AN OVERVIEW OF THE REGULATION OF URANIUM MINING, MILLING, REFINING AND FUEL FABRICATION

by

W.D. Smythe

Atomic Energy Control Board
Ottawa, Canada

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on Ontario Hydro Affairs

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Director, Fuel Cycle Branch
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Introduction

The mining, milling, refining and fabrication of uranium into nuclear fuel are activities, sometimes collectively called the front end of the nuclear fuel cycle, that have one common characteristic; the handling of natural uranium. The occupational and environmental hazards resulting from these activities vary widely. Uranium presents a radiological hazard throughout these activities but the principal culprit is radium which creates an occupational hazard in the mine and mill, and an environmental hazard in the waste products produced in both the mill and the refinery. The chemicals used in both these latter processes also present potential occupational and environmental hazards. The final step of fuel fabrication, involves neither chemical processes nor radium and consequently presents the least potential for occupational and environmental hazards.

The extent of the Atomic Energy Control Board's regulatory interests in this area is summarized in Table 1.

(Projection no. 1)
The Regulatory Process

For all nuclear facilities, the Board has established distinct administrative steps for the implementation of its authority. (projection no. 2). These consist of a public information program, site acceptance, approval to construct and a licence to operate. Steps 3 and 4 could be considered more formal because they are directly referred to in the Regulations and are undertaken on specific authority from the five-member Board. The applicant must convince the Board in detailed written submissions that the plant will meet the health, safety and security requirements of the regulations. The submissions include such things as detailed descriptions of the site, the design and construction of the facility, methods for limiting the radiation exposure of workers, methods for minimizing any release of radioactivity or chemical effluents to the environment, analyses of postulated accident conditions and many other aspects related to occupational and public health and safety. Details for these submissions are normally available in the form of guidelines.

Steps 1 and 2 are not specifically mentioned in the Regulations but they have been in use for a number of years. The first is a requirement that the prospective operator of a nuclear facility conduct a program to inform the public of its intentions in a manner which will enable the public to understand them and express its point of view. This is not a requirement for a public hearing although a hearing would undoubtedly serve the purpose.
The second step is a requirement for the prospective operator to apply for a site acceptance. This involves a written submission to the Board describing the general characteristics of the facility, of the site, and the possible environmental impact of the facility on the site. Guidelines for the preparation of this submission and criteria by which it will be assessed are available to the applicant for most nuclear facilities and are in preparation for others. In many cases, the applicant may be required by an environmental agency to prepare an environmental impact statement and submit it to a formal hearing or review process. The impact statement normally includes the type of information required by the AECB for site acceptance and can be submitted for that purpose. If a hearing is required by another agency the AECB normally withholds any site acceptance until the results of the hearing are available.

There are other procedures common to all nuclear facilities. Licences to operate are issued for a limited period of time and renewed periodically provided compliance with the licence has been satisfactory. Nuclear facilities are inspected by AECB officers or persons appointed as inspectors under section 12 of the Regulations. Finally the decommissioning or closure of the facility is subject to the same review and surveillance as the operation.

Recognizing that a number of government agencies both Federal and Provincial, have an interest in the operation of nuclear facilities, the AECB normally invites representatives of these...
agencies to join a technical review group to review written submissions from the applicant before approvals and licences are issued. This type of coordination usually carries on after a licence is issued for various technical issues that arise including the renewal of an operating licence.

In summary, the Atomic Energy Control Board is involved at all stages of the siting, construction, operation and eventual decommissioning of nuclear facilities. It requires that the facility be designed and built to ensure safe operation and finally that it is operated according to safe principles. The Control Board is concerned with occupational health and safety, with public health and safety and with protection of the environment so far as it affects public health and safety.

