

**HOTLAB 2016 Karlsruhe, Oct. 2-6 2016**

**Abstract**

**RECENT EXPERIENCE IN THE SHIPMENT OF  
SENSITIVE NUCLEAR MATERIAL  
USING INF CLASS VESSELS**

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**ABSTRACT**

Published by the International Maritime Organization (IMO), the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Waste on Board Ships (INF Code) sets requirements over and above those of the general maritime regulations specifically with regard to ship design, damage stability, fire protection, structural resistance, electrical supply, health physics, ship management, training and emergency planning.

International Nuclear Services (INS) is a wholly owned subsidiary of the UK's Nuclear Decommissioning Authority (NDA) and currently operates a number of INF Class 3 vessels both on behalf of our shareholder the NDA and on behalf of our subsidiary company Pacific Nuclear Transport Ltd (PNTL). Several of these specialist vessels have during recent years been made available for the shipment of a broad range of nuclear cargoes from research material and radioactive sources to high security Category I shipments with the support of the UK's Civil Nuclear Constabulary.

This paper covers INS's experience of transporting sensitive nuclear material on our INF Class 3 vessels for customers, research centres and governments on a global basis.

**1. Introduction**

The requirement to transport nuclear materials around the world safely and securely has existed since the beginning of nuclear programmes. However, in recent years we have seen growing pressure on operators to demonstrate increasing levels of safety and security, not only from Competent Authorities but equally from NGOs, media and general public perception. Increased attention to the safety & security of shipments of radioactive materials has been driven by many factors, including accidents such as those at Chernobyl and Fukushima, but perhaps above all by the perceived threat of terrorism.

International Nuclear Services (INS) and its subsidiary Pacific Nuclear Transport Ltd (PNTL) have over the last 40 years, safely, securely and successfully transported over 2,000 casks of nuclear material, covering over five million nautical miles. The first purpose-built vessels designed in 1979 to transport spent fuel between Japan and the reprocessing plants at La Hague (France) and Sellafield (UK) were already constructed and equipped in excess of

INF3 standards, the highest level of the INF Code which was to be introduced initially on a voluntary basis some fourteen years later.

Based essentially on the design of the first generation ships and incorporating improvements from 30 years of operational experience, the second generation of ships was introduced from 2008 with the construction and delivery of three new PNTL vessels, Pacific Heron, Pacific Egret and Pacific Grebe.

In addition to the three current PNTL vessels dedicated essentially to shipments of Mox fuel and Vitrified High Level Waste from France and the, UK to Japan, INS also operates an additional INF Class 3 vessel, the Oceanic Pintail, which is readily available to a broad range of customers for the safe and secure shipment of many types of nuclear material.

In recent years there has been an increasing demand for complex and often sensitive nuclear transport operations. At the same time public concern for nuclear safety and security is becoming more acute, with particular attention to the security of nuclear shipments.

The U.S., through its Global Threat Reduction Initiative (GTRI), now known as the M3 (Material Management & Minimization) programme, has in recent years supported further transports of sensitive nuclear materials whilst maintaining an acute focus on the need to maintain and reinforce nuclear security.

INS has responded to this requirement by making available specialist vessels on numerous occasions to transport nuclear material from research institutions around the world to the USA.

For many years purpose-built INF class vessels, particularly the INF3 vessels, were dedicated to specific sectors of the nuclear transport business, in particular the shipment of spent fuel, vitrified waste and Mox fuel between Europe and Japan. Smaller consignments have relied on regular shipping lines and conventional ships or on a limited number of INF1 & INF2 class vessels available worldwide.

The availability of specialist INF class vessels for a wider range of transport operations has in recent years enabled INS to offer to customers on a global basis the many advantages of an INF class vessel, from the outstanding maritime safety features to the capability of Category I security, coupled with the inherent positive public perception surrounding the use of specialised ships.

INS offers a complete nuclear fuel management and nuclear materials transport service for its customers worldwide. This covers design and licensing of packages in multiple jurisdictions, advice on the complexities of nuclear liabilities and international treaty obligations, management of loading, land transport, inter-modal transfer to appropriate vessels, maritime transportation and onward land transport to the destination. This is backed up by comprehensive stakeholder management plans, management of the regulatory interfaces and the necessary 24/7 emergency response arrangements required by international regulations.

