countries are 10 - 100 times less than the American figures. The first comment which must be made is that it is necessary to distinguish between a microwave hazard and a microwave effect. Clearly there must be some <u>effect</u> when microwaves interact with a medium, whether it is an animal or a piece of inanimate material. Whether the effect constitutes a hazard depends very much on the circumstances and upon personal opinion. However it would be emphatically agreed that cataract is an undesirable effect and that the risk of its production in those exposed to microwaves must be reduced to negligible proportions. To date no cases of biological injury

have been observed in man which can be clearly and unambiguously attributed to microwaves at incident power levels of 10 $mW.cm^{-2}$ or below. As large numbers of military personnel have been under close medical surveillance[4] over a period of time longer than that during which cataract would be expected, this result is reassuring. At higher power levels lens opacities in humans due to microwaves have been reported[5], as have retinal lesions[6] due to microwaves of an unspecified power level. Also there are the well known cases of glassblowers cataract or furnace workers cataract which occurred in the days before protective goggles were mandatory. These latter cases of cataract were due to infra-red radiation but the low frequency end of the infra-red region merges into the high frequency end of the microwaves region; the basic difference between the opacities is that they occur more superficially in the lens for infra-red radiation.

At microwave power levels below 10 $mW.cm^{-2}$ various effects have been reported. For example mice exposed to microwaves of an incident power level of 0.5 $mW.cm^{-2}$ were affected in that the circadian rhythm of the mitotic index of the bone marrow cells was shown[7] to be significantly altered 24 hours and 48 hours after exposure. After three days a full recovery was observed, with no significant difference between the exposed animals and the controls. There is no reason to expect that similar effects would not be observed in man. At still lower power levels - even as low as 5 $\mu W.cm^{-2}$ - effects on isolated nerve and muscle fibres of the frog have been reported by Russian workers[8]. These effects include a slowed conduction of nerve impulses and an increased synaptic delay. At slightly higher power levels (30 $\mu W.cm^{-2}$) inactivation of the brain of cats and rabbits has been described[8] and in the same paper numerous effects on the central nervous system of animals are reported at incident power levels of between 1 - 10 $mW.cm^{-2}$. One must presume that these effects are reversible and therefore need not necessarily be designated a hazard. However, in the same publication it is claimed that irreversible damage to the reproductive system of mice can occur at exposures of 10 $mW.cm^{-2}$ and evidence is also advanced that lens opacities can be produced in rabbits my microwaves of power level 10 $mW.cm^{-2}$. Another relatively low-level effect, which has been reported by French workers[9], is the reduction in the sensitivity to paralysing drugs of rats irradiated with 3 GHz microwaves at an intensity of 5 $mW.cm^{-2}$.

The above facts taken together appear to indicate the possibility of contradiction between the conclusions arrived at by different workers in the field of the biological effects of microwaves. Of the various reasons that might be proposed to account for this, two are particularly worthy of consideration. They are the difficulty of measuring power levels accurately and the variation with frequency of the biological effect for a given incident power level. In other words it is only possible to make strict comparisons between two experiments concerned with the biological effects of microwaves if the frequency is the same and if the dosimetry is accurately controlled in both cases. Until such time as a small isotopic and wideband field sensor [1,10,11] is developed and the effect of geometry is understood[12] the errors associated with the measurement of incident power level at the surface of an animal are likely to be large. Given an accurate value of this power level a knowledge of the electrical permittivity and conductivity of the appropriate tissue (e.g. lens) is required to calculate the energy actually absorbed[13]. Although there is an understanding of the electrical properties of tissue below 1 - 2GHz it is necessary to make the corresponding measurements at frequencies higher than this, particularly as there is good reason to expect rapid changes with frequency of these electrical parameters as the frequency is increased[14]. Furthermore absorption of energy in the water immediately adjacent to the biological macromolecules (bound water)[14] will become increasingly important at the high frequency end of the microwave region, as will the possibility of resonance absorption[15]. Increased research effort in the areas of dosimetry and the electrical properties of tissue over a wide frequency range will help to resolve some of the apparent ambiguities and contradictions existing in the field of microwave biological effects and their associated hazards.

All references are to the International Symposium on Biologic Effects and Health Hazards of Microwave Radiation, Warsaw, October 1973, sponsored by the World Health Organisation, the U.S. Department of Health, Education and Welfare and The Scientific Council to the Minister of Health and Social Welfare, Poland. Proceedings are published by the Polish Medical Publishers, Warsaw, (1974). References to earlier work can be obtained by consulting this volume.

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(2) R.L. Carpenter, E.S. Ferri and G.J. Hagan, pp 178 - 185
(3) J.C. Villforth, pp XIII - XVI
(4) B. Appleton, p 330
(5) M.M. Zaret, pp 294 - 301
(6) B. Tengroth and E. Aurell, pp 302 - 305
(7) P. Czerski, E. Paprocka-Slonka, M. Sickierzynski and A. Stolarska, pp 67 - 74
(8) Z.V. Gordon, A.V. Roscin and M.S. Byckov, pp 22 - 35
(9) B. Servantie, G. Bertharion, R. Joly, A.M. Servantie, J. Etienne, P. Dreyfus and P. Escoubet, pp 36 - 45
(10) R.R. Bowman, pp 217 - 227
(11) R.C. Baird, pp 228 - 236
(12) D.E. Beischer and V.R.Reno, pp 254 - 259
(13) H.P. Schwan, pp 152 - 159
(14) E.H. Grant, pp 309 - 316
(15) K.H. Illinger, pp 160 - 172

BIOLOGICAL RISKS RESULTING FROM THE USE OF LASERS

L. Miro

Between 1960, when Maiman and Javan developed the first laser beam and 1967-1969, research has centred mainly on the principle of laser emission itself with a view to creating new types of laser and increasing the levels of power and energy emitted. Since then, while theoretical research continues in the laboratories of universities and large industrial firms, there is an increasing tendency for laser-based systems to be devised and put into use. At present, such systems are used in metrology, data banks, telecommunications, holography, machining, microelectronics, nuclear research and medicine, and this list is not exhaustive.

It is quite clear that in view of these applications, which are as numerous as they are varied, users have felt concerned about the dangers which might arise from such systems and during recent years we have seen many regulations of a more or less official nature introduced to deal with the use and installation of lasers. It is therefore useful, at a time when lasers are being developed for industrial use, to try to evaluate the risks involved.

The first feature of this problem is that it seems impossible to solve it without understanding the nature of laser radiation and the manner in which it reacts on tissues.

