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WORKSHOP ON TRITIUM SAFETY AND ENVIRONMENTAL EFFECTS, OCTOBER 15-17, 1990, AIKEN, SOUTH CAROLINA: SESSION SUMMARIES (U)

Charles E. Murphy Jr.
Editor

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ABSTRACT

Tritium management is an important aspect of safety for fusion and fission energy systems. While the fundamentals of tritium health physics and environmental transport are reasonably well understood, there are still some circumstances where a better understanding of tritium behavior would be desirable. Consideration of cost efficiency suggest that it is in the interest of the entire nuclear fusion and fission industry to cooperate in advancing the state of knowledge of tritium safety.

A meeting was held on October 15, 16, and 17, 1990 to discuss the state of tritium safety and environmental effects. The meeting was organized with the help of the International Energy Agency planning committee consisting of K. Steinmetz, Y. Seki, G. Nardella, and G. Vivian. Representative of tritium production facilities and heavy water reactor power production were also involved. The meeting was organized to address seven topics in tritium safety that were thought to require further work. The topics were: 1) materials science, 2) environmental models, 3) environmental model validation, 4) tritiated organic compounds, 5) human dosimetry, 6) tritium sampling and measurement, and 7) long-term environmental databases.

The meeting was held at The Houndslake Country Club in Aiken, S.C. Thirty-eight papers were presented by the participants. In addition, group discussions were held during the evenings. A summary of the sessions and the group discussions was prepared by the chairmen and is the primary subject of this report.

CONTENTS

LIST OF TABLES

INTRODUCTION

Tritium management is an important aspect of safety for fusion and fission energy systems. While the fundamentals of tritium health physics and environmental transport are reasonably well understood, there are still some circumstances where a better understanding of tritium behavior would be desirable. Consideration of cost efficiency suggest that it is in the interest of the entire nuclear fusion and fission industry to cooperate in advancing the state of knowledge of tritium safety.

During 1986 and 1987, tritium release experiments were organized in France and Canada to provide additional information about one specific area, the behavior of tritiated hydrogen (HT) in the environment following an atmospheric release. These tritium release experiments were followed by workshops in Saclay and Cadarache, France. The primary goal of these workshops was to share the results of experiments carried out during the releases and work towards a consensus in interpretation of the data gathered. Many of the results were presented at the 3rd Topical Meeting on Tritium Technology in Fusion, Fission, and Isotopic Applications, May, 1988, Toronto, Canada. The group of research scientists at these meetings also discussed the general status of tritium safety assessment and environmental effects and a list of areas needing further study was developed.

Discussions following these meetings led to the development of a proposal to the International Energy Agency (IEA) for cooperation in safety and environmental effects. The research proposed was divided into seven specific areas, as needed for fusion energy development: 1) materials science, 2) environmental models, 3) environmental model validation, 4) tritiated organic compounds, 5) human dosimetry, 6) tritium sampling and measurement, and 7) long- term environmental databases.

In the spring of 1990 another workshop was proposed among the research scientists who had participated in the French and Canadian release experiments. It was decided to use the format of the IEA proposal for the meeting agenda. The meeting was organized with the help of the IEA planning committee consisting of K. Steinmetz, Y. Seki, G. Nardella, and G. Vivian. The objective of the meeting was to review the status of research in these seven areas and promote cooperation between interested research groups. A chairman was selected to organized a sessions for each of the activities in the IEA proposal (chairmen are listed in Table 1).

The meeting was held at The Houndslake Country Club in Aiken, S.C. during October 15, 16, and 17, 1990. The agenda followed the outline of the IEA proposal with the following sessions. Thirty-eight papers were presented by the participants. In addition, group discussions were held during the evenings. A summary of the sessions and the group discussions was prepared by the chairmen and is the primary subject of this report. Tours of selected Savannah River Site facilities were made on October 18, 1990.

Table 1. Sessions and Session Chairmen

Materials Science

Dr. Rion Causey
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Environmental Models

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Environmental Model Validation

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Tritium Sampling and Measurement

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Tritiated Organic Compounds

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Human Dosimetry

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Long-term Databases

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SESSION SUMMARIES

Materials Science

Rion Causey , Fusion Research Division , Sandia National Laboratories, Livermore, California, USA

There were four papers presented in the Materials Science Session. The first of these papers was given by Dr. M. Murata of JAERI. The title of his presentation was "Measurements of HTO Permeability for Rubber and Plastic Films". The purpose of the reported work was the measurements of the permeability parameters for several different rubber and plastic films and the effects of desiccation on these parameters. The conclusion of the report was that polyethylene and butyl rubber have low permeabilities for tritium, and that desiccation restores the original permeabilities.

