THE CONTROL OF EMISSIONS FROM NUCLEAR POWER REACTORS IN CANADA

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INTRODUCTION

Nuclear power reactors in Canada are of the CANDU pressurized heavy water design. These are located in the Provinces of Ontario, Quebec, and New Brunswick. Most of the nuclear generating capacity is in the Province of Ontario which currently has 16 commissioned reactors with a total capacity of 11,500 MW(e). There are four reactors under construction with an additional capacity of 3400 MW(e). Nuclear power currently accounts for approximately 50% of the electrical power generation of Ontario. Regulation of the reactors is a Federal Government responsibility administered by the Atomic Energy Control Board (AECB) which licenses the reactors and sets occupational and public dose limits.

DERIVED RELEASE LIMITS

Derived limits for the release of radionuclides are based on a methodology endorsed by the AECB and documented in the Canadian Standards Association Standard N288.1. Release limits are calculated such that no member of the public receives a dose in excess of the dose limit set for the public by the AECB. This dose limit is currently set at 5 mSv per year (effective dose equivalent). The methodology incorporates the environmental transfer model shown in Figure 1.

In this model the quantity of radioactive material in any compartment is given by X(i) and transfer from any compartment i to compartment j is characterized by a transfer parameter P(ij) such that the amount in compartment j arising from transfer from compartment i under steady state conditions is P(ij)X(i). Thus the quantity represented by any compartment j is given by:

$$X(j) = \sum_i P(ij)X(i)$$

where the summation is over all compartments transferring into compartment j.

The standard presents equations for calculating the transfer parameters P(ij) on a site specific basis, and in addition, gives default values to be used where no site specific data are available. The default values have been chosen based on data in the scientific literature and are believed to be conservative. Derived release limits are calculated separately for releases to air and surface water. They are given by the following equation:

$$DRL = \frac{\text{Annual Dose Limit}}{X(9)/X(0)}$$

where X(0) is the release rate to either atmosphere or surface water.

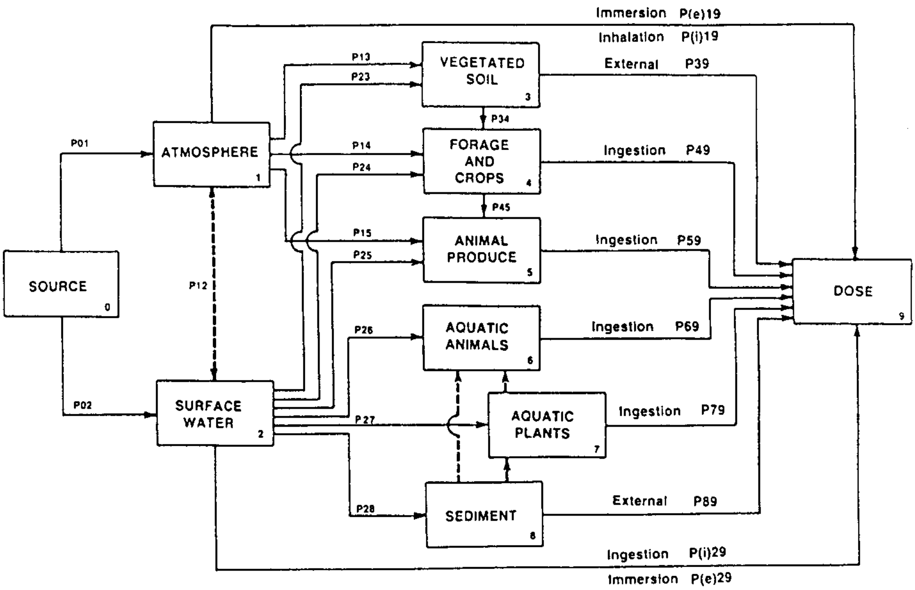

Figure 1: Environmental Transfer Model

Derived release limits are calculated for each radionuclide which contributes significantly to the source term. Limits for releases to air and surface water are calculated independently. Account must therefore be taken of multiple exposures to a critical group from all radionuclides and release sources (air and water). The dose limitation requirements will be met under the following additional condition.

$$\sum_i \sum_j \sum_k \frac{R(ijk)}{DRL(ijk)} < 1$$

where R(ijk) = actual release of radionuclide i, from effluent source j (air or water), and source facility k (takes account of a multiple facility site);

and DRL(ijk) = derived release limit for radionuclide i, effluent source j, and facility k.