If we consider the history of its development, the laser, which is an acronym of "light amplification by stimulated emission of radiation", should be an amplifier of optical electromagnetic waves using a quantum process. In fact, "lasers" are basically generators of coherent electromagnetic radiation at optical frequencies. In "conventional" optics, a light source radiates in all directions in space and the waves associated with the different photons which make up this radiation have a variable phase. Besides, all photons do not necessarily have the same wavelength. On the other hand, with laser emission, the waves associated with the photons are all in phase, there is radiation

in only one given direction and all the photons have the same wavelength.

In brief, a laser beam is therefore an emission of electromagnetic waves coherent in space and time whose wavelength is in the visible infra-red or ultra-violet region.

There are different types of laser, classified according to their wavelength their energy or power and their mode of emission.

Some have a pulse length of 1 to 500 ms. They are said to be "relaxed". Others have even shorter pulse lengths of about 4 to 50 ns, which allows considerable instantaneous power of some 50 gigawatts or more to be reached. These are what the Americans call "Q Switched" lasers. In such cases it is usually the energy produced by the laser which is considered. Finally there are continuous wave(CW) lasers,which are classified according to the power of the laser during the exposure time. It should also be noted that pulsed lasers can operate at repeated intervals and that in that case account should be taken of the frequency with which the pulses are repeated and of the exposure time.

The biological effects of laser radiation are complex. There are in fact several processes by which the laser reacts on living matter: firstly, the thermal effect resulting from the absorption by that matter of the enormous amount of energy contained in the laser beam and from its local degradation into heat.

Because of the intrinsic properties of the laser beam - it does not scatter and can be focused - the energy which it carries can be concentrated by classical optical methods (mirrors, lenses, etc) on very small surfaces. The degree of heating which this produces is sufficient not merely to burn the tissues within a very limited area but very often literally to volatilize them.

This thermogenetic effect is normally considered overall, i.e., it burns all types of cells irradiated by the laser beam. However, the effect can be much more selective with only a definite type of cell or even a constituent substance of the cell being destroyed.

In fact, certain tissues or certain substances, because of their chemical composition, selectively absorb light on a given wavelength. Thus, most amino acids have an absorption peak at 280 nm; vitamin B12 shows three absorption peaks at 278, 361 and 550 nm; diphosphopyridine nucleotide (D.P.N.H.) selectively absorbs 260 and 340 nm. Therefore if a laser beam, whose wavelength corresponds to an absorption peak of one of these substances is used for irradiation, most of the energy will then be selectively absorbed by that substance. The result is the destruction or denaturation "in vivo" of one or other cellular constituent though this does not lead to the death of the cell. This selective effect has been experimentally established for Cytochrome B, which is one of the links in the oxidoreduction chain governing cellular respiration and which shows an absorption peak at 564 nm. It is the only link in that chain which fixes molecular hydrogen in the presence of oxygen. When a cell culture is irradiated with a 1 mW laser on a frequency of 530 nm, a reduction in the cellular respiration rate of more than 60% is noted. If the same culture is irradiated with a ruby laser (694.3 nm) or with a He Ne laser with a frequency of 632.8 nm, using the same power, no effect on the respiration is observed. In the former case histochemical studies show that only Cytochrome B is inhibited.

Another biological effect is determined by the electric field which accompanies the laser beam. Because of its spatial coherence, this field can reach considerable levels comparable to those of interatomic fields. It is therefore not surprising that it can affect the physical constants of the milieu it passes through, such as conductivity or the dielectric constant, or that it can upset the balance of certain chemical reactions and even reshape certain molecular systems.

At the very least, it alters membrane polarizations, thus disturbing ion exchange in the cells and giving rise to functional disorders of the tissues.

The laser also acts on living matter in a purely mechanical way, by producing shock waves at the place of impact, caused by the pressure of radiation which is considerable at that point.

These waves force back the cells by forming a definite crater or by directing the molecules in the direction of the laser beam.

Moreover, these shock waves give rise to very marked ultrasonic phenomena which, spreading into the surrounding milieu, can cause lesions in living tissue at some distance.

Finally, the laser shows effects never previously obtained in practice with non-coherent light: these are the non-linear effects.

Thus, with the laser beam, in certain conditions and in certain milieux, the wavelength of the beam itself can change : a red beam may produce a green beam which in its turn can produce an ultra-violet beam. While red is inactive from the biological point of view, ultra-violet, especially if emitted in these conditions, is very harmful to living cells. Moreover, these same non-linear effects can cause acoustic waves (Brillouin effect) which must be taken into account biologically, although our understanding of this phenomenon is still very imperfect. Finally we must not ignore the multiphoton effect, i.e., the ability of several photons to combine their energy. While with non-coherent light the chance of such an effect being produced is practically nil, it is considerably increased in coherent light, since it is a function of the 4th power of the electric field of the wave which, as we have seen,is of great intensity. Also, red laser photons can have an effect which is similar to that of blue, ultra-violet or even γ-ray photons.

We can see, therefore, that the action of lasers on living matter is complex. Depending on the type of apparatus used and especially on the modus operandi, one or other of these effects will predominate, although it will not be possible to isolate any one of them. This fact, combined with the fact that many of the effects described are still not clearly understood, justifies the caution we must use in estimating the risks arising from the use of lasers.

Since the laser emission is in the visible part of the spectrum, it was reasonable to assume that the eye would be the organ most at risk, and this has been experimentally established, making the eye the critical organ in this type of radiation.

If we are concerned simply with the lesions which lasers may cause to the eye, it is quite clear that the thermogenetic effect is of central importance. However, while it may seem easy a priori to establish treshold values of energy or power beyond which radiation would result in a lesion, it is in fact the case that the parameters involved, either physical (wavelength, mode of emission, length of exposure, power or energy emitted etc.) or physiological (focusing properties of the eye, condition of retinal circulation, degrees of pigmentation, diameter of the pupil etc.) are so numerous that the problem is very complex.

In fact, the standards at present in use were drawn up on the basis of the least favourable readings for these physiological parameters, since it is usually impossible to monitor or anticipate them because they vary from one subject to another and in the same subject from one moment to another. The diameter of the pupil can vary from 2 to 7 mm depending on the amount of light, so the standards were based on a pupil diameter of 7 mm. The standards therefore take the form of sets of tables which allow the risk in each case to be determined individually.

Basically, it is necessary to remember that ultra-violet and infra-red lasers, in particular CO_2 with a wavelength of 10.6 μ, are more dangerous for the cornea and the lens than for the retina, particularly since the beams are invisible to the eye and the intensity can be so low that the subject is not consciously aware of it. The most likely risk in that case is cataract formation.