The second talk was by Dr. R. Dickson of Chalk River Laboratory. His presentation was on "Tritium Interactions with Steel and Construction Materials in Fusion Devices". The purpose of his research was screening of building materials to examine tritium sorption and to determine the tritium source terms for safety systems. His conclusions were that permeation and sorption of tritium on steels were fairly well understood, and that low permeability coatings also sorb less tritium. It was also concluded that materials such as aluminum, copper, gold, molybdenum, and tungsten have low permeabilities, and that the migration is strongly affected by grain boundary diffusion at lower temperatures. For glasses, ceramics, and graphite, the permeability is low at high temperatures. It was also concluded that paints are undesirable in tritium areas, and that concrete has a high sorption capacity for HTO.

The third talk was by Dr. G. Longhurst of EG&G, Idaho. His talk "Tritium Retention and Migration in Beryllium" was directed toward the use of beryllium in fusion reactors. Beryllium's primary use in fusion reactors will be as a neutron multiplier in the blanket. As such, there will be tritium production through various nuclear reactions. The tritium formed there will be retained in helium bubbles and as $Be(OT)_2$ at oxygen inclusions. Longhurst showed data suggesting all of the tritium would be released if the beryllium were heated to temperatures above 600°C where it would undergo rapid swelling.

The last talk was presented by Dr. R. Causey. His talk was on "Tritium Inventory Predictions for ITER". He showed that the tritium retention mechanisms for the Physics Phase of ITER would be primarily due to the codeposition of sputtered carbon along with tritium on cool surfaces near the diverter. Inventories in the range of 200 to 900 grams of tritium were postulated. Increasing the temperature to minimize this codeposition would result in large amounts of retained tritium in the bulk of the graphite.

As part of the review process for the meeting, it was requested that the status of the science and technology in each session be discussed. The discussion given here will include suggestions by several participants on how this IEA group can work together to perform tritium research without inefficiencies due excessive duplication of efforts. Glen Longhurst of EG&G listed the following areas for collaborative research: development of plasma-sprayed materials that will be suitable for plasma-facing components and the determination of tritium retention and transport characteristics in these materials; evaluation of the heat of transport coupling coefficients for plasma-facing components; development of improved ways of measuring inventories in storage media as well as tritium contaminated materials;

develop devices and procedures for shipping large quantities of tritium; evaluation of permeation pathways from tritium systems that result in large building emanations; evaluate HT to HTO to OBT conversion mechanisms for materials other than soil; expand the database on tritium interaction with molten salts; develop improved decontamination methods. Dr. R. Jalbert of Los Alamos made the following suggestions for material science research needs: work on accountability/inventory of tritium in first wall materials, molecular sieves, and tritium plumbing materials; research on permeation through materials; conversion of HT to HTO upon release in different environments; process monitoring; glove box monitoring; detritiation of glove box atmospheres; shipping and waste disposal problems; and the examination of embrittlement problems with tritium handling equipment. G. Nardella of the DOE had the following suggestions: the true purpose of the IEA Materials Science group should be to develop through experiments/analysis an understanding of what the inventory of tritium is in the different fusion reactor systems, and to determine how each of the different amounts can be released, and what the mechanisms are that allow the release; further, it was suggested that this group concentrate on the longer term and not worry about presently existing machines such as T-1R and JET.

Environmental Models

Geoff L. Ogram, Ontario Hydro, Ltd., Toronto, Ontario, Canada

Mathematical models of the environmental behavior of tritium are used to predict the impact (radiation dose) of tritium releases for the purposes of impact assessment and safety analysis of facilities that handle large amounts of tritium (e.g, planned fusion test reactors, heavy water reactors, tritium production reactors, and tritium recovery facilities).

Eleven papers were presented dealing with following topics: the present understanding of the environmental behaviour of tritium; improved models of accidental HT (tritiated hydrogen) and HTO (tritiated water) releases; the application of these models, together with experimental results, to safety analysis; modelling studies such as sensitivity analysis and definition of worst case release conditions; new models for the treatment of continuous, routine HT emissions; and modelling of tritium in the food chain.

Present Understanding of Environmental Tritium Behaviour

C. Murphy (Westinghouse Savannah River Company) presented a review of the present understanding of tritium behaviour in the environment and stressed the importance of communicating essential aspects of scientific knowledge in such a way that decision makers can readily understand implications. This review is available as report WSRC-RP-90-462.

HT and HTO Acute Release Models

W. Raskob, P. Rocco, G. Ogram and O. Edlund described recent improvements to the acute HT and HTO release models UFOTRI (Kemforshungszentrum Karlsruhe, KfK), SCIROC and AVACTA (CEC Joint Research Centre - Ispra), ETMOD (Ontario Hydro) and H3DISP (Studsvik), respectively. Most models

are now capable of describing in detail the dynamics of tritium transfer between air, soil and vegetation following HT and HTO releases.