These dose limits are applied to a "critical group" which represents those individuals who are expected to receive the highest dose from emissions from the facility in question. Release limits are therefore "site specific".

OPERATIONAL TARGETS

In recognition of the principle that doses should be kept as low as reasonably achievable, design criteria and operational targets are set at a small fraction (currently 1%) of the derived release limits. In practice, actual releases for most radionuclides are well below even these targets.

EFFLUENT MONITORING

Monitoring of all significant release pathways for radionuclides is conducted to ensure compliance with the DRLs and station operational targets. Monitoring may be continuous, as for releases to atmosphere, or on a batch basis, for controlled pumpouts of liquid holding tanks. The major emissions from CANDU pressurized heavy water reactors are noble gases and tritium. Carbon-14 has been shown to be significant only for Ontario Hydro's Pickering Generating Station.

ENVIRONMENTAL MONITORING

Environmental monitoring programs may be needed to achieve any of the following objectives:

(1) To validate the environmental pathway model or any transfer parameter used in the model.
(2) To provide a check on the effluent monitoring design and operating systems by comparing doses estimated from effluent monitoring with those from an environmental monitoring program.
(3) To show compliance with licensing limits where effluent monitoring is not possible or feasible.
(4) To provide direct measurements, which may be more convincing to members of the public than effluent monitoring, which would help allay public concerns and foster public confidence in the control of the licensed activity.
(5) To contribute to the preparedness for off-site emergency situations where the case so warrants.

Another standard (Canadian Standards Association Document N288.4)(in preparation) presents guidelines and criteria for determining if an environmental monitoring program is necessary in relation to a specific facility.

The proposed guidelines would require an environmental monitoring program if the sum of the committed effective dose equivalents to a typical member of a critical group from all radionuclides and pathways from one year of operation is estimated to exceed 50 uSv.

An environmental monitoring program would not be necessary, under most conditions, if the sum of the committed effective dose equivalents to a typical member of a critical group from all radionuclides and pathways from one year of operation is estimated to be less than 5 uSv per year.

An additional criterion would call for an environmental monitoring program where the release potential from the facility is such that, in the event of an accident, the sum of the effective and committed effective dose equivalents to a typical member of a critical group might exceed 5000 uSv.

Experience from operating CANDU stations has shown that the dose to a typical member of a critical group is between one and five uSv per year. An environmental monitoring program would therefore be required under the third criterion. The programs in place concentrate on measurements of external dose from noble gases, airborne levels of tritium, and levels of tritium and carbon-14 in foodstuffs. Using Ontario Hydro's Pickering Nuclear Station as an example, the total dose to a member of a critical group during 1986 was estimated to be 36 uSv of which 20% is from tritium, 40% is from noble gases, and 40% is from carbon-14.

CONCLUSIONS

Emission and environmental monitoring data show that the dose to a critical group resulting from the operation of nuclear power plants in Canada is only a small fraction of that due to the natural background. This provides a confirmation that the release limits and targets which have been set continue to provide a satisfactory degree of protection to the public.

REFERENCES

(1) Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities. Canadian Standards Association CAN/CSA-N288.1 (1987).

(2) Guidelines for Radiological Monitoring of the Environment. Canadian Standards Association Draft Document N288.4 (1987).

(3) Radioactive Release Data from Canadian Nuclear Generating Stations for the Period 1972-1986. Atomic Energy Control Board Document INFO-0210 (Rev.1), (November 1987).