On the other hand, lasers emitting in the visible band are extremely dangerous for the retina. In effect, the eye's dioptric system concentrates the almost parallel and very energetic beam of light which strikes it on a point situated on the retina with a diameter of between 10 and 200 μ. The increase in the density of energy registered is therefore about 10^5. Thus if the radiance of a laser beam is 5 mW cm^{-2} at the cornea, it reaches at least 500 W cm^{-2} in the retinal image. It is therefore easy to understand in these conditions that the pigmentary epithelium can be very rapidly destroyed, but only over a very small area. Since this epithelium cannot be regenerated, an optic hole results, a kind of blind spot, of which the subject is

not aware because of the areas of visual integration in the occipital cortex.

If there is only one lesion, the resulting visual damage will be negligible. On the other hand, if there are multiple lesions, the functional impairment will become progressively more serious, hence the increased danger of repeating pulsed lasers and CW lasers. In effect, there is a tendency for the eye, by its abrupt and unconscious movements, to present a different part of the retina several times per second to an incident beam, and multiple retinal lesions may therefore occur as a result of exposure to radiation from lasers of this type for a relatively long period of time.

Finally we have until now considered only lesions of thermal origin. However, it seems that repeated exposure of the eye to less intense low energy beams, subliminal from the thermal point of view, can eventually lead to permanent alterations in the physiology of the eye. In this connection, we should remember the selective effect of certain wavelengths on various chemical mediators and the existence of other physiological effects about which little is known at present.

The second organ affected by laser radiation is the skin, but since the skin has no automatic focusing system it is much less sensitive than the eye. The general problems - occurrence of lesions, their thermal origin, the possible effect of repeated low intensity exposures, safety standards - are the same as those which apply to exposure of the eye; the only difference is in the energy or power involved, since there are much higher energy thresholds for this type of lesion. Finally, it should not be forgotten that skin heals and that the short term consequences of a cutaneous lesion caused by a laser are less serious than those for an ocular lesion.

Safety standards have until now dealt only with the thresholds beyond which laser lesions could occur. However, in view of the wider use of lasers in metrology, in particular their use in aviation altimeter systems and in public may be affected by laser radiation. In such circumstances, the lesion threshold level is of secondary importance to the question of function. Let us take the example of someone driving his vehicle on a motorway and unexpectedly being struck in the eye by a laser beam from some surveying equipment. The destruction of a certain number of cones and rods in that person's retina becomes of secondary importance to the psychophysiological reaction which will result from

the impact of the laser, and the road accident which that reaction may cause. In effect, hospital emergency departments are quite familiar with accidents which happen as a result of the driver being dazzled, even momentarily. In such a case, it is necessary to establish not the lesion threshold but the dazzle threshold in order that safety limits may be determined before a given piece of apparatus is used in public.

In conclusion, it is clear that at present most permitted exposure levels are established on the basis of physiopathological data relating exclusively to thermal effect. In view of the knowledge currently at our disposal, it seems natural and even desirable to determine as quickly as possible lesional levels which are universally accepted, easy to apply and based on the hazards resulting from thermal effect. However, it is quite clear that such a table of permissible exposures will be incomplete since it will not take account of other physiopathological effects.

It is therefore essential to intensify the work being done to define these effects more precisely and to create a central body capable of coordinating research and collating results and so gradually supplementing our knowledge of the real hazard arising from a particular wavelength or from different aspects of laser radiation. In this way it would be possible to update the safety standards for laser apparatus, which would ensure an increasing degree of protection for workers and the public.

DISCUSSION

Dr WIJKER (Netherlands)

Are the resonance lines a consequence of the introduction of (thermal) quantisized vibrations in the molecules?

Dr GRANT (U.K.)

The answer to the question is yes. Those lines, in other words the resonance absorption, are due to the resonances between quantisized energy levels in the molecules with a frequency of about 10^{10} Hz.

Dr GIUBILEO (CEC)

Is it possible that the disturbance in the circadian rhythm of mitoses in the bone marrow is a secondary effect of neurohormonal disturbance? I should like to know whether any histological lesions have been observed in nerve cells.

Dr GRANT (U.K.)

Unfortunately I just can't answer that question, that particular branch of microwave effects is an area that I have not worked in myself, and I don't know much about. It was my intention to try to be as comprehensive as possible and to describe the work which has been carried out by various other people. So I was merely describing the results of the Polish work, but I am not competent enough, I am afraid, to give an interpretation.

Dr FABER (Denmark)

I think if I had to answer the question, I would say that any measurement of circadian rythm is to such an extent depending on the total state of the animal body, that some sort of central regulation must be involved.

Dr PELLERIN (France)

Could Dr Grant and Dr Miro give us their opinion as to the existence of biological damage thresholds for non-ionizing radiations, as suggested by the ICRP in Report No. 22 for ionizing radiations?

Dr GRANT (U.K.)

We have to discriminate between the thermal and the non-thermal effects. Regarding the thermal effects there must be a threshold for biological injury, which is more or less 10 mW/cm^2. But the non-thermal effects, such as the effect on the central nervous system, if these are clearly and unambiguously proved, then I suppose that there must also be a threshold which will be very difficult to evaluate and it would be considerably lower than the threshold for thermal effects.

Dr MIRO (France)

In reply to the question on thresholds for non-ionizing radiations, I agree in part with Dr Grant that we must make a distinction between the thermal effects of non-ionizing radiation, on the one hand, and the non-thermal effects on the other. As far as the thermal effects are concerned, I think that we now know roughly what we should aim at, and that the dose of 10 milliwatts per cm^2, which has been adopted by all western countries, is probably right - although we may have to adjust this figure, I think that roughly speaking it is the right one. However, as far as the non-thermal effects are concerned we are still completely in the dark because it is quite impossible to make exact measurements, as Dr Grant just pointed out. As soon as you put an animal in a microwave field you automatically alter the field. As all measurements at these energy levels are based on the effects of the electric field, your measurements will automatically be incorrect. Until we manage to solve this problem, we will be unable to solve the problem of dosimetry and safety standards relating to non-thermal effects. There is another phenomenon which also affects measurement. Living organisms, both animals and human beings, can divert ultrashort waves. We have actually carried out an experiment which involved taking a radiation emitter and placing a sheet of plastic underneath it, with neon tubes below that, so that when we put an animal on the plastic underneath it, with neon tubes below that, so that when we put an animal on the plastic sheet, we obtained waves reflected on the neon tubes. If we put two animals on the sheet, the reflected waves are displaced with the animals, but when the animals approach each other there is a certain moment even before the animals are touching, when the two reflected waves join to form one. In other words, the animals themselves will influence the field experienced by other animals. Our knowledge of these effects is still imperfect and it is clear that they are liable to affect the fields we are trying to measure.