The UFOTRI model describes dynamically the intercompartmental transfer of tritium between biospheric compartments (atmosphere, soil, vegetation, grazing animals) and calculates radiological impact from inhalation, skin absorption and ingestion. Results were presented showing that resuspension of deposited HTO from soil and vegetation may greatly spread contamination beyond the area directly impacted by a short-duration HT release plume.

For HT releases, the Ispra and Ontario Hydro papers stressed the importance of modelling short range atmospheric dispersion correctly (accounting for building wake, local terrain and other site specific effects), as ground-level HT concentrations directly affect the amount of tritium deposited to soil via oxidation and subsequently available for reemission as HTO. The AVACTA and UFOTRI models treat atmospheric dispersion by segmented plume methods allowing changes in wind speed and direction in space and time to be accounted for. The atmospheric dispersion module in the AVACTA code has been tested against tracer experiments at Ispra giving agreement within a factor of five in most cases. Predictions of the SCIROC code, which uses the simpler Gaussian plume model to describe atmospheric dispersion, were also compared to the results from the 1986 HT release experiment in France and gave reasonable agreement.

Model sensitivity analyses presented by M. Murata (JAERI), W. Raskob (KfK) and O. Edlund (Studsvik) indicated that the parameters that control the rate at which HT in air near ground level is converted to HTO in soil (ie, HT deposition velocity, HT oxidation rate in soil, soil water content, etc) are very important in controlling the dose impact of HT releases. The JAERI results also indicated that the HTO exchange velocity, transpiration rate and evaporation rate (parameters which control the rate of reemission of HTO from the soil to the atmosphere) were of somewhat lesser importance and that the 1-hr dose was usually more sensitive to changes in input parameters than the 7-day time-integrated dose.

Models (such as those discussed above) describing the behaviour of HT releases are often complex, particularly because of the need to treat the secondary plume formed by the re-emission of HTO formed by the oxidation of HT in soils. Y. Belot (CEA) presented a simple model intended for more rapid calculations.

Areas identified for future acute release model development included incorporating more accurate descriptions of atmospheric turbulence near ground level (to model secondary re-emission plumes more accurately), developing probabilistic models and appropriate probabilistic input parameters, developing methods to ensure that model inputs are consistent (eg, exchange velocities, wind speeds, etc), improved treatment of HTO washout, and developing/incorporating OBT models (see below).

HT Chronic Release Models

B. Neil (Ontario Hydro) described the development of a steady-state environmental pathway model for chronic HT releases which will be used as a basis for setting revised emission limits for the Darlington

NGS Tritium Recovery Facility. The model is based on transfer factors which relate concentrations of tritium in various environmental compartments to the concentration of HT in air. Probability distribution functions are input for each of the transfer factors and a probability distribution for dose is calculated. Estimates of the most critical transfer parameter, which relates HTO to HT in air, were made from the rates of the controlling processes (HT deposition to soil and HTO reemission) and from time integration of results from the 1987 HT release experiment (which simulated an acute release). It was concluded that further experiments are necessary to establish reliable values of the key transfer parameters relating the steady-state HTO concentrations in air, soil and vegetation to the concentration of HT in air.

Models of Organically Bound Tritium

I. Brearley (UKAEA) described the TRIDOS foodchain model which treats dose to humans via direct exposure and ingestion of crops, milk and meat. Recent work included addition of modules to calculate OBT in vegetation and animals, and the investigation of suitable metabolic models to treat incorporation of tritium into humans. For short HTO exposures it was found that the Belloni and Bennet metabolic models, which allow incorporation of tritium into long lived OBT, gave committed doses that were significantly greater than the dose contribution from HTO alone.

This provoked discussion with the conclusion that further investigation was needed to determine whether this was indeed the case. It is planned to add a dispersion model to TRIDOS which will then be incorporated into the accident consequence analysis system CONDOR for PRA's on fusion plants.

Safety Analysis

R. Failor (LLNL) described an ongoing effort to use data from the 1986 and 1987 HT release experiments in Canada and France for the safety analysis of LLNL's tritium facility. She pointed out that the availability of real data, rather than model projections alone, gave much greater credibility to attempts to avoid over-conservative assumptions in safety analysis.

C. Bunnenberg and M. Taeschner (NIR) presented an extrapolation of experimental data from the 1986 French HT experiment to derive worst-case doses for HT and HTO releases (the worstcase is the combination of environmental conditions that gives highest dose). Considering both plume and post-plume, or reemission, phases of the plume the derived worst-case dose was about 10^{-4} Sv g^{-1} for HT, with a value about ten times higher for HTO.