## **2. Specific features of INF class ships operated by INS**

The International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on board Ships, or INF Code, became a mandatory addition to the SOLAS regulations on 1<sup>st</sup> January 2001. The Code is divided into three categories or classes of INF vessels:

INF 1 – less than 4,000 TBq

INF 2 – less than 2,000,000 TBq (200,000 TBq Pu)

INF 3 – no restriction on quantity

The INF code imposes specific requirements in the following areas which are graduated from INF1 class vessels for small quantities of radioactive materials to INF3, the highest and most stringent category, for vessels able to transport unlimited quantities of radioactive material:

- Damage stability
- Fire safety
- Temperature control of cargo spaces
- Structural considerations
- Cargo securing arrangements
- Electrical power supplies
- Radiological protection
- Management and training
- Shipboard emergency plan
- Notification in the event of an incident



Photo. Oceanic Pintail

As INF3-class vessels – the highest level of the International Maritime Organization’s INF Code – the vessels we operate have a wide range of safety features, including a double hull around cargo spaces, twin engines and a comprehensive suite of built-in redundancy to all critical operating systems. There is always a back-up system ready to be brought into operation if the need arises.

This safety-in-depth approach extends to the crews, who are the most experienced nuclear cargo personnel in the world. All of our senior navigating and engineering officers hold certificates of competence for a higher rank than the one they serve. Hence, should the ship’s Master for whatever reason be momentarily unable to assume command of the vessel, the second officer is a qualified Captain and would be fully capable of replacing the Master.

The vessels’ design provides an outstanding level of protection to the cargo, in addition to that provided by the material packaging. This protection is provided by impact resistant structures between the two hulls and the duplication of all essential systems to provide high reliability and accident survivability. It also has enhanced buoyancy and additional fire fighting equipment, including a hold flooding system and spare electrical generators. The vessel is designed to remain buoyant and manoeuvrable even with all cargo holds completely flooded.

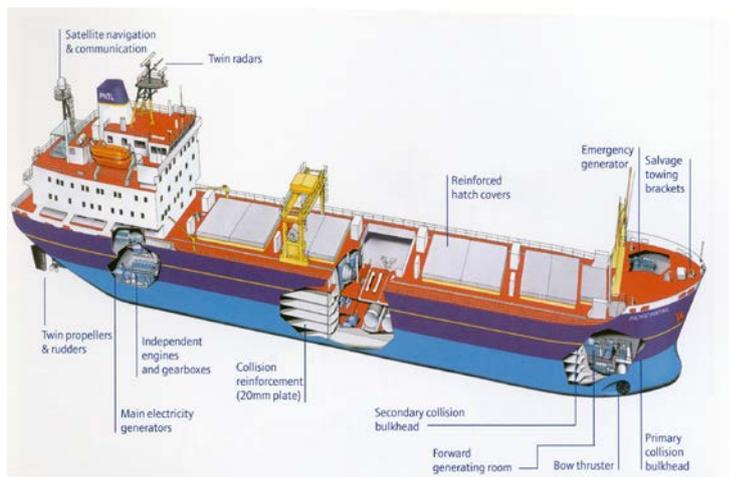


Figure 1: principal features of an INF 3 vessel

In addition to the specialist vessels operated on behalf of our subsidiary PNTL, INS operates another INF3 vessel on behalf of our shareholder the UK government's Nuclear Decommissioning Authority (NDA).

The Oceanic Pintail is available for a wide range of materials and indeed has been used on many of the shipments mentioned above.

Oceanic Pintail has recently undergone extensive refurbishment to broaden the capability of the vessel to cover a more extensive range of flasks and ISO containers, further enhancing the vessel's operational flexibility to meet the requirements of our customers.

Oceanic Pintail's design and operation meets all the relevant regulations for nuclear transports by sea.

As required by the International Atomic Energy Authority, in the unlikely event of an emergency situation developing, Oceanic Pintail would be supported by our in-house emergency response team, which is on 24-hour standby, coupled to the global resources of internationally renowned salvers SMIT-TAK International.

### 3. Recent transport experience

INS has undertaken several shipments of research materials, test reactor fuel and radioactive sources from Europe to the US under GTRI, a cornerstone of U.S. and International policy, as well as the shipments of Low Level Waste (LLW), Intermediate Level Waste (ILW) and High Level Waste (HLW). Some of our recent shipments are listed below:

#### **Early 2011: Shipment of radioactive sources from Europe to USA.**

A number of sources, packaged in American S300 containers and an ISO 20' container were transported to the port of Cherbourg where they were loaded aboard an INS vessel for onward shipment to the USA as part of the GTRI programme.