Dr JAMMET (France)

Our approach to non-ionizing radiation should be based on what we have learnt so far about ionizing radiation. Radiation protection

has to do with lesions, not with non-injurious effects - we know that both types of radiation can have temporary, reversible neurological and opthalmological effects, but these do not constitute injuries and should not be taken into account when establishing safety standards.

Dr MIRO (France)

I agree entirely with Dr Jammet, on all but one point. There can be injurious effects which are unstable but nevertheless constitute an injury for the person concerned, even at low exposure levels. When Dr Grant said that there had not been any clinical experiments, he was obviously unaware of the work done in France at the time of the Algerian war, when there was de facto, unintentional experimentation on human beings. During the war, it was necessary to put a certain number of persons in very confined radar stations, and, for reasons of security, these men were obliged to stay inside the enclosure 24 hours a day. We compared these enclosures with identical ones without radar facilities and we found a difference, significant to 1 in a thousand, in the occurrence of neurovegetative phenomena of varying severity, but which in some cases led to loss of consciousness for several hours, so that the persons affected had to be hospitalized. When the patients arrived at the hospital in Constantine, no anomalies could be detected apart from some disturbance of ionograms and blood resistance. As soon as it is clear that phenomena can occur and can affect relationships between individuals - for there was a high level of psychological disturbance - we have a duty to take account of this, in sensitive subjects, and to protect them from such risks.

Dr PELLERIN (France)

In the most interesting example just given us by Professor Miro, was proper account taken of psychopathological symptoms, possibly linked with the extremely unusual conditions in which the soldiers had to work?

Dr GRANT (U.K.)

I would like to make a comment to the contribution of Dr Jammet. He said that there are a lot of similarities between the situation of

ionizing and non-ionizing radiation, but there is a very important difference: the quantum energy of ionizing radiation is about 10^9 times greater than the quantum energies due to microwaves and this is the reason of course that in the one case there is sufficient energy to cause ionization and in the other case there is not. The damage caused to the nuclides of the cells by ionizing radiation cannot occur with the microwaves because there is no sufficient quantum of energy. A question to Mr Miro about these experiments in the Algerian war. What power levels were these men exposed to?

Dr MIRO (France)

The power level was approximately 0.3 milliwatts per cm^2. On the other hand, the studies made after this discovery were carried out in French bases where the problem was completely different, as the persons concerned could return to their homes and were only exposed for a certain length of time during the day. However, for a number of bases with particularly high exposure levels, the information we obtained was identical. When we contacted one of our Russian colleagues, he confirmed that the same type of neurovegetative symptoms had been found there too in isolated bases. This indicates that, after all, workers must be present for a certain time or be exposed to a certain radiation intensity, before these phenomena can be observed.

Dr JAMMET (France)

A certain amount of information is available, particularly from the Soviet Union, on persons showing psychopathological symptoms after exposure to ionizing radiations. But what exactly is the situation for persons exposed to radar radiation 24 hours a day? No doubt they must be exposed to high-energy doses. When a person is exposed to high doses of ionizing radiation to the whole body, he or she will, first of all, be affected by nausea and vomiting. In this case the body is subjected to ionization, whereas with non-ionizing radiations, it is exposed to thermal stress. However, in the case of non-ionizing radiations, the energy levels are extremely low and it is unlikely that they could cause significant phenomena. No electromagnetic radiation, ionizing or otherwise, can give rise to these symptoms when the energy levels in-

volved are very low. I am not suggesting that there are no effects on the nervous system and the eye, but that these effects are not injurious and should be considered as negligible.

Dr RECHT (CEC)

This is an example of the caution with which we should approach and interpret scientific information. What concerns us here is the interpretation of this information in terms of public health. We may consider that any anomaly which can be detected at the level of cell cultures or at the psychosomatic or enzymatic level can have repercussions in certain sectors of the environment, but we should not then conclude that these repercussions are "per se" evidence of adverse effects.

NATURE OF MEDICAL EXAMINATIONS OF PERSONS WORKING WITH LASER BEAMS

Dr Renz (FRG)

Wherever people are exposed to particular health hazards in connection with their occupations, industrial medical precautions must be taken.

This principle also applies to the use of laser beams, a branch of modern technology which is still in the process of development.

Lasers are sources of intense, sharply focused radiation in the visible band or the invisible infra-red or ultra-violet regions of the spectrum. In the previous lecture Professor Miro gave a full account of the biological hazards. But it should be noted that the effect produced by lasers, if one discounts extremely brief and highly intensive irradiation, is mainly one of heat. In short, laser injuries are usually localised burns.

The main danger caused by laser beams is to the eyes. One must distinguish between radiation capable of penetrating the eye and radiation which is absorbed in the outer layers of the cornea. The eye refractors are pervious to light whose wavelength lies between 400 and 1 400 nm, i.e. to visible laser light and radiation in the near infra-red region.

Because of the special physical properties of laser radiation, the beam which was already well focused can be extremely sharply focused on the retina. The size of the retinal image is limited only by defraction. In extreme cases, the intensity of the beam may thus be increased more than a hundred thousand fold. The eyeground may therefore be injured by radiation of relatively low intensity.

Injury to the eyeground and especially to the retina may range, according to radiation intensity, from very slight damage to limited groups of cells to rare cases of devastation of portions of the eye. Laser injuries to the eyeground are mainly limited burns on the retina which later cicatrize.

An injury of this type was reported by Florian and Laue. Dr Florian was kind enough to provide me with the slide which I am about to show.

This is a photograph of the eyeground with a limited burn centrally located in the region of maximum visual acuity. It was calculated that this injury was caused by radiation of not more than 40 m-Joule from a ruby laser. The visual power of 5/4 which was known from earlier examination, was reduced as a result of the accident to 5/20.

Damage to the retina caused by burning is usually irreversible. Where the retina is scarred, it no longer performs any optical function.

In the vicinity of the macula or the optic nerve even minor burns cause permanent impairment of vision.

Less severe, peripherally located injuries usually have no subjective effect on the victim. It is thus quite possible for such peripheral damage to the retina not to be detected until a routine eye test is carried out.

In one accident in which the point of impingement was outside the fovea the objective result observed was a limited scotoma. The subjective effect of focussing the damaged eye with the undamaged eye closed was a minor blank spot.