G. Ogram presented the results of simulations carried out for the PPPL safety analysis and the ITER reference case, the latter illustrating that the dose from an HT plume is far less than an HTO plume, and that the HTO resuspended during the post-plume phase dominates the dose for an HT release.

Tritiated Organic Compounds

Yves Belot, CEA. Fontenay aux Roses, France

Tritiated organic compounds may be formed by radiation mediated reactions inside tritium handling or processing facilities, or by biological incorporation processes which occur within the environment. The relative significance of these compounds for the assessment of public or occupational doses requires additional investigation.

The first paper was a review by Y. Belot of CEA of the incorporation of tritium into organic matter of vegetation. It was pointed out that the rate of uptake of tritium by vegetation depends strongly on the chemical form of tritium on release, and that certain organic forms of tritium are taken up by vegetation at a much higher rate than simpler inorganic forms. It was shown that a part of the incorporated tritium persists in vegetation or derived food a long time after exposure and hence cannot be neglected in the assessment of dose to man.

A second talk was given by S. Diabate of KfK who presented new experimental data on the deposition of HT to various types of plants. It was shown that the deposition rate of HT to vegetation was about 1×10^{-8} m/s, while its uptake rate into the organic constituents of plants was only about 1×10^{-11} m/s. These experiments confirm that the incorporation of HT into vegetation is extremely slow and can be neglected.

A third talk was by D.W. Hayes of SRL who had measured the organically bound tritium in fish from a chronically exposed lake. The tritium concentration in the free water was found to be very close to the concentration in the lake water suggesting that the free water was in equilibrium with the lake water. The ratio of the organically bound tritium to the free water tritium was found to vary between 1.25 and 1.72. This excess of tritium in organic matter is similar to the excess formerly observed in terrestrial vegetation: its origin is still unknown.

In a last talk, Y. Belot of CEA, pointed out the potential importance of tritiated formaldehyde in the incorporation of tritium to vegetation. A methodology was developed to determine this compound in gaseous effluents containing HTO and HT as dominant species. First measurements on the effluents of a tritium-handling facility have shown that the ratio of tritiated formaldehyde to tritiated water was comprised between 0.05 and 2×10^{-2}. Further work is necessary to assess the importance of this specific compound.

Long-Term Databases

Charles Murphy, Westinghouse Savannah River Company, Aiken, South Carolina, USA

The interest in long-term databases is generated by the need to validate computational models of tritium transport and cycling. These models are incorporated into the models which are used to determine the dose to populations in the vicinity of environmental tritium sources.

The presentation by R. Kurzeja showed how experimental atmospheric tracer releases were used to validate models of short-term (accident scenario) atmospheric dispersion. These experimental databases were quite ideal compared to databases from monitoring programs, i.e. the spacing and timing of sampling points was optimized to determine the atmospheric concentrations at the scale of the models that were to be validated.

It was found that the normal criterion for model evaluation and comparison (the squared deviation between the predicted and the observed concentration) was more stringent than needed for most accident analyses. Other comparisons which used less stringent criteria, such as the ability to predict the peak concentration, or the overlapping of the predicted and measured plume boundaries, were found to be useful in ranking models. However, model ranking was not consistent in that the same models were not best in every comparison. There was some indication that better physics in a model, and the ability to make better use of input information did improve the performance of a model.

The other two databases were developed from monitoring data. The spatial and temporal scale of these databases was aimed at assessing the annual dose from operations of nuclear facilities. The Chalk River database consists of site location, a site physical and climatological description, the annual emission records, atmospheric levels of HTO and HT, deposition in precipitation, and surface and sub-surface water concentrations. The atmospheric transport is characterized by a preference for flow along the Ottawa River channel.

The SRS databases provides annual atmospheric releases (HT and HTO separate in later years), associated air, rain water deposition, soil, vegetation, milk and other food concentrations, and the population distribution in the vicinity of SRS. The annual data is reported by sampling station and variations of concentration with distance and direction can be calculated. The data was shown to be consistent with the concentrations used to make estimates of the SRS dose from tritium releases.

Because the processes which determine the environmental tritium concentrations are complex and the environment influencing the annual averages is variable during the year, it is not likely that the monitoring data can be used to determine model parameters or choose between closely related models. However, any successful model of long-term tritium transport should be able to predict the annual integrated concentrations in the environment in the vicinity of a tritium source, and in this sense, these databases can be used in model validation.

The members of this session were represented in the evening group meeting on recommendations for the three groups directly concerned with modeling (environmental modeling, model validation, and long-term databases). It was recommended that the modelers who want to use the data should provide some idea of the form in which the data would be of most use. With this information it would be possible to collect the database in a useable format and make it available for model validation.

