EMERGENCY PROCEDURES FOR COPING WITH NUCLEAR REACTOR ACCIDENTS

1. INTRODUCTION

Careful design, construction and operation of nuclear reactors in compliance with exacting codes, standards and licence conditions provide the primary assurance against reactor accidents which may endanger the health and safety of the operator and of the general public. Additional assurance is provided by the incorporation into the design of the reactor of one or more completely independent protective shutdown systems which will over-ride the normal power regulation system to shut a reactor down should an unsafe condition develop. The protective system is one of a number of special safety systems designed to prevent a reactor accident or to minimize its consequences in the unlikely event that one were to occur. Still further assurance results from the provision of a complete containment barrier, or containment system as it is called, in the form of a reinforced or pre-stressed concrete building which houses the entire reactor.

In spite of the very high level of assurance attained as a result of the exacting requirements which must be complied with in the design, construction and operation of nuclear reactors in Canada, prudence dictates that emergency procedures be prepared to cope with such an accident should one ever occur. These procedures fall into two basic categories "on-site" and "off-site" and, as their titles imply, are intended to apply to postulated reactor accidents the consequences of which are either limited to the site of the nuclear reactor or extend beyond the site.

The licensing of nuclear reactors in Canada is the responsibility of the Atomic Energy Control Board as a result of the Government of Canada's decision in 1946 to enact the Atomic Energy Control Act which declared atomic energy a matter of national interest. The jurisdiction of the Board does not extend
beyond the nuclear installation and the special substances involved. Hence, although the requirement for and approval of on-site emergency procedures falls within the jurisdiction of the Board, off-site emergency procedures are a provincial responsibility.

2. **ON-SITE EMERGENCY PROCEDURES**

An application for reactor construction and operating licences must be supported by the submission of a Safety Report which includes a detailed description of the proposed reactor, the special safety systems and other safety measures which are to be incorporated into the design and operating procedures of the reactor and an analysis of postulated accidents. Before issuing an operating licence, the Atomic Energy Control Board requires the applicant to prepare written procedures to cope with such postulated accidents, to obtain the necessary emergency equipment and to train operating personnel in the use of such procedures and equipment.

Basically, on-site emergency procedures cover the following topics:

1) probable nature and extent of possible emergencies;
2) organizational arrangements for coping with emergencies. These will include specific authorities, responsibilities and duties and the means of notifying the personnel concerned;
3) means of assessing the hazards posed by a particular accident;
4) initial action to be taken to account for personnel and to provide treatment for injured persons, if any;
5) notification of appropriate federal, provincial and municipal authorities; and
6) follow-up action to be taken after further information about a particular accident has been obtained.
The on-site emergency procedures are reviewed by the staff of the Board as well as by advisers drawn from appropriate federal, provincial and local authorities to ensure that such procedures are consistent with and take into account any actions that may be necessary should the consequences of the accident ultimately extend beyond the reactor site.

After any necessary additions or revisions have been made to the on-site emergency procedures and following approval by the Atomic Energy Control Board, they are issued as part of the operating procedures of a reactor. Subsequent to their approval, the procedures are reviewed periodically and any necessary revisions incorporated. In particular, the results of emergency drills and retraining of personnel are carefully reviewed.

3. **OFF-SITE EMERGENCY PROCEDURES**

As stated in the introduction, the responsibility for off-site emergency procedures, or contingency plans as they are also called, lies with the provincial authorities. However, because of the interdependence of on-site and off-site emergency procedures, the Atomic Energy Control Board requires that reactor operators cooperate with and assist the provincial authorities. Advice and assistance where required is also provided to provincial authorities by the staff of the Board.

A prime example of the interdependence of the two categories of emergency procedures is the prompt notification of the local authorities which is a requirement in both cases.

A second example is in connection with the provision of information to local and provincial authorities regarding the nature and extent of an emergency. Specially equipped and trained teams of station operating personnel conduct radiation surveys around the station out to a radius of about five miles, depending on the location of the station. Results of the surveys are radioed to the station so that a rapid appraisal can be made as to whether there is any cause for concern about an off-site
release. Depending on the nature of the emergency, station personnel and facilities may be called upon to assist the public authorities in implementing the off-site plan.

4. THE NATURE OF THE HAZARD

In a nuclear reactor, the nuclear reaction takes place at a controlled and limited rate. This is quite a different situation from that of a nuclear weapon in which the nuclear chain reaction proceeds relatively uncontrolled and is over in a fraction of a second. Consequently, a large explosion in a nuclear reactor similar to a nuclear weapon explosion is technically impossible. Also, the thermal and blast effects associated with a nuclear weapon explosion are not of concern in a nuclear reactor, but both the reactor and the weapon produce radioactive fission products which are of concern.

Under normal operating conditions, the fission products produced in a nuclear reactor are contained within the metal cladding which surrounds the fuel. Indeed, there are at least three containment barriers to prevent the escape of such fission products; namely, the fuel cladding, the high integrity piping of the reactor cooling systems and the concrete or concrete and steel containment of the reactor building. If a serious reactor accident were to occur involving failure of the coolant system piping and melting of the fuel cladding, some fission products would be released into the reactor building. A small fraction of such fission products might be released to the reactor containment system even though the specifications of such systems are extremely rigorous.

Should such fission products escape from the containment system, they would mix with the air to form a radioactive "cloud". The dispersion of this "cloud" will depend upon the distance which it travels and on the local meteorological conditions. Passage of the radioactive cloud beyond the reactor site
would pose a hazard to the public in three different ways:-

1) external exposure due to direct radiation from its passage;

2) internal exposure from inhalation or absorption through the skin of radioactive materials;

3) internal exposure from ingestion of food and water containing radioactive material through fallout (or rainout) of radioactive material from the cloud and its deposition on the ground or surrounding bodies of water.

As indicated earlier, the magnitude and relative importance of these three effects will depend on the nature and extent of the accident, the location of the reactor and the weather at the time of the accident. Exposure to the radioactive cloud can be reduced by remaining indoors with the doors and windows closed. The effects of inhalation of radioactive iodine can be mitigated to a considerable extent by the prompt administration of potassium iodide pills to limit the radiation dose to the thyroid (such administration, however, should be done under medical direction - hence the desirability of the local Medical Officer of Health being a member of any off-site emergency organization).

After passage of the cloud, temporary evacuation from any seriously contaminated areas, until the radioactivity has decayed to non-hazardous levels or until clean-up operations have been completed, will reduce the dose to members of the public in the area.

Similarly the condemning of food and water supplies found to be seriously contaminated will further limit the radiation dose.

5. SUMMARY

Nuclear power plants are playing an increasing role in providing our growing electrical energy needs. Primary assurance against the risks of reactor accidents is provided by careful and closely-regulated design, construction, and operation of the plants.
Further assurance is provided by independent protective shutdown systems and by an effective containment system.

Emergency procedures are also provided to further minimize risk to plant operators and to the general public in the unlikely event of a serious reactor accident. On-site emergency procedures are reviewed by the Atomic Energy Control Board and its federal, provincial, and local advisers. Off-site emergency procedures are the responsibility of provincial authorities and are carefully coordinated with the on-site procedures.

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