Such damage to the retina can only be caused by laser beams whose wavelength lies between 400 and 1 400 nm. Damage caused by the use of lasers whose radiation in the infra-red or ultra-violet band of the spectrum lies outside this range, are to be regarded as injuries to the cornea of the anterior segments of the eye, and to the skin in general. As in this case the beam is not focused by the eye, the radiation intensity required for damage to the cornea or to the skin in general is greater by many factors of ten than that which may cause injury to the retina.

The main critical organ is thus the eye, especially in cases where radiation penetrates the eye. Precautionary examinations of persons who work with lasers are therefore primarily eye tests.

There are many national and supranational laser safety rules or draft rules regarding medical surveillance e.g.

American national standard for the safe use of lasers of 1973 ANSI Z 136.1

Guide on protection of personnel against hazards from laser radiation: British Standards Institution BS 4803 : 1972

European List of Occupational Diseases: Appendix II - C 3b Lasers

Draft Recommendation by the Commission of the European Communities to Member States on protection of individuals against the hazards arising from laser radiation.

Trade Association principles for industrial medical examinations of persons exposed to hazards arising from laser radiation, which were published in 1973 in the Federal Republic of Germany.

At a recent meeting in Dublin the World Health Organization also produced a significant report which based its approach to medical examinations on the ANSI.

Most of these standards prescribe examinations if there is a possibility of injury through working with laser beams. In the American standard the comprehensiveness of the examination depends on the degree of risk.

It is generally agreed that personnel should undergo a pre-employment examination before starting to work in the vicinity of lasers. During a worker's employment routine examinations for purposes of surveillance are conducted at regular intervals. It is usually recommended that examinations be carried out once a year. Many standards state that the intervals between examinations are to be determined by the medical officer responsible taking into account the degree of hazard involved in each case. In certain circumstances an examination may be required ahead of schedule e.g. in cases of severe eye affection or of unacceptable known or suspected exposure to lasers.

It is recommended that a final examination be carried out when a worker ceases to be employed in the field.

The main purpose of pre-employment examinations is to screen out persons who already suffer from significant impairment of one eye. It must be decided in the light of the impairment observed whether the risk of further damage as a result of a laser accident is acceptable. One of the principal aims of subsequent examinations is the detection of any laser injury, especially to the eyeground. As I have already mentioned, laser injury to the peripheral region of the retina need to necessarily be detected by the worker.

As an example we may take the following case, of which I can show you a slide.

The picture shows a number of small grey-black pigmented foci of a quilling seam pattern. These were detected by Laue and Florian during the routine examination of a worker employed in the vicinity of a laser. They were identified as burns from a ruby laser operating at a frequency of 50 Hz.

The following specific tests are always necessary:

Prior scrutiny of the family, individual and occupational anamnesis;

Determination of the visual acuity of each eye, i.e. vision without corrective glasses and where necessary with corrective glasses;

Test of colour vision;

Inspection of anterior segments;

Examination of refractors;

Examination of the eyeground by means of pupil dilation.

Other tests - some of which are carried out only if there are special grounds for doing so - are as follows :

Test of field of vision;

Test of foveal vision with Amsler grating;

Test of colour vision by means of an anomaloscope;

Measurement of intra-ocular pressure;

Examination of binocular visualization, i.e. binocular near and far vision.

Careful recording of data is important in these examinations, especially in the examination of the refractors, and above all the eyeground. In order to identify a possible laser injury it is important to describe even small deviations from the normal condition and to determine their location carefully.

The American standard stipulates that in the case of persons exposed to particularly high risk photographs should be taken of the eyeground in the vicinity of the macula and the point of entry of the optic nerve. The study group which drew up the Trade Association principles for industrial medical examinations in the Federal Republic of Germany argues that this comparatively costly method of examination should be used only when there are special grounds. Thus far both views are in agreement.

The Trade Association principles are based on the assumption that standard examinations must be capable of being carried out by any ophthalmologist with normal ophthalmological apparatus.

The opinion on criteria of suitability for employment given below is that of the German study group which drafted the Trade Association principles for industrial medical examinations. Measurement of visual power i.e. vision without corrective glasses, and visual acuity i.e. vision with corrective glasses is of particular importance in determining suitability for employment in laser work. Visual acuity i.e. vision with corrective glasses must be at least 0.5 or 5/10 in both eyes. Reduction of visual acuity to below this level as a result of laser injury must be prevented.

The study group also feels that binocular visualization must be examined.

Binocular vision must be sufficiently good to provide normal stereoscopic vision.

Tests of colour vision are of particular importance when the person in question works with lasers whose radiation lies in the visible band.

Such a worker may be exposed to a greater risk of disturbance of colour vision as a result of working with certain lasers. It may also be possible to detect secondary disturbances of colourvision resulting from the effects of lasers.

Examinations of the anterior segments and the refractors and of the retina by pupil dilation make it possible to detect anatomical changes. Pathological changes which may be exacerbated by working with lasers may be grounds for excluding a worker from this employment.

As a general rule persons exhibiting acute, chronic and progressive pathological changes of the eyes, which are already causing or may give rise to decisive impairment of the visual apparatus should be excluded from working with lasers.

Recording of data is particularly important in detecting anatomical changes. The symptoms by which laser damage is recognised may be entirely atypical. Cataract, for example, or scarring and changes in the retinal pigment, which have nothing to do with laser effects, are known to be frequent occurrences. Much greater importance therefore attaches to records of medical data as a means of anticipating accidents and giving advisory opinions.

In routine examinations particular attention will be paid to alterations in the data observed both to detect any laser effects, and to clear personnel for continued work in the field.

The skin may be regarded as the second critical organ, in addition to the eyes. While the risk of laser-induced skin burns does not compare with that of eye damage, caution is called for in certain cases. If changes have already taken place in the skin, the effects of lasers may lead to additional inadmissible damage. The following are examples

of such changes :

prior damage to the skin by ultra-violet radiation, x-rays, toxic substances e.g. arsenic;

pre-cancerous cutaneous diseases;

semi-malignant and malignant tumours in skin damaged by ultra-violet radiation, x-rays or arsenic.

In cases of acute and chronic dermatosis work in the vicinity of lasers is not advisable.

The American standard, the paper of the World Health Organization and the discussion of lasers in the European List of Occupational Diseases therefore recommend a skin examination. This is also being considered at present in the Federal Republic of Germany. It is certainly reasonable, however, to restrict such examinations to personnel working with high-intensity lasers.