#### **Late 2011: Shipment of AGR fuel elements from UK to Sweden.**

An A2 Flask containing a number of AGR fuel elements, complete with a trailer and truck combination, was delivered from the UK to Sweden. For the return leg the vessel was loaded with an empty A2 Flask and the same trailer and truck combination was utilised.

#### **Late 2011: Shipment of HLW from UK to Japan.**

3 HLW flasks were loaded in the UK and shipped to Japan. This was the 14<sup>th</sup> such shipment of these flasks from Europe to Japan carried out by INS.

#### **Early 2012: Shipment of plutonium materials between Sweden and the USA.**

In 2012, supporting its customer AB Svafo, INS undertook the marine transport of separated plutonium under armed guard from Sweden to the US for permanent secure storage.

This was the first transport of separated Plutonium under the GTRI programme, carried out with the utmost discretion and on our INF3 vessel, Oceanic Pintail.

This shipment was undertaken on a greatly accelerated timescale and was completed prior to the Nuclear Security Summit in Seoul, Korea. It was held up as an example of Sweden delivering on its non-proliferation commitments at the summit, which was attended by world leaders.

This great success for Sweden and the US, in which INS played a key role, represented a perfect example of how INS contributes to the successful delivery of intergovernmental agreements on the custody and transportation of specialist nuclear materials.

#### **Mid 2012: Shipment of spent MTR fuel and sources from Germany to the USA.**

Three ISO containers loaded with MTR fuel were collected from Germany and safely delivered to the USA.

#### **Mid 2012: Shipment of ILW from the UK to Belgium.**

A consignment of two complete packages, each package comprising 1 x R74 transport flask containing 3 cemented ILW waste drums, truck, trailer and transport frame was successfully transported from the UK to Belgium. This was the first of six identical shipments.

#### **Early 2014: Two shipments of highly enriched uranium and plutonium materials from Belgium and Italy to the USA**

Two separate shipments enabled Belgian and Italian customers deliver on previous commitments to reduce inventories of excess plutonium and highly enriched uranium by safely and securely transporting it to the USA for processing and secure storage.

#### **Mid 2015: MTR from Germany to USA**

#### **Early 2016: Shipment of approximately 20kg of plutonium from Switzerland to the USA**

Plutonium belonging to the Swiss Confederation was removed from the Paul Scherrer Institute and transported to the USA under the M3 programme.

#### **Early 2016: Shipment of highly enriched uranium from Germany to the USA**

More than 135kg of highly enriched uranium was shipped from Germany to the USA, again as part of the M3 programme.

## **4. Security**

The vessels we operate are equipped to meet the physical protection requirements for the shipment of highly sensitive Category I material in compliance with the "International Guidelines INFCIRC 225" published by IAEA. Security regulators from many countries including UK, USA, France, Sweden and Germany have previously inspected the vessels and are familiar with the on-board security features and operational arrangements.

## **5. Conclusions**

In recent years there has been an increasing demand for complex and often sensitive nuclear transport operations. With the development of programmes such as the GTRI and the growing interest in nuclear energy around the world as a means to counter fewer resources and higher prices of traditional fuels, the requirement for maritime transport of nuclear material can be expected to grow significantly.

At the same time public concern for nuclear safety and security is becoming more acute, with particular attention to the security of nuclear shipments.

For many years purpose-built INF class vessels, and particularly the INF3 vessels, were dedicated to specific sectors of the nuclear transport business, in particular the shipment of spent fuel, vitrified waste and Mox fuel between Europe and Japan. Smaller consignments have relied on regular shipping lines and conventional ships or on a limited number of INF1 & INF2 class vessels available worldwide.

The availability of specialist INF 3 vessels for a wide range of transport operations has enabled INS to offer to customers not only in Europe but on a global basis the many advantages of an INF class vessel, from the outstanding maritime safety features to the capability of Category I security, coupled with the inherent positive public perception surrounding the use of specialist INF ships.

The transport operations described in this paper are examples of how the use of a dedicated INF class vessel can meet the requirements of customers and competent authorities, providing unequalled maritime safety, reliability and security, both in real terms and in the perception of the general public and the media.