Uranium Mining and Milling

An understanding of the historical development of the AECB's role in the regulation of uranium mining and milling is important to an understanding of its present role and I would like to mention some of the important points in this history. The Atomic Energy Control Act gives the Board the power to make regulations generally "for developing, controlling, supervising and licensing the production, application and use of atomic energy" and specifically to make regulations "respecting mining and prospecting for prescribed substances", defined in the Act to include uranium. Shortly after the passing of the Act in 1946, the Board agreed with the Province of Saskatchewan that
the Province's rules regarding prospecting and staking would apply and that a Board licence would be required during the development and mining stages. In the early 1950's the Board came to an agreement with officials of the Ontario Department of Mines concerning licensing arrangements. At that time, the Board's interests were directed to the security of uranium and information regarding its reserves, production and disposition and it was understood that provincial authorities would take responsibility for health and safety. The Board agreed to include in its licenses a condition requiring compliance with provincial laws respecting mine safety.

Health and safety matters had traditionally been the responsibility of the provinces and in the early days the Board had no regulations dealing with radiation protection. However, after consultation with the provinces it was agreed that the Board would include in its regulations, radiation protection provisions based on advice from the Dominion Council of Health and the recommendations of the International Commission on Radiological Protection (ICRP). These provisions were drafted by an interdepartmental committee, approved by the provinces and finally incorporated into the Atomic Energy Control Regulations in 1960.

Radiation exists in several forms in a uranium mine but the most serious health hazard comes from a radioactive gas called radon and its radioactive decay products called "radon daughters".
The potential hazard of these radon daughters was recognized in the early days and in the late 50's the Ontario Department of Mines adopted a target maximum permissible concentration of 1 working level. The AECB did not include specific provisions for radon daughters in its 1960 regulations but it maintained close contact with radiological experts who were concerned about the problem. It was involved with other agencies in a review of the scientific evidence available on the effects of radon daughters. The result of this review was that in 1967 the Ontario Department of Mines issued a Mine Order requiring a progressive reduction in the maximum permissible exposure to radon daughters from 12 working level months (WLM) in 1967 to 4 WLM in 1975.

In 1974, the AECB reviewed its procedures for the licensing of uranium mines and subsequently took steps to improve them. It established a mine safety advisory committee consisting of experts from various provincial and federal government agencies to advise the Board on licensing matters. The Board subsequently changed its requirements for information from applicants concerning radiological safety and environmental protection and modified its licence format to reflect this emphasis.

The Royal Commission on the Health and Safety of Workers in Mines in Ontario was established in September 1974 and both the activities of the Commission and the recommendations in its report have influenced the AECB.
In 1976 the AECB published interim limits for exposure to radon daughters together with an explanation of their derivation. After a period of discussion with industry, The United Steelworkers of America and members of the public, the interim status was removed in 1978. The AECB organized and sponsored a Uranium Mine Inspector's Training Course which has been held twice a year since 1976. The AECB has also developed guidelines for the measurement of radon daughters. Notwithstanding the regulations which specify maximum permissible exposures to radon daughters, the AECB now includes a code of practice in its mine licenses which is designed to ensure that actual exposures are kept as low as reasonably achievable below the regulatory limits. For various measured concentrations of radon daughters, the code specifies a set of remedial actions which are designed to minimize personnel exposure.

In 1975 the AECB initiated a research and development program in support of all its various regulatory activities. Part of this program has concentrated on problems related to the uranium mining industry including:

a) the development of improved methods for the measurement of radon daughters

b) the development of personal radon daughter dosimeters
c) epidemiological studies
d) the use of sputum cytology for early detection of cancer.

As I have described, the historical regulation of health and safety in uranium mining in Ontario involved close co-operation
between the Atomic Energy Control Board and provincial agencies responsible for health and safety. In October 1978, the Department of Justice gave a legal opinion that uranium mines and mills are works and undertakings within the meaning of Section 17 of the Atomic Energy Control Act and therefore "federal works" as defined in the Canada Labour Code. The opinion went on to say that Part IV of the Canada Labour Code, (the part dealing with safety of employees) would apply in all those areas not covered by the Atomic Energy Control Regulations. Labour Canada subsequently incorporated Part IX of the Ontario Mining Act by reference as a regulation under Part IV of the Canada Labour Code in August 1979 and more recently, replaced that reference by a reference to the Occupational Health and Safety Act, 1978 and Regulations for Mines and Mining Plants.