It should however be borne in mind that irradiation of the skin by lasers operating in the visible and infra-red bands is not nearly as important from the biological point of view as overexposure of the eyes. Unlike eye injuries, injuries to the epidermis can usually be healed or reversed. The effects may vary from slight reddening to blistering, depigmentation, ulceration with scarring of the skin and in extreme cases even damage to the organs beneath, though only when the laser radiation is at an extremely high energy level.

When working with ultra-violet lasers consideration must, however, be given to the well-known carcinogenicity of ultra-violet radiation.

In this connection, mention must be made of the 1973 study of the carcinogenic effects of visible ruby laser light by Ehlers and Florian. They had exposed mice to radiation from a xenon flash-light lamp and a ruby laser. It is clear from the study that the histological and quantitative histochemical results available even from prolonged experiments on animals give no indication of a carcinogenic effect of ruby laser light.

DISCUSSION

Dr HILL (U.K.)

In the U.K.A.E.A. codes of practice we require initial and final retinal examination but we do not require annual examination for the following reasons.

1. No successful treatment is available for any burns seen.
2. It is not an accurate method of monitoring the safety of laser operations.

If the accuracy of examination is to be increased we would require to use unacceptable methods such as fluorescein angiography.

Dr JOLIVET (CEC)

The last speaker referred to the European List of Occupational Diseases, but occupational disorders liable to be caused by laser radiation are not in fact included in this list. They have been put on a waiting list - the Member States have been invited to examine the possibility of including them in the list proper, and to compare and discuss all the information available on these diseases, with a view to improving treatment of victims. An explanatory memorandum has been drafted for this purpose by a team of Community experts, and it was no doubt this document to which Dr Renz was referring in his paper. There are two topics that were not touched on in Dr Renz's talk, probably owing to lack of time. These concern the protection of workers - the matter of protective goggles or spectacles, and the cladding of work premises. This is outside the scope of today's symposium, but it is a field where there is much to discuss and a possible subject for future research. It might perhaps be a good idea to discuss these two points at another conference dealing specifically with this topic.

Dr VIGAN (CEC)

With regard to the hazards created by lasers, which are due to direct beams and which are caused by reflected radiation? Is reflected radiation as harmful as the direct beam? Is there not some kind of absorption which makes the reflected laser less harmful? As for taking photographs of the back of the eye, I think this is important from the medico-legal point of view, as in the event of an accident where the victim claims damages, it could be used as evidence and compared with earlier photographs.

Dr RENZ (FRG)

First of all I should like to reply to Dr Hill of Great Britain. Of course it is true that there are one or two things one could say about routine examinations. Obviously you have had some unfortunate experiences with them. Of course the frequency of routine examinations should not be the same for all cases. It must depend on the degree of risk, and perhaps also on any damage already observed in one of the eyes of the person concerned. At the same time, it should be acknowledged that routine examinations are not completely useless. In certain cases, as in the slide I showed, they can in fact indicate real laser lesions, though of course not all laser damage, particularly if this is beyond the pigmentation of the eyeground. But some laser damage is peripheral and is not observed subjectively, except when several parts of the back of the eye are damaged. Then there may, in some circumstances, be a sudden loss in the field of vision. The other point is that over a certain time, say after 10 years of work with lasers, the eye can be affected by certain disorders and the risk involved ceases to be tolerable.

As for the second question - yes, I was referring to the annex to the list of occupational diseases; I did not know whether this paper had been finally adopted or not.

In reply to Dr Vigan, I would say that of course we should only photograph the back of the eye when there is reason for concern, or when there is an immediate requirement for some kind of documentation.

Photographing the eyeground, especially taking photographs of several areas, is far from pleasant for the patient. In our opinion it should definitely not be included in routine examinations.

Dr STOTT (U.K.)

May I first put a point of information. I understood that, contrary to what Dr Renz has stated, the recent WHO meeting decided that routine medical surveillance was not necessary but that epidemiological research was needed involving periodic eye examination of some groups of workers.

This leads me to my second point. Yesterday someone made what is to me the most profound remark of this meeting. He said that in respect of ionizing radiations we have become the "prisoners of history". He meant that although we are beginning to doubt the value of some of the medical procedures which have become customary, for many reasons, some of them political, it is almost impossible to depart from them.

We should be very careful that we do not create a similar trap with regard to non-ionizing radiation. I would ask the Community to sponsor special studies of selected groups of workers to devise meaningful information before formulating rigid directives and legislation.

Dr MIRO (France)

I should like to make one comment and ask Dr Renz one question. First of all, the comment. I think that it is far more important, from the workers' point of view, to protect them by individual and collective safety means, than to give them routine checks with more or less complicated and numerous examinations. Setting up controlled areas subject to certain standards, and making workers wear spectacles or goggles would, I think, guarantee workers more safety than would medical surveillance, although this should only be reduced, not done away with entirely.

Secondly, I should like to ask Dr Renz to tell us what are the

physiopathological reasons for carrying out systematic examination of colour vision in workers using lasers.

Dr RENZ (FRG)

To reply to Dr Stott's comment - I was not present at the WHO meeting in Dublin, I only saw one of the documents from the meeting, and that was based entirely on the American standard which stipulates very detailed examinations. I am aware that the use of routine examinations was questioned at this WHO meeting, but I also have the impression from some participants that the problem has not yet been fully discussed. I expect Dr Miro will be able to confirm this. As for the other point mentioned by Dr Miro, the protection of the individual, I too feel that this should be foremost. I would have preferred to speak on protection methods in work with lasers, as I know rather more about that than eye examinations. But the subject I was given by the European Commission was, "The nature of medical examination of persons working with non-ionizing radiations". Dr Miro also asked about the significance of colour vision tests. Certainly there is some doubt as to whether these help to show up laser effects, but time and again it has been noted that colour vision is comparatively easy to test and can provide some indication of an additional hazard, for example when the work involves lasers which give off green or red light, and there is corresponding colour blindness. The person concerned must then take special care.

Dr FABER (Denmark)

If I may answer the question to the problem on the colourvision I understand that you can have laser lesions, which only would hit one of the types of colourvision and that with more careful study you are able to recognize these lesions and find their presence after a laser accident. But this is very much a specialist's job, which creates a very heavy piece of work and for this reason I was very doubtful whether there really is a reasonable balance between work and results.

Dr JAMMET (France)

In reply to a comment made here to the effect that the safety standard for ionizing radiation had led us into a trap, I should like to say that on the contrary, I believe that the system of ICRP standards has helped to make the nuclear industry one of the safest there is. We should follow this example when it comes to devising standards for non-ionizing radiation.

