Development of the INF Code and its relationship to the Ships of the Pacific Nuclear Transport Fleet.

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Abstract Until the adoption of the INF Code as a voluntary instrument in 1993, there were no special construction or equipment requirements, of an advisory or mandatory nature, for ships carrying radioactive materials. Any cargo ship could be used for transporting virtually unlimited quantities of these materials. This paper gives a brief insight in to the development of the PNTL Fleet and the correlation to the INF Code.

1. Background

In 1985, Italy voiced concerns at the Maritime Safety Committee of IMO about the lack of special requirements and a need to ensure adequate fire protection in cargo spaces and damage stability for ships carrying irradiated nuclear fuel, particularly non-purpose built ships. The MSC delegated its sub-committees to consider the matters raised by Italy depending on the area of expertise required. The MSC widened the scope of consideration to include purpose and non-purpose built ships and cover issues such as hold cooling, ventilation and radiation protection. The Sub-Committee on Ship Design and Equipment (DE) was requested to oversee and develop what would become the INF Code. Interestingly, during this process the Working Group on Class 7 (radioactive materials) of the Sub-Committee on the Carriage of Dangerous Goods reported that additional fire protection measures were unnecessary on ships used for the carriage of irradiated nuclear fuel because of the protection provided by the packages used for such cargoes. However, the Sub-Committee would not accept that opinion.

The International Atomic Energy Agency (IAEA) is the United Nations agency responsible for formulating international regulations and standards that are designed to ensure adequate safety in all aspects of the civil nuclear industry's operations, including the transport of radioactive materials by any mode of transport. The IMO adopts IAEA standards in Class 7 of the IMDG Code, which covers radioactive materials. The philosophy of the IAEA is the safety during transport of radioactive materials should be ensured by the package regardless of the mode of transport. Packages containing INF Code materials when designed and tested to IAEA standards are capable of protecting people and the environment in very severe accident conditions without additional protection from the vehicle, in this case, the ship. The eighth session of the IAEA Standing Advisory Group on the Safe Transport of Radioactive Material (SAGSTRAM) took the view that there was no need, on safety grounds, for specific ship design or fire protection requirements to be applied when transporting irradiated nuclear fuel in larger quantities. The Director General of IAEA wrote to the Secretary General of IMO in May 1991 proposing that the risk associated with sea transport of INF be assessed by IAEA in close collaboration with IMO and that modification of IAEA regulations should be considered, if it were found that such risk was indeed more severe aboard ship than on land. This led to the formation of a Joint IAEA/IMO/UNEP Working Group.

The Joint IAEA/IMO/UNEP Working Group sat for two sessions in December 1992 and April 1993 and, amongst other things, was tasked “To study the adequacy of existing provisions for the safe transport of irradiated nuclear fuel by sea. To take into account the impact of marine casualties, such as fire, explosion, or breach of the hull, on packaging integrity. To assess the probability of such casualties occurring.” Both sessions were well attended by representatives from member Governments, intergovernmental organisations and non-government organisations including environmental groups.

The Joint Working Group agreed, by consensus, on the draft INF Code and to extend its coverage from irradiated nuclear fuel to plutonium and high-level radioactive waste. The member states agreed that there was no information or data in the papers submitted to both sessions that would cast doubt on the adequacy of the IAEA regulations. The papers submitted supported the existing experience and knowledge of member states and indicated low levels of radiological risk and environmental consequences from the marine transport of radioactive material.

The INF Code was adopted as a voluntary code by the IMO’s 18th Assembly in November 1993. It contained requirements for: damage stability, fire protection, temperature control of cargo spaces, structural considerations, cargo securing arrangements, electrical supplies, radiological protection equipment, management, training and shipboard emergency plans. It designated ships into the classes INF1, INF2 and INF3 which are each determined by a maximum level of aggregate radioactivity that can be carried, this is unlimited in the case of INF3. The requirements become more stringent for each class.

Following the adoption of the INF Code, a number of delegations at IMO continued to push for the addition of so called ‘complementary measures’ which related to the adequacy of the package design and tests, environmental impact and the consequences of severe accident scenarios, restriction and exclusion of ships from particularly sensitive sea areas, route planning, prior notification and consultation with coastal states, location and salvage of a sunken ship and lost flasks, emergency preparedness and response, liability, tracking of ships by a shore based authority, adequacy of requirements for marking and labelling and securing of flasks. They also pushed for the INF Code to be made mandatory.

In March 1996, at the request of the Secretary General of IMO, a Special Consultative Meeting was held at IMO in London, to which all entities with an interest in the transport of radioactive materials were invited to attend and discuss their concerns.In 1998 the INF Code was amended to include a specific requirement for ship-board emergency plans and notification to the nearest coastal state in the event of an incident. At the same time ‘guidelines’ for the compilation of these emergency plans were adopted.

The INF Code as such, presented no problems to BNFL. BNFL, through its subