

## **The Global Movement of High-Energy Commercial Radioactive Materials (Cobalt-60)**

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### **INTRODUCTION**

Since the establishment in 1946, Nordion International Inc. has grown from a three-person, departmental operation of a Canadian Government-owned corporation into an international, profit-making, private corporation employing more than 500 people at facilities in North America, Europe, and Asia. Nordion serves customers in three major markets; industrial radiation processing, research and nuclear medicine. Nordion's Canadian operation has designed and installed approximately 1,000 irradiation systems (which include high-energy radioactive sources) in over 100 countries. Annually it makes more than 200 export shipments involving high-energy commercial radioactive materials (RAM). The company also serves (in Part) its European customers from its subsidiary, Nordion Europe S.A. located in Fleurus Belgium, while its Asia Pacific Sales office in Hong Kong provides sales and customer support services to the growing Pacific Rim market. (Nordion International Inc., Corporate Profile, 1994). In addition, Nordion uses its extensive network of authorized sales agents and distributors to help ensure prompt and efficient service for Nordion's customers worldwide. The Company is the world's leading supplier of Cobalt-60, the radioisotope most commonly used as a high-energy source in commercial radiation processing operations.

### **PRODUCT USAGE AND SUPPLY MANAGEMENT**

#### **Cobalt-60 Uses**

Cobalt-60 is a well known in medicine as the primary source of high-energy radiation used routinely for cancer treatment. But, there are many other beneficial uses such as surgical gloves and gowns and sutures and needles and scalpels and syringes; the treatment of food products to kill disease causing microbes like salmonella in poultry, to eliminate economically harmful insect such as

Mediterranean fruit fly, to destroy bacteria, yeast and molds in fruits and vegetables, and to extend the shelf life of some products like mushrooms and strawberries. In addition, new applications such as the sterilization of hospital wastes and the sanitation of municipal sewage sludge are emerging. The prospect is that, worldwide, there will be increases use of and demand for high-energy commercial radioactive materials.

### **Shipping and Receiving for Processing**

After neutron activation, the "bulk" Cobalt-60 is shipped from the Nuclear Power Reactor to the processing facility where it is made into commercial sources. The safe transport of Cobalt-60 is essential to the viability of the gamma processing technology worldwide. Producers and users of sources are stringently regulated. Transportation packages are rigorously tested. Specialized equipment is utilized, and carriers are trained specifically for the carriage of radioactive materials. Moreover, the shipping and receiving of the "bulk" product as well as the finished sources are closely monitored, controlled and stringently regulated.

### **Supply Chain Management**

**A Definition** - "An Integrative Approach to Manage the Total Flow of a Distribution Channel from the Source of Supply to The Ultimate User." (The International Journal of Logistics Management, Volume 4, Number 2, 1993). In order to meet customer service objectives while maintaining compliance changing and more rigorous national and international requirements an integrated approach seemed appropriate. Subsequently, we formed and maintain a cross-functional team. The core of the team consists of representatives from purchasing, sales, production, distribution, and installation and service departments. Other internal experts are recruited and used as required. In addition, Third Party Relationships are created with Specialized Carriers and International Freight Forwarders. This cross-functional team makes it possible to ensure that Cobalt-60 shipments are consistently prepared, executed and monitored in accordance with regulatory requirements. For high-energy RAM products, the supply chain does not end with installation in the customer's facility. RAM sources can be recycled and re-used, and eventually they must be disposed of.

## **PRODUCT PROCESSING, PACKAGING FOR TRANSPORT**

### **Cobalt 60 Processing**

A typical "bulk" cobalt capsule contains 99.9% pure Cobalt 59 slugs. The metallic slugs (2.54 cm x 0.63 cm diameter) are nickel plated to reduce the potential for contamination release and are welded into a Zirconium alloy inner capsule. Inner capsules are assembled into reactor target bundles and placed into nuclear power

reactors for activation (conversion of Cobalt 59 to Cobalt 60). After activation, target bundles, now containing approximately 90% Cobalt 59 and 10% Cobalt 60 are extracted from the reactor and placed into a 10 meter deep, water filled storage bay. Under water they are loaded into transport packages which are transported to the Cobalt Processing Facility. Then the bundles are dismantled and the Zircalloy inner capsules are further sealed in stainless steel "outer capsules." The finished product is most often the C-188 Cobalt 60 source.

### **Transport Packaging**

First, a RAM package for Cobalt-60 sources must be designed to a mass, volume and shape that can be easily and safely handled and transported. Second, the RAM package must be designed that it can be properly secured in or on a conveyance during transport. And third, the RAM package must be able: to retain the radioactive material; serve as a shield to reduce radiation to an acceptable level; and promote heat dissipation. High-energy commercial RAM shipping packages intended for international use must meet Type B(U) requirements of the International Atomic Energy Agency (IAEA) Regulation for the Safe Transport of Radioactive Materials Series 6 (1985). In Canada, Nordion's Cobalt-60 shipping containers are tested to include: a free fall test, from a height of one meter onto a rigid hardened steel pin; a free-fall test, from a height of 9 meters to a specially prepared concrete steel surface; and a heat test involving complete immersion in a fire at 800 C for 30 minutes.

### **Safety**

The transportation of radioactive materials is governed by strict national safety regulations based on internationally produced and accepted guidelines. In Canada, The Atomic Energy Control Board's comprehensive regulations and its inspection and licensing systems cover all aspects of Cobalt-60 operation. Nordion thoroughly trains its operating personnel in the proper handling of Cobalt-60 and they follow stringent, well-defined safety procedures. In addition, all carriers and freight forwarders are trained at Nordion's Kanata, Canada, facility in the required aspects of handling, offering for transport, and transport of radioactive materials.

### **REGULATORY COMPLIANCE**

All transports must be compliant not only with the international guidelines but also the national regulatory body. The national competent authority in Canada is the Atomic Energy Control Board. Design, manufacturing, quality control and quality assurance procedures and the product must be approved. For international transport, The International Atomic Energy Agency, Vienna, is responsible for the procuring and maintaining international standards and regulations for the safe transport of radioactive materials. (International Atomic Energy Agency, Vienna,

(1990, Safety Series No. 6, 1985 Edition , As Amended , 1990). The International Civil Aviation Organization deals with the technical instructions for the safe transport of dangerous goods by air as well as the International Air Transport Association which reflect procedures for the shipper and operator by which articles and substances with hazardous properties can be safely transported by air on all commercial transport. In addition, the International Maritime Organization deals with the international maritime dangerous goods code. (International Maritime Organization, London, 1990). All regulatory requirements must be satisfied prior to proceeding with any RAM transport covering any or all of the above modes of transport.

All transports must be compliant not only with the international guidelines but also with the local regulatory body. In Canada, the national regulatory body for transportation is Transport Canada which produces, maintains, and obtains industry compliance for The Transport of Dangerous Goods Act and Regulations. While some sections of this Canadian regulation differ slightly from the international guidelines, it is very consistent with respect to the transport of radioactive materials. However, this logical and coherent situation is frequently not the case internationally. Several countries have additional regulations which are not routinely discussed or otherwise communicated internationally. These unique regulations can be the biggest challenge and barrier to the industry in general, and add to the logistics function in particular. These potential regulatory surprises alone justify the existence of a well-trained and experienced logistics team. They also highlight the need for and importance of networking between logistics professionals and the spirit of sharing knowledge for the good of the whole industry.

## **TRAINING REQUIREMENTS FOR TRANSPORT**

Transport Canada requires that all carriers and freight forwarders, utilized in the offering for transport, and transport of dangerous goods require training in the handling, offering for transport, and transport of dangerous goods. This training is readily available and frequently offered by certified and registered training organizations specialized in dangerous goods. However, often these programs do not allow sufficient time for Class 7 (Radioactive Materials) training. Subsequently, Nordion supplements this with specialty one-day training in Class 7 (Radioactive Material) goods. This training, focuses only on Class 7 (Radioactive Materials) and re-emphasizes and explains the regulatory requirements in detail. The seminar also provides good discussion and understanding of many practical issues not mentioned in the regulations. (Nordion International Inc., Transportation of Dangerous Goods, HOT RAM, Class 7, Only).

## **INFORMATION MANAGEMENT**

The key to establishing a solid logistics network for the global movement of high

commercial RAM sources is in the management of information. While there are significant and formal requirements for the collection and holding of regulatory and quality records, it is the overall management and sharing of key information that paves the way to effectiveness and efficiency. Some examples are as follows:

### **Regulatory Record Keeping**

The consignor of any dangerous good is required by regulation to retain key records pertaining to the global movement of dangerous goods for 2 years or render available 15 days after receiving a written request from an inspector the shipping documentation and any other documentation required by the regulation for the transport of dangerous goods.

### **Information Technology**

Carriers involved in surface transport of specialty products have now invested in technology based information systems. Tracking of vehicles using on board vehicle computers which feed information back via satellite to a corporate dispatch/monitoring station on a continuous or periodic update feed basis are becoming almost essential in order to maintain commercial competitiveness. Usually vehicle location, fuel consumption, delivery status including the estimated time of arrival are constantly monitored. Virtually all country transport industry service providers use electronic data or facsimile transmission of bills of lading and other customs documentation to expedite clearances.

## **THIRD PARTY LOGISTICS**

### **Third Party Partnerships**

Motivated in part by the current economic environment, more companies are forming partnerships with third parties for a wide range of reasons involving a wide range of services and functions. Normally, in the nuclear industry, the processing of radioactive materials by third parties is not feasible due to the high cost of processing facilities, problematic site approval, licensing processes and a myriad of product quality issues. Consequently, only certain services, and functions are usually performed by third parties. Some of these are part of the logistics of the transport and handling of Cobalt-60, specifically, warehousing and international freight forwarding.

### **Warehousing**

Normally, most industrial Cobalt-60 is shipped to offshore locations by the marine mode. This almost always involves on-route warehousing. Most third party warehouses offer and Nordion uses, several standard services as well as storage. Some warehouses can also be contracted to perform tailored services. One tailored

service is the required securing of the Cobalt-60 transport package. The transport package must be transferred from the inland road carrier to an open-top sea container and secured in a specific manner. The warehouse provides knowledgeable labor and supervision, lumber and other tiedown materials to precisely secure the Cobalt-60 transport package into the sea container.

