THE APPLICATION AND REGULATION OF NON-MEDICAL RADIOACTIVE SUBSTANCES IN CHINA (TAIWAN)

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ABSTRACT

Based on the Atomic Energy Law of Taiwan and regulations regarding radiation protection, an operating system has been established for the approval and regulation of import (production), installation, licensing, safety inspection, record keeping, storage, transfer, transportation and abandonment of nonmedical radioactive materials and equipment capable of producing ionizing radiation.

In order to ensure that all equipment capable of producing ionizing radiation can meet the respective standard of radiation protection in accordance with the ALARA principle, nonmedical equipment capable of producing ionizing radiation is divided into six catagories depending on its inherent shielding ability, operation limit, characteristics of the radiation and the required degree of surveillance for achieving the purpose of radiation protection. The six catagories are: 1. Protective equipment, 2. Immobile closed equipment, 3. Automatic operating equipment, 4. Mobile equipment, 5. Unsealed radioactive substances, 6. Consumer products and other radioactive sources with different properties. Each category has its specific requirements in radiation protection.

INTRODUCTION

The Radiation Protection Department of the Atomic Energy Council (AEC) in Taiwan, started issuing specific license for radioactive substances from 1978. Since then, application for utilization of radioactive substances has been growing significantly in the field of industry, agriculture and scientific research sectors. Until now, approximately nine hundred specific licenses for radioactive substances have been issued. Over ninety five percent of these licenses belong to sealed sources. In order to ensure the accountability of all licenses as well as the radioactive substances, the Radiation Protection Department of AEC introduced computer system in 1985 for regulatory assistance.

This paper presents the application of radioactive substances for non-medical use in Taiwan and how these radioactive substances are regulated by the government authority.

INDUSTRIAL APPLICATIONS

Radiation Processing

There are four irradiators in Taiwan. One of these irradiator is for commercial use, the other three irradiators are for research and development purposes. The designed capacity of the commercial use irradiator is five million Curies of Cobalt-60 source and major applications include sterilization of medical products, prolonging preservation time of agricultural products, etc. Table 1 shows radiation processing facilities and applications in Taiwan.

Table 1. Radiation processing facilities and applications in Taiwan

Facility	Source	Purposes
National Tsing-Hwa University	Cobalt-60 ($3*10^4$ Curies)	R&D
Industrial Technology Research Institute	Cobalt-60 ($4*10^5$ Curies)	R&D
Institute of Nuclear Energy Research	Cobalt-60 (10^6 Curies)	R&D, Service
China Biotech Corporation	Cobalt-60 ($5*10^6$ Curies)	Medical device sterilization, Agricultural products irradiation

Radiography for Non-Destructive Test (NDT)

The total number of licensees for radiography in Taiwan is fifty in 1997 with a total of about 190 radiographic apparatus. The major radioisotope in radiographic apparatus is Iridium-192 with activities ranging from 20 Curies to 100 Curies. Radiographic apparatus for field operation with Cobalt-60 source is gradually being replaced by the users in Taiwan because of the heavy shielding that causes operational inconvenience. In recent years, radiographic apparatus with a selenium-75 source has been introduced by some licensees for thinner welding inspection due to longer half life and lower gamma ray emission in comparison with Irridium-192.

Nuclear Gauges

Nuclear gauges are widely applied in industrial firms and engineering companies for process control, road paving, metal composition analysis and many others. The application for process control includes density measurement, level measurement, weight measurement, thickness measurement etc. Cobalt-60, Cesium-137, Americium-241, Krypton-85 and Strontium-90 are the radioisotopes commonly used in nuclear gauges for process control. The activities of these radioisotopes range from milli Curies to several Curies. The nuclear gauges for process control are usually referred to as fixed type gauges. On the other hand , road paving jobs use portable type nuclear gauges for moisture and density measurement to control soil quality. For moisture measurement, neutron sources of Am-241/Be are commonly used while Cesium -137 is the radioisotope for density control. The total number of fixed type nuclear gauges in Taiwan is approximately 350 and the total number of portable nuclear gauges is approximately 80.

Other Applications .

For gas chromatography, Nickel-63 is used in election captured detectors. Fe-55, Cd-109and Am-241 are the sources for quantitative analysis of elements, such as the measurement of sulfur in oil. Pm-147 and C-14 are the typical radioisotopes to monitor the air quality. Slurry-digging ships use Cobalt-60 source to measure the slurry density in pipes. In 1980s, lightning arresters containing Am-241 source have been introduced by some agents, but they are replaced gradually by advanced devices without radioisotopes. Co-60, Sr-90, Cs-137, Am-241, Cf-252 are the major sources used for calibration of instruments, source activities, film badges etc. Currently, self illuminated devices use beta sources, such as H-3 and Pm-147, to activate the fluorescent materials.

ACADEMIC RESEARCH APPLICATIONS

Research institutions and universities use varieties of sealed and unsealed sources for research and teaching purposes. At present, 34 licensees of sealed sources have been issued and 27 licensees of unsealed sources

have also been issued by AEC. For unsealed sources, H-3, C-14, P-32, S-35, I-125 and I-131 are the major radioisotopes used mostly to serve as tracers for research work in life science.