The present working relationship consists of officers of the Ministry of Labour acting as agents for Labour Canada in matters of conventional occupational health and safety and as agents for the AECB in matters of radiological health and safety. The AECB designates officers of the Ministries of Labour and the Environment to act on its behalf subject to section 12 of the Atomic Energy Control Regulations. The AECB issues licenses to the mine-mill operator and inspects the facility to ensure compliance with the licence and to audit the work of provincial inspectors. The AECB maintains an office in Elliot Lake with a staff of one officer and one secretary for the latter purpose. Officials of all three agencies consult frequently on matters related to licensing, inspection and enforcement.
A most significant development for the AECB in the years following the Royal Commission has been its relationship with The United Steelworkers of America. This has developed from initial meetings to discuss need for regulations governing exposure to radon daughters, to frequent consultation on health and safety in the mines and mills. Before issuing licences, standards or guidelines, the AECB invites comments from interested organizations including the United Steelworkers.

Uranium Mill Tailings

The wastes discharged from the milling process, normally called tailings, present special waste management problems. Since the amount of uranium contained in Elliott Lake ore is typically a fraction of a percent, one ton of ore produces one ton of tailings. In the milling process the ore is crushed to the size of fine sand in order to facilitate the chemical extraction of uranium. The crushing imparts two characteristics which affect the management of the tailings; it increases the volume of the tailings by approximately 40 percent more than the volume of the ore in its natural state and it makes the small amount of residual uranium and the more significant amount of radium that remains in the tailings, more accessible to the environment. A small amount of the chemicals used in the milling process is also discharged with the tailings and becomes accessible to the environment. A final characteristic of the tailings in the Elliot Lake area which is common to many other types of tailings in Northern Ontario is the presence of iron sulphide commonly known as pyrite. This material combines with oxygen to form among other things, sulphuric acid - an environmental contaminant which has received much attention lately.
Historically uranium tailings have been managed in the same manner as tailings resulting from other mining and milling operations. Because of the large volume of material and the economics of moving it, the common method of management has been emplacement on the surface relatively near the mill in a location that permits containment by both natural and man-made barriers. Surface management of course, means that the tailings are subject to natural climatic and geological forces.

In the early years of uranium mining, insufficient attention was paid by both industry and government, to the potential environmental consequences of tailings management methods and there was environmental damage from which we are slowly recovering. The problems with uranium tailings were not seriously attacked until 4-5 years ago but since then there have been substantial improvements in both remedial work on abandoned tailings and emplacement of new tailings. Many of these improvements however require continued human intervention and can only be considered reliable during the operating phase of the facility or during an extended period of surveillance. Improvements that would ensure long term environmental acceptability are still under development and will require considerably more time and money.

Uranium tailings are classified as radioactive waste for the purpose of AECB regulation and control. They are subject to the same regulatory philosophy and licensing process that is applied to other types of radioactive waste. Analogous to the review of safety for a nuclear plant, the pre-licensing review of a tailings management system involves reviews of dam design,
methods of emplacing the tailings, effluent treatment and close-out procedures at the termination of operations. One aspect of radioactive waste management philosophy is the distinction between storage and disposal. Storage is a method of management which requires human intervention and surveillance while disposal is a passive method from which one could walk away with assurance that the method will remain safe. The present systems of tailings management are satisfactory for the operating life of the mill but they require human intervention such as effluent treatment and must therefore be considered storage methods. The objective for long-term management should be disposal and indeed most of the current analysis and research and development is directed toward this. The dominant characteristic of tailings which will influence final management methods will be the very large volume of the material. The final achievements must recognize this practical consideration even if it means compromising the philosophical objectives.

In later sessions of these hearings you will hear considerably more detail about the technology of uranium tailings management and the work that is being done to improve that technology. I would like to make some general comments about the latter aspect. When the AECB first started to look seriously at the state of uranium tailings management, it recognized that most of the thinking and research was concentrated on short-term problems - those that are relevant during the operating phase. There was some work on revegetation but no significant effort on alternative long term management methods. The AECB raised awareness of this in meetings with other government agencies and industry. In 1976 the Joint Panel on Occupational and Environmental Research for Uranium
Production was organized under the auspices of the Canada Centre for Mineral and Energy Technology (CANMET) to coordinate and disseminate the results of research work on uranium tailings. More recently CANMET has taken the lead in organizing a major research effort on tailings. I believe you will hear more of this program later in the session.