### **International Freight Forwarding**

There may be several reasons why Nordion International Inc. utilizes a freight forwarder for offshore shipments. High-energy commercial Cobalt-60 sources are shipped in large but not numerous quantities. A freight forwarder normally has many clients and therefore can exploit some degree of bulk buying power and justify staff and expertise. Freight forwarders help Nordion to serve its special customers better at lower cost. However, they need to be trained and educated in the unique aspects of RAM transport and logistics. Once we make this educational investment, we prefer to keep the same freight forwarder.

### **PHYSICAL DISTRIBUTION AND TRANSPORTATION**

The movement of large quantities of high-energy RAM packages worldwide is not an easy task. The Physical Distribution and Transportation involves diverse and changing regulations, restrictions on the permitted physical movement of the packaged product. Education of persons not familiar with the product and its characteristics frequently encounter with customs, port safety, and regulatory bureaucrats in different languages, a limited selection of qualified carriers and sometimes deliberate obstruction by officials personally opposed to the nuclear technologies. In order to minimize any delays in the process, key events are addressed prior to shipment.

### **Logistics Planning**

Much work is done prior to the consignment leaving the facility. The logistics planning begins with a customer inquiry or request to purchase Cobalt-60. Contractual obligations, traffic and trade lanes are studied and regulatory peculiarities and obligations reviewed. Depending on the request, the arrangements may be made from shipment ex- works to installation site and return.

### **Transportation Documentation**

Radioactive Material (Cobalt-60) is a controlled regulated product. Consequently, all parts of the logistics process must be documented. *A normal international transport* may require a local inland truck bill of lading, packing slip, shipping labels, commercial invoice, certificate of origin, export customs declaration, and instructions to carrier or freight forwarder.

In addition to the aforementioned, Cobalt-60 transport also requires a copy of the customer site license (the local government's license that permits the customer to possess radioactive material), transport permits and proof of availability of locally and specifically trained personnel and:

- An Emergency Response Plan (form),
- Special placards for RAM (Class 7),
- Export license from the Canadian government for RAM,
- Transport package certificate (proof that the transport meets international safety requirements),
- Proof of Notification (that all relevant authorities along with the final destination have been notified of the shipment),
- Routing Notification,
- Dangerous Goods Declaration,
- Consignor's Certificate (Shipper's Certification that the package and shipment conforms to all international regulations).

The management of this documented information is foremost. The consignment must be identified as a RAM consignment at all times by those who transport it. The customer, freight forwarder, warehouseman, shipping agent, ship first mate or captain, port authorities, competent authorities, and local carriers must all be kept informed.

#### **Disposal-Return of High Energy RAM Sources to Manufacturer**

A sampling of Cobalt-60 sources are returned from field use for routine quality and performance monitoring. Decayed sources are returned for recycling, re-use or disposal. Most countries require licensed installation persons, modal conveyance, carriers and facilities. The return of Cobalt-60 sources is mostly the reverse of the aforementioned process. However, each country has unique regulatory requirements regarding the transport of radioactive materials within and out-of their country. An illustrative difference is insurance. In Canada, non-fissile (not capable of exploding) radioactive materials like Cobalt-60 are not defined as nuclear. In most European countries larger quantities of radioactive material are considered nuclear" whether or not they are fissile. The logistics consequences of this difference is that expensive nuclear liability insurance by an acceptable third party is required to be in place prior to shipment. The insurance question is frequently complex. How much insurance? For what period? Who are the acceptable payees and payors? Who are the acceptable third party insurers? Another difficulty is that not all countries allow radioactive materials within their marine ports. Therefore the carrier choice and trade lane alternatives are limited. Change in port rotation by adding ports that do not want any radioactive materials within their waters on the return voyage often eliminate certain trade routes in which radioactive materials may be transported. Often marine carrier's cargo acceptance is changed without notice due to the unfounded mistrust of the industry

or personal conviction of a leading official. With access to and the cooperation of competent authorities, competent logistics specialists (networking) this mistrust and subsequent restrictions may too be managed.

## CONCLUSION

To quote G.L. Jankowski and C.G. Tapley from their paper Twenty Five Years Experience in Shipping Large Quantity. Low Activity RAM Products - "A greater awareness of the high level of safety in the movement of radioactive consignments should be induced into, at the very least, the transport industry in an attempt to educate workers and prevent problems caused by basic mistrust of these materials". (PATRAM '86 Proceedings, Davos, Switzerland).

While opportunities for global trade and subsequent transport and logistics services are increasing, the ever present public concern regarding the environment and transport industry safety will challenge logisticians. The transport of dangerous goods challenges will be more rigorous if the shipments involve the international transport of high energy commercial radioactive materials. The logistics professionals that thrive on this business are those who focus a dedicated portion of their effort on doing this business well; on forming partnerships and networking. "uneducated" logisticians are often perplexed by the regulatory complexity of RAM transport. They often make errors that make it more difficult for the next shipper to get the job done.

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