Tritium Sampling and Measurement

Mikio Murata, Japan Atomic Energy Research Institute, Tokai-Mura, Naka-Gun, Ibaraki-Ken, 319-11, Japan

There were three papers presented in the Tritium Sampling and Measurement Session. The first of these papers was given by Dr.R.M.Brown of CRNL. The title of his presentation was "Developments in Tritium Sampling and Measurement at Chalk River". The purposes of the reported work were the studies of the oxidation of HT on several drying agents, the improvement of passive HTO sampler and the measurement of OBT in food items using the mass spectrometer He-3 ingrowth technique. The conclusion on the first subject was that some batches of Molecular Sieve have significant oxidation but consistently low oxidation on anhydrous $CaSO_4$ and that the latter should be used for reliable high HT/HTO discrimination in air samplers. The sensitivity of the passive HTO sampler has been improved and exhibited the lower limit of detection 1 Bq/m^3 for 30 L air sampled. He also showed OBT to HTO ratios of the food items were in the range of 0.55 to 3.32 though OBT concentrations in them differed in the order of three.

The second talk was by Dr. D. L. Dunn of Savannah River Laboratory. The title of his talk was "Collection and Analysis of Environmental Tritium at SRS". He presented the radiometric group tritium program such as canister maintenance, sieve preparation and certification, canister deployment and retrieval, sample preparation, liquid to gas conversion and radiometric analysis. It was concluded that application of the massive shielding and the anticoincidence shielding as well as the sample preparation yields for a typical proportional counter in the system a background counting rate <1 cpm. He also showed that the detection limits of their system were 0.02 pCi/g for HTO, 0.1 pCi/m^3 for HT, T_2 and 0.01 pCi/cm^3 for CH_3T, CT_4.

The last talk was presented by Dr. G. Hall of Savannah River Laboratory. His presentation was on "Analysis of Very Low Levels of Tritium With the He-3/He-4 Static Gas Mass Spectrometer". The purpose of his present research is to establish the He-3 ingrowth technique having a detection limit of 1 pCi/mL as an alternative method. It was concluded that use of the dual collector static gas mass spectrometer specially designed for helium isotope detection demonstrated a detection limit of 0.5 pCi/mLwith 3 ml sample and 90 days wait time. He also presented his new goal as a detection limit of 0.1 - 0.05 pCi/ml through improvements in the source efficiency of the mass spectrometer system.

The members of this session were present in the evening group meetings on recommendations for the three groups concerned with modeling (Environmental Modeling, Model Validation. Long-term Databases) and for the Materials Science group. The followings items were suggested as tritium sampling and measurement research needs: high HT/HTO discrimination, He-3 ingrowth measurement, OBT measurement, skin contamination, tritiated carbon aerosol, process monitoring, glove box monitoring, measuring inventories in storage media as well as tritium contaminated materials.

Environmental Model Validation
Dr. W. Gulden, The NET TEAM, Garching Bei Muchen, Germany

Two computer codes were used to perform parametric studies: W. Raskob presented results of first probabilistic analyses with UFOTRI to identify "dominating" parameters for accidental tritium releases and O. Edlund reported H3DISP results on postcalculations and detailed parametric studies for the French tritium release experiment of 1986.

Some of the computer codes presented in more detail in session 2 have been assessed by comparison with tritium release experiments and by participation in benchmark calculations. Reviews of these results were presented by H.-W. Bartels for normal operation releases and W. Gulden for accidental releases.

G. Ogram presented results on a series of laboratory measurements of HT deposition velocities (v_d) for different soil types and proposed a mathematical model for the calculation of v_d. Measurements, illustrating the HTO transport in a small forest, were documented and reported by H. Amano, and finally some ideas about possible future large scale experiments were presented by G. Ogram to stimulate discussion.

Status of Computer Codes

The following tables summarize the results evaluated from the presentations. Table 2 characterizes the level of modelling in the computer codes for accidental tritium releases. This table representing the opinion of the chairman also includes codes presented in session 2.

Table 2. Computer codes for tritium transport and dose calculation, accidental releases

Name of computer code	Organization	Status of modelling	Participation in benchmark calculation		Ingestion model included
			ITER	best estimate	
ETMOD	OH, Canada	M/H	x	x	
UFOTRI	KfK, FRG	M/H	x	x	yes
H3DISP	Studsvik, Sweden	M/H	x	x	
TRILOCOMO	Studsvik, Sweden	M/H			yes
TRIDOS	UKAEA/SRD, UK	M	x		yes
TRIMOD	CEA, France L				
SCIROC	JRC, Ispra	L	x		
T-AVACTA	JRC, Ispra	L			
TRIDOSE 90	JAERI, Japan	L	x		?

H all important models included adequately, assessed by comparison with experiments
M most important models included, partly assessed by comparison with experiments
L not all important models included

In Table 3 the processes, their importance for modelling (defined as high, medium and low), and the status obtained in modelling in the best computer codes are listed. Models still needing improvement are marked by * in column 3, and the need of further experimental data is indicated in column 4:

Table 3. Processes to be included into accidental tritium transport and dose calculation models

Process	Importance	Status of modeling	Experimental data need
Atmospheric dispersion	H	H	
Atmospheric conversion HT to HTO	L	-	
Wet deposition	M/H	L*	
Condensation/dew	L/M	L	
Dry deposition HTO			
Plant	H	M/H	x
Soil	H	M*	x
Free Water surface	L	-	
Dry deposition HT			
Plant	L	-	
Soil	H	M/H*	
Free water surface	L		
Re-emission			
Soil surface	M/H	M/H	x
Root/plant uptake	H	M/H	
Synthesis of T into organics			
Plant	H	L/M*	x
Soil	L		
Transport through food chain	H	M	x
Absorption of tritium from			
air in humans HT	L	M	
HTO	H	H	
Translation of exposure to dose	H	M/H*	

Measurements and Model Validation Experiments

The laboratory measurements for different soil types of deposition velocities, HTO depth profile in the soil, soil water content, organic content and texture resulted in a proposal for a mathematical model for the calculation of the deposition velocity. The experimental results have been used to verify this model.

The study of HTO transport in a small forest during a whole year clearly showed the importance of seasonal effects for tritium concentration in plants.

Four possible environmental validation studies have been outlined. They are listed according to its priority allocated by the experts after discussion:
1. Studies for environmental HTO levels resulting from chronic HT release
2. HTO dispersion experiments
3. HT dispersion experiments under winter conditions
4. Studies (of e.g. HTO washout and HTO re-emission from soils and vegetation) in the vicinity of existing tritium handling facilities

Tritium Safety and Environmental Effects

Dr. R.G.C. McElroy, AECL Chalk River, Nuclear Fusion Program, Chalk River, Ontario, Canada

The session on human dosimetry at the Aiken meeting on Tritium Safety and Environmental Effects consisted of six papers (see Appendix A). This synopsis concentrates on common themes and discussions rather than attempting to individually summarize these presentations.

The following issues were identified as requiring further effort or consideration:

(l) The dosimetry of OBT.

The role of OBT in the dosimetry of the inhalation or ingestion of HTO is well understood. Following an intake of HTO, some tritium is incorporated as OBT in the soft tissue. Since the integrated activity in the soft tissue cannot exceed that in the body water, the dose to the body water is an upper limit to the dose to the whole body (body water plus soft tissue). That is, the contribution of the activity in the soft tissue is more than offset by the increased mass involved. Recently, some papers and reports have appeared in conflict with this argument. In actuality, the conflicts are more apparent than real. A clear and complete review focusing on this aspect of tritium dosimetry seems required to dispel the confusion.

The dosimetric consequences of ingesting foodstuffs containing OBT is more complex. It seems generally accepted that most ingested OBT is catabolized to HTO. However, a small fraction is not. The relevant question is the dosimetric significance of this fraction. What are the relevant models, and how much OBT is there in typical diets? Both of these aspects deserve further effort.

(2) The correct Q value to use in calculating dose.

This is more of a political question than a scientific question. Further effort in this area is not recommended. It is noted that the most recent recommendations of the ICRP (ICRP-60) recommend a radiation weighting factor of 1.0 for photons and electrons of all energies.

(3) Age dependent effects.

The question of fetal doses, suckling infant doses and the whole general question of age dependent dose conversion factors requires further explicit consideration.

(4) Lung dose from HT. While the direct dose from HT does not seem particularly significant in most exposure scenarios, the question as to whether there is any dose to sensitive tissue in the lung should be addressed. Does the entry in ICRP 30 on HT have any validity? It would be useful to model HT when the new ICRP lung model becomes available.

(5) Skin dose from contaminated surfaces.

For occupational radiation protection, the question of dose and dose assessment arising from skin contact exposure to T2 gas-contaminated surfaces must be solved. The current situation is that it appears that the skin dose may be limiting in some situations, and that dose assessment is difficult, but that significant doses do not seem possible.

(6) Dosimetry of volatile organic compounds such as formaldehyde, methane.

These compounds do not seem to be major problems but the dosimetry is not currently firmly based. This should be addressed.

(7) Workplace hazards such as metal tritides and tritiated oils.