ADDRESS BY DR. E. MASTROMATTEO

Representative of the International Labour Office

First of all I should like to express my thanks to Dr Recht for his invitation to attend this meeting. I am attending as an observer from the Occupational Safety and Health Branch of the ILO in Geneva and I am grateful for the opportunity given to speak. Since its formation in 1919 the ILO has been concerned about occupational safety and health. The ILO has attempted to harmonize occupational safety and health protection by means of international conventions, recommendations, codes of practice and guides.

In Canada I worked in Toronto with the Ministry of Health. I had some experience as provincial health authority for two nuclear power plants. In Ontario there was provincial control of all users of X-ray equipments and there are about 40 000 radiation workers regularly monitored. The monitoring data have consistently shown that only about 1 worker in 1000 exceeds 5 rem/year.

I have followed the discussion of yesterday and today with great interest. I appreciate the opportunity given to me - to speak on the issues raised.

Radiation hazards are real; control and medical supervision are needed. The hazards from radiation, however should be handled in the same way as many other hazardous work exposures. Controls should be realistic and should not impose unnecessary administrative burdens on

the user or serve to exaggerate the hazard.
Now turning to the points raised here in discussion.

Radiation Workers

I feel that there should be only 2 classes of workers in terms of radiation work :

1. Radiation Workers
2. Non Radiation Workers

I am not convinced of the need on a health basis to make a subdivision into 2 categories for workers in radiation exposure. Once a radiation worker has been defined, the same requirements for control and medical supervision should apply. The medical supervision should follow the same general approach to that for industrial workers exposed to hazardous agents in the work environment.

Qualification of Physician for Medical Supervision of Radiation Workers

In regard to the qualification of physicians for medical supervision of radiation workers, I feel that a medical doctor with training in occupational medicine and in radiological health could be considered as a basic qualification. Physicians having equivalent experience should also be considered to have qualification in this field. Physicians trained in nuclear medicine or in radiology with suitable experience in occupational health would, of course, also be well qualified in this field.

Form of the Medical Supervision

I stated earlier that the medical supervision should follow the same general principles as that of industrial workers exposed to other hazardous agents.

I agree with the statements made that there are few medical contra-indications to work in radiation exposure. I agree also that periodic medical examinations have low yield in terms of detecting the effects of radiation exposure in the worker.

Nevertheless I feel that we are stuck with both pre-employment, and periodic examinations for radiation workers. In some places, however, there is a strong trend to the use of ancillary health personnel, for example, the nurse in carrying out these health assessments and this could certainly be explored for radiation workers. There is another aspect in medical supervision referred to by participants here as the open door policy. Radiation workers should be encouraged to visit the medical officer whenever they have personal health questions whether relative to radiation exposure or not.

Another point relates to return to work after illness.

Radiation workers with short term absences could return to their regular work without too much formality; workers with long term absences should be asked to produce a medical certificate stating their fitness to return to radiation work. This worker should be seen in the plant medical centre before return to radiation work.

Latter two points may be more productive than annual periodic exams.

Maintenance Workers in the Nuclear Power Industry

The question of maintenance workers received much discussion yesterday. May I give my own personal impression on this question. If outside workers are used they should not be used to dilute the individual exposure dose because of improper design or improper operation of nuclear reactors. In principle I am against increasing the exposure base until we have more information on the dose response effects of low dose levels over long period of time. In addition, if outside workers are brought in for maintenance work in radiation exposure they should be subjected to the same control and medical supervision.

Medical and Exposure Records

I support the need for adequate records of health and exposure data for radiation workers. I am sure that the trend will be to simplified computerised systems and it is intriguing to consider typing

in radiation data with all other medical and occupational exposure data. I also support the need for confidentiality in any record keeping and dissemination system.

We have a good exposé of the system used in France. My own impression is that this system is quite detailed; a more simplified system, again involving the use of ancillary personnel, may be considered. The French system, however, provides a good basis for further discussion on medical and exposure records.

Medical Emergencies

Doctors in nuclear power stations should of course have emergency procedure prepared in advance should there be accidental overexposure of workers. While outside the theme of this symposium, the physician should also be involved in emergency plans covering accidents involving off-station exposures to the general public. This is a question actively discussed in Toronto where a large nuclear power station was built within 25 miles of the centre of the city with a population of 3 million people.

Tripartite Interests

As you all know the ILO is a tripartite organization with representatives of government, workers and employers.

Yesterday there were statements that management should designate radiation workers on the basis of medical advice available to management. I agree with this. The decision should not, however, be a unilateral one. This decision should be subject to overview by a government health authority who would also review the medical supervision, radiation control, record keeping and emergency planning. I am sure that this is the case in each country.

On this general area I would like to make one final point. Occupational safety and health questions are now occupying attention by labour unions. Recently I attended a meeting of an international union called to discuss occupational safety and health. Based on this meeting

I believe that occupational physicians can expect more activity by organized labour in the following fields - all pertinent to radiological health :

1. critical questioning of exposure limits for workers
2. change in philosophy that present agents in the work environment are safe until proven harmful to the philosophy of being harmful until proven safe
3. increased concern especially for agents which cause cancer
4. increasing pressure by organized labour to have OSH matters as matters for collective bargaining

I am sure that there will be increased emphasis of all medical supervision of workers exposed to hazardous agents at their work. Occupational physicians will have to respond to this in the most efficient manner possible. Medical supervision and control of radiation exposure involve multidisciplinary team action and the physician has a key role to play. I am sure this symposium will help to aim these viewpoints and to harmonize them in the European Community.

ADDRESS BY DR A. LAFONTAINE

Representative of the European Office of the World Health Organization

The World Health Organization asked me to act as its representative at this symposium organized by the Health Protection Directorate of the Commission of the European Communities and devoted to the medical supervision of workers exposed to ionizing and non-ionizing radiations.

On behalf of Dr Kaprio, Director of the Regional Office of WHO, I should like to emphasize the great interest which WHO takes in Euratom's efforts to protect the population and workers against the risks of ionizing and non-ionizing radiations, and I must first congratulate the organizers and thank the participants for their cooperation.

This symposium has been particularly interesting. Not only has it provided information on the conditions, organization and effectiveness

of the medical supervision of workers and considered the as yet little-explored subject of non-ionizing radiations, but at the same time it has also enabled us to compare rather different points of view, pin-point gaps in our knowledge and map out new fields for study.

I should like to point out once again that health as understood by the World Health Organization is not only the absence of sickness or infirmity, but the state of complete physical, mental and social well-being. It is the concern of both the individual and the species, in other words it applies to all persons whoever they may be, to successive generations and to environmental conditions.