At the international level, the AECB has pushed hard through its membership on radioactive waste management committees of the Nuclear Energy Agency and the International Atomic Energy Agency for consideration of the long-term problems of uranium tailings. At the Nuclear Energy Agency which includes in its membership, all the major uranium producing countries outside of the Soviet Bloc, Canada is participating in a program which will define long-term performance criteria and methods for assessing the performance of tailings management techniques.

The AECB believes that all of this work is essential and that it must continue to be given a high priority.

Uranium Refining

Uranium refining is a chemical process which takes the product of the mill (called yellowcake) and removes all impurities to leave pure uranium. The only operating refinery in Canada, at Port Hope, produces both uranium dioxide for domestic use and uranium hexafluoride for export. Both radiation and process chemicals particularly hydrogen fluoride, present occupational hazards. The small amount of radium present in the yellowcake feed material is not sufficient to produce significant levels of...
radon in the plant but it eventually becomes concentrated in waste products and these materials must be carefully managed. Eldorado Nuclear Limited has been given permission to recycle these waste products through the mill at Rio Algom and the heap leaching process of Agnew Lake Mines for extraction of both small amounts or uranium and more significant amounts of sulphuric acid. The eventual waste from this recycling process is very similar to the normal waste from the mill and is sent to the tailings area.

Last summer there were persistent problems with airborne chemical effluents from the plant in Port Hope. These releases were the product of a very old plant running at full capacity and were most serious during adverse weather conditions. Modifications have been made to the plant which are expected to eliminate the problem.

As you are well aware, there has been a remedial action program in Port Hope to clean up contamination from the very early days of operation when radium was the product of the refining operation. Waste was buried in various locations around the town sometimes indiscriminately, and contaminated construction materials were diverted from the plant for private use. Where these materials were near the foundation of a building or actually part of the building, radon gas could accumulate in unventilated spaces creating a hazard. This has been a valuable but very expensive lesson in the consequences of poor radioactive waste management practice.
Uranium Fuel Fabrication

The process of fabricating uranium oxide into nuclear fuel is a metallurgical and mechanical one which does not involve chemicals. It therefore does not have any of the problems associated with radium or process chemicals. At the beginning of the process where the uranium oxide is a powder, ventilation must be carefully controlled to prevent inhalation of uranium by the workers and filter systems are used to control releases to the environment. Once the uranium is pressed into pellets there are no further problems with dust. Waste products consist of uranium scrap, sweepings and filter material all of which is recycled to the refinery. Contaminated garbage is sent to the Atomic Energy of Canada Limited waste management facility at Chalk River.
## TABLE 1

**NUCLEAR FACILITIES LICENSED BY AECB**

<table>
<thead>
<tr>
<th></th>
<th>ONTARIO</th>
<th>SASKATCHEWAN</th>
<th>ALBERTA</th>
<th>QUEBEC</th>
<th>NEW BRUNSWICK</th>
</tr>
</thead>
<tbody>
<tr>
<td>URANIUM MINE-MILL</td>
<td>5 (2)</td>
<td>3 (1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>REFINERY</td>
<td>1 (1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FUEL FABRICATION</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>URANIUM EXTRACTION</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>(From Phosphoric Acid)</em></td>
<td></td>
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<td></td>
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</table>
STEPS IN THE LICENSING OF A NUCLEAR FACILITY

1) PUBLIC INFORMATION PROGRAM

2) SITE ACCEPTANCE

3) CONSTRUCTION APPROVAL

4) LICENCE TO OPERATE (LIMITED PERIOD)

5) SITE CLOSURE

CHARACTERISTICS OF THE LICENSING PROCESS

1) APPROVAL IN STAGES

2) BURDEN OF PROOF ON THE APPLICANT

3) INSPECTION AT ALL STAGES

4) JOINT REVIEW BY REGULATORY AGENCIES
BRUCE NGS 'A'
STEAM GENERATORS

NOTE CLOSE COUPLING
BETWEEN STEAM DRUM
BOILERS AND PIPING

Fig. 2
FIG. 3  CUTAWAY VIEW OF BOILER AND STEAM DRUM