REGULATION OF NON-MEDICAL RADIOACTIVE SUBSTANCES

Fundamental Regulations

The fundamental regulations in Taiwan concerning the radiation protection are listed as follows:

1. The Atomic Energy Law.
2. Details for Implementation of the Atomic Energy Law.
3. Safety Standards for protection against Ionizing Radiation.
4. Safety Transportation of Radioactive Materials .
5. Regulatory Operation Procedures for Sealed Radioactive Materials.

Licensing of Radioactive Substances

According to the Atomic Energy Law, radioisotopes below certain activity are exempted from the requirements of regulations and radioisotopes above the exempted quantity should apply a specific license. For sealed source with proven sealing conditions, the exemption activity is allowed to raise one order of magnitude. Table 2 shows some commonly used radioisotopes and their respective exemption activities.

Table 2. Exemption Quantities of some radioactive Materials

Radioisotopes	**Exemption Activities (Bq)**
H-3, Kr-85, Tl-201	$5*10^6$
C-14, S-35, Fe-55	$5*10^5$
P-32, Ni-63, Se-75, I-125, Pm-147, Ir-192	$5*10^4$
Be-10, Co-60, Sr-90, Cd-109, I-131, Cs-137, Am-241	$5*10^3$

Every holder using radioactive substances above the exemption quantity should apply a specific license. Before applying for the license, the holder should send appropriate personnel to attend a training course regarding radiation protection and then pass the test held by AEC to receive an operator‘s license. The requirements of application for a license include the operator’s license, the radiation safety documents of the radioactive substances and a radiation protection plan. According to Safety Standards for protection against Ionizing Radiation, a radiation protection plan should at least contain the following contents, such as the managing organization of radiation protection, personnel protection, medical surveillance, area control, radioactive material control, abandonment of radioactive material, treatment of accidents, record keeping, etc.

After reviewing the license applications, AEC will allow the applicator to import or transfer the radioactive materials and set up for testing. The testing report should then be submitted to AEC for further inspection regarding radiation safety, As soon as AEC completes the radiation safety inspection, a specific license will be issued to the applicator. Figure 1 shows the licensing procedures of sealed radioactive materials.

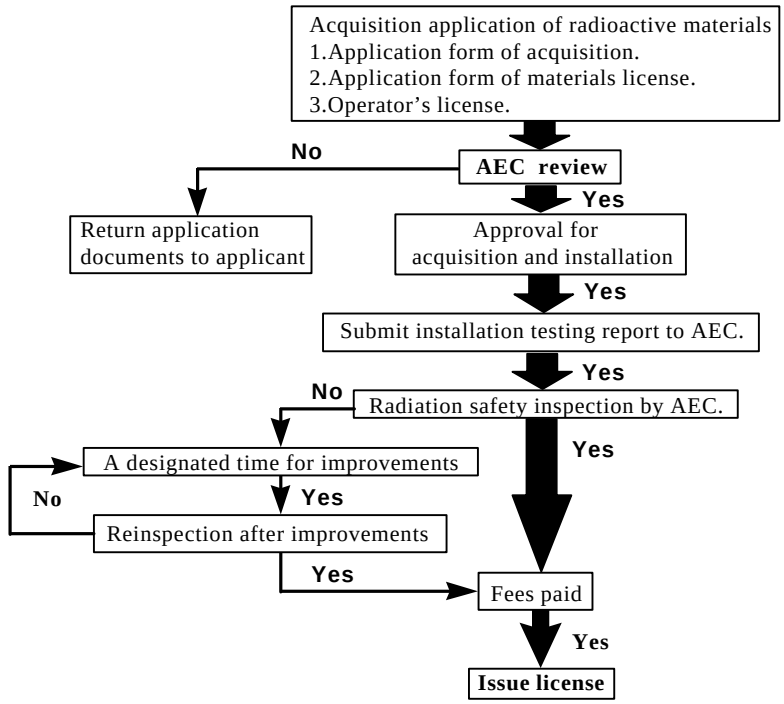

Figure 1. Flow Chart for Licensing Application of Sealed Radioactive Materials.

Abandonment of Radioactive Substances

For sealed radioactive substances that have decayed to certain unavailing activity, the licensee should follow the procedures in the Regulatory Operation Procedures for Sealed Radioactive Materials to abandon the radioactive material. An application form along with a abandonment plan describing the basic information of the radioactive material, packaging and transportation as well as the destination of the radioactive material should be submitted to AEC for reviewing. Under the permission of AEC, the licensee can transfer the radioactive material to the receiver for further treatment and AEC terminates the regulatory control afterwards.

Inspection of Radioactive Substances

According to the Details for the Implementation of the Atomic Energy Law, every licensee should submit a report to AEC every six month describing the status and radiation detection data of the controlled radioactive substances. In order to make sure that all controlled radioactive substances are in satisfactory condition, AEC conducts on site inspection periodically. For convenience of inspection, a checking list is established by AEC for inspectors, The major contents in a check-list includes the consistency of the license, radiation dosimetry and protection, radiation detection and instrumentation, radiation operation area, radiation protection plan, record keeping etc.