My colleague representing the International Labour Organization has already expressed his views with great clarity; I can only endorse them by emphasizing the danger of setting up artificial classifications in the field of health protection and of confusing the organization of supervision with its objectives.

Protection must be extended to all exposed workers, no matter where they may perform tasks entailing a risk of irradiation. To concentrate this protection on the nuclear industry would be to neglect the persons most at risk. Furthermore, it is unthinkable that the doctors responsible for such supervision should not at the same time concern themselves with the risks for the population at large, if only on account of possible genetic repercussions; hence the necessity to avoid subtle distinctions.

To be effective, supervision also requires a multidisciplinary approach, but a multidisciplinary team must be directed by the doctor, who is the only person capable of systematically evaluating health hazards both at the individual and group level, taking into account both the absorbed doses and the other risks of chemical and physical origin, as well as various anamnestic data. Hence the doctor must be completely familiar with working conditions and the nature of the hazards, and must take action as necessary to ensure that the protective measures adopted are appropriate for both the workers and the environment. Furthermore, it seems perfectly logical to us that a

physician specializing in radiological protection should both exercise supervision under normal conditions and be ready to act as effectively as possible in the event of accidents involving any persons - workers or others - exposed to a high level of radiation.

I have regretted to hear some doctors complaining of the restrictions imposed by the numerous regulations and standards that have been issued. In my view, the protective measures relating to ionizing radiations are amongst the most realistic and effective in existence. I can only hope that the same approach will be adopted with respect to the non-ionizing radiations referred to during this symposium, which are currently a matter of concern for the European Office of the WHO; above all, I hope that from the outset, the problems of the protection of man and his environment will be considered concurrently with the technical aspects of research projects to develop new sources of energy.

If some of my comments have been rather forthright, this is precisely because the exchange of views was so specific, realistic and constructive. I trust that these suggestions help to improve the medical supervision of workers exposed to ionizing or non-ionizing radiations, and hope, finally, that fundamental research will clarify certain obscure points, such as whether there is or is not a threshold value for certain mutagenic and carcinogenic effects.

I am convinced that the Commission of the European Communities will be able to play an active part in such studies, and shall close this address by expressing the wish that they will go forward rapidly.

Dr RECHT (CEC)

Yesterday I had an opportunity to make a few comments which would have been equally appropriate to the conclusion to today's session. Allow me to go over them again, very rapidly, from another angle.

The title of this colloquium was in two parts, one administrative and one scientific. What is the precise scope of the first part? The medical supervision of workers exposed to radiation currently affects more than 250,000 persons in the nine countries of the Community. The nuclear power sector, which is well represented at the colloquium, only employs a fifth of the exposed workers and the other 4/5 do not at present seem to be as well covered by medical surveillance. It is our duty to try and harmonize arrangements for the application of the standards in a progressive way. We must concern ourselves, then, with all types of work involving exposure to radiation, be they medical, industrial or research activities. Our discussion has made it clear that medical supervision must originate with the doctor, but the role of the works doctor in industry is seen differently in certain Community countries. In some countries there is a very real staff problem. Works doctors should take an interest in the work done and fulfil all the functions laid down in international ILO and Commission agreements. In other countries, the doctor's role is not nearly as wide. We cannot take the attitude that medical intervention is only required for exposure levels of 25 rem and more, as is sometimes the case in the USA. If this were so, the doctor's task would be a summary one, or he would only be consulted very rarely. The situation of the medical officer in industry is a general problem calling for a great deal of attention. It would be unacceptable if the organization of medical surveillance in the nuclear industry were not subject to the principles and rules of occupational medicine and were treated differently from other industrial activities involving risks for workers, and we will try to harmonize systems of occupational medicine in a progressive way. We attach particular importance to the need for the principles and methods of occupational medicine to be applied in all activities involving exposure to radiation.

This symposium has been most useful; guidelines have been clarified and points have been made which we may be able to incorporate in the finalization

of the Basic Safety Standards. There is no doubt that radiation protection is based on multi-disciplinary teamwork, in which the doctor must play an active and efficient role. It is important for all the data relating to each worker's health to be examined and assessed at some point by the person whose prime responsibility is health.

Because of the key importance of nuclear power in public opinion and in that of workers, we intend to hold a conference in 1975 or 1976 on the psychological aspects of medical supervision and the role of the doctor vis-à-vis the worker. The responsibility of the doctor will be all the greater, for when a worker is worried he will turn to the doctor, not to his employer, in the hope that the former will give an objective opinion as to the risks of his work. The works doctor must have a certain freedom from the economic constraints that dominate business considerations.

The problem of classification of A and B workers has been very widely discussed. The Basic Standards stipulate that there should be a distinction, but this should be within the meaning of the ICRP recommendations - to simplify administrative procedures, a distinction is made between two classes of workers, and classification must be effected with precision and maximum certainty. The evaluation of doses for these two categories must be carried out with the minimum of error. It is a "problem of evaluating the risk" and the idea of workers being "liable to" receive a certain dose is perhaps the central one. This idea of being "liable to" receive certain doses is applicable within the limits set out by the ICRP in publication 9, for controlled sources of radiation. Conditions indicate that accidents may occur with these sources and some abnormal single exposures of some 10 rem are foreseen. Under normal circumstances work with a radiation source can lead to some accidents calling for intervention by maintenance personnel, or rescue or repair workers.

As for the other problems discussed at this symposium, we have heard some fascinating papers, and it is clear that our researchers are at the forefront of research on certain measurement and decontamination techniques. The subject of lasers is one which we have approached with caution, since the

Commission is intending to submit recommendations, not directives. This is a new field of science and the advice we have received today, to approach the matter with caution, has been noted and will be incorporated in the proposal for a recommendation.

The proceedings of this colloquium will be published as soon as possible. I should like to thank all the speakers and everyone who has taken part in the discussion and declare the colloquium on the medical supervision of workers closed.

F a b e r (Denmark)

Before we close the meeting finally we have to thank Dr. Recht for arranging this symposium, which has given us a very interesting outlook on the problems of the medical survey of the radiation workers. The meeting has brought us information about a large number of problems with which we are not quite in agreement; it has given us information on a number of things which we have to think over and it has given us some information about what the Commission is doing at present. All of these things are more than sufficient to have filled the two days. We are all happy to have been here and to have had this opportunity of discussion. I think many others want to continue the discussion of the medical survey of the workers and I hope this will be possible. We thank Dr Recht and his assistants for the work they have done in getting us together here and by these words I think I will close the session for today.

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