Some key issues with respect to the radiological hazard of metal tritides include:

* The solubility of the tritides in lung fluid.
* A measure of the emanation rate of tritium betas from the surface of the tritide particle and whether these beta particles are capable of depositing their energy in sensitive tissue.
* Is there such a thing as a respirable metal tritide or will tritides of respirable size will burn spontaneously in air.

Plasma interactions with the wall can result in tritiated dust within the tourus of a fusion machine. The chemical composition of this dust is dependent upon the composition of the tourus lining, but may include carbon and/or beryllium. The chemical and radiological hazard of this dust needs to be addressed.

Tritiated oils can arise in the operation of tritium facilities. Prudence requires that the dosimetry of these oils be understood.

(8) Bioassay techniques - in particular, efficient and sensitive methods for OBT in urine.

OBT in urine is a marker for certain modes of tritium uptake, uptake from T2 gas-contaminated surfaces for example. Common bioassay methods for OBT are effective but labour intensive.

(9) Sensitivity analysis of dosimetry models.

Many tritium dosimetry models are becoming quite complex. An analysis of sensitivity of dose determinations to uncertain model parameters is required to intelligently assess the model predictions.

Currently there are ongoing or planned programs in all of these areas. These should continue and they should be supplemented by staff exchanges or visits and the holding of mini-workshops. No major holes were identified at the meeting - although there was no discussion of microdistributional effects. Thus, there does not seem to be a need for any major rationalization or reorganization of programs. However, there are probably some other players who are not currently involved in this program who should be.

In summary, we are in good shape, but there is much to be done.

TASK GROUP REPORTS

Environmental Modelling, Model Validation, Tritium Sampling and Measurement, and Long-Term Data Bases

Geoff L. Ogram, Ontario Hydro, Ltd., Toronto, Ontario,Canada

An informal evening session was held to discuss possible initiatives or opportunities for international cooperative research under this IEA program. Suggested guidelines were that initiatives must supply information necessary to advance fusion safety and be suitable for a voluntary cooperative program, and that initiatives may include ongoing or planned programs which would benefit by a collaborative approach. Participants from the Sessions on Environmental Modelling, Model Validation, Tritium Sampling and Measurement, and Long-Term Data Bases met and identified the following possibilities for further consideration:

- A field experiment to simulate a chronic HT exposure and give direct information on resulting steady state HTO levels in soil, vegetation and air.

- Y. Belot, of CEA, is planning (i) experimental field studies of HTO reemission from small plots contaminated by exposure to HT, and (ii) experiments to measure the uptake of various tritium species by vegetation (especially trees). Belot invited participation by other laboratories interested in cooperative research.

- P. Rocco (JRC-Ispra) suggested considering experiments that could be undertaken in the large chamber at ETHEL.

- Studies of HTO washout and HTO emissions from soils at existing sites where small, chronic HTO releases occur.

- Further application of existing data bases. This may include looking at means of standardizing data, deducing information on important environmental transfer parameters, establishing a working group comprised jointly of modellers and experimentalists to determine the best ways to assemble/analyze/interpret data, etc.

- A detailed evaluation study (benchmark) for acute HT release models using results from the Canadian HT experiment.

Tritiated Organic Compounds

Yves Belot, CEA, Fontenay aux Roses, France

An evening group meeting was devoted to the establishment of recommendations. As concerns tritiated organic compounds, it was recognized that minor components may become important if they have relatively high deposition rates. Additional research is requested on the identification and determination of the organic species that may be formed in special circumstances as a result of chemical homogeneous reactions in the atmosphere, as a result of heterogeneous reactions at the surface of various materials, or as a result of biochemical reactions in living tissues. This research is linked to investigations in the field of dosimetry. McElroy of CNRL listed the following areas of research which are particularly related to tritiated organic compounds: consequences of ingesting foodstuff containing organically-bound tritium; consequences of contamination by skin contact; dosimetry of volatile organic material.

APPENDIX A: PAPERS PRESENTED

Tritium Sampling and Measurement Chair: M. Murata, JAERI, Japan

R. M. Brown, AECL, Canada, *Developments in Tritium Sampling and Measurement at Chalk River.*

D. L. Dunn, WSRC-SRL, USA, *Collection and Analysis of Environmental Tritium at SRS.*

G. Hall, WSRC-SRL, USA, *Analysis of Very Low Levels of Environmental Tritium with the He-3/He-4 Static Gas Mass Spectrometer.*

Environmental Models Chair: G.L. Ogram, Ontario Hydro Ltd., Canada

C. E. Murphy, WSRC-SRL, USA, *Conclusions and Recommendations from a Review of Environmental Tritium Transport and Cycling in Support of the U.S. New Production Reactor Program.*

W. Raskob, KfK, Germany, *The Modelling of Tritium Behavior in the Environment.*

Y. Belot, CEA, France, *A Code to Predict the Atmospheric Concentrations of HTO Following an Accidental Release of HT.*

P. Rocco, ISPRA, *Modelling Activities at ISPRA*

M. Taeschner and C. Bunnenberg, NIR, Germany, *Identification for Worst Case Conditions for Tritium Releases from Fusion Facilities.*

M. Murata, JAERI, Japan, *A Sensitivity Analysis of an Environmental Dose Prediction Model in Accidental Tritium Gas Release Conditions.*

B.J. Neil, Ontario Hydro, Canada, *On the Development of a Model for Chronic HT Releases.*

D. Leng and I. Brearley, SRD, England, *Modelling Chemically Bound Tritium in the Foodchain model TRIDOS.*

R. Failor, LLNL, USA, *Applications of Recent Field Release Experimental Data to Safety Analysis.*

S. B. Russell and G. L. Ogram, Ontario Hydro, Canada, *ETMOD (Ontario Hydro's Environmental Tritium Model) Update.*

Environmental Model Validation Chair: W. Gulden, The NET TEAM, Germany

O. Edlund, Studsvik, Sweden, *Postcalculations and Parametrical Studies for the French Tritium Field Experiment Carried Out 15 October 1986.*

W. Raskob, KfK, Germany, *Parameter Studies with the Environmental Tritium Model, UFOTRI.*

W. Gulden, NET, Germany, *Doses to the Public due to Accidental Tritium Releases.*

H.-W. Bartels, NET, Germany, *Comparison of Predictions of Doses Following a Continuous HTO Release.*

T.G. Dunstall and G.L. Ogram, Ontario Hydro, Canada, *Diffusion and Biological Oxidation as Component Processes Regulating the Deposition of Tritiated Hydrogen to Soils.*

Bunnenberg, K. Schubert, and M. Taeschner, NIR, Germany, *Experimental Results and Modelling Proposals for Tritium Re-emission from Soil.*

Amano, JAERI, Japan, *Tritium in a Small Forest.*

G. L. Ogram, Ontario Hydro, Canada, *Future Full Scale Model Validation Experiments: A Discussion.*

Tritiated Organic Compounds Chair: Y. Belot, CEA-Fontenay au Roses, France

Y. Belot, CEA, France, *Incorporation of Tritium into Organic Matter of Vegetation: A Review.*

S. Diabate, S. Strack and M. Hettinger, KfK, Germany, *Tritium Behaviour in the Soil-Plant-Atmosphere Continuum.*

D. W. Hayes, WSRC-SRL, USA, *The Tritium Concentration of Water and Flesh of Fish Exposed to Chronic Tritium Discharges.*

Y. Belot, CEA, France, *Determination of Tritiated Formaldehyde in Effluents from Tritium Facilities.*

Long-Term Databases Chair: C.E. Murphy

R. Kurzeja, WSRC-SRL, USA, *Results of the U.S. Department of Energy Atmospheric Model Validation Study.*

R. M. Brown, Chalk River Laboratory, Canada, *Tritium Monitoring Data for the Chalk River Site.*

L.R. Bauer, WSRC-SRL, USA, *Tritium in the Savannah River Environment: Assessment of the Environmental Transport and Dose Commitment from 35 Years of Tritium Release Data at the Savannah River Site.*

Human Dosimetry Chair: R.G.C. McElroy, Chalk River Laboratory, Canada

Robin Hill, BNWL, USA, *Tritium Radiobiology and Health Physics: A Review.*

D.K. Myers, AECL, Canada, *Realative Biological Effectiveness of Tritium Beta Rays.*

D.W. Whillans, Ontario Hydro, Canada, *A Reconsideration of the Dose Equivalent Received from Intakes of Elemental Tritium Gas.*

Michele Legare, AECB, Canada, *Dosimetry for Skin Contact Exposure with T_2 Gas Contaminated Surfaces.*

L. R. Bauer and D. Hamby,WSRC-SRL, USA, *A Sensitivity and Uncertainty Analysis of an Atmospheric Tritium Dose Model.*

S. Diabate, KfK, Germany, *Significance of OBT and Its Consideration in Existing Tritium Models.*

Materials Science Chair: R. Causey

Murata, M. and H. Yamamoto, JAERI, Japan, *Measurements of HTO Permeability for Rubber and Plastic Films.*

R. Dickson, Calk River Laboratory, Canada, *Tritium Interactions with Steel and Construction Materials in Fusion Devices.*

Glen Longhurst, EG&G- Idaho,USA, *Tritium Retention and Migration in Beryllium.*

Rion Causey, Sandia N.L., USA, *Tritium Inventory in the Plasma-facing Components of the International Thermonuclear Experimental Reactor (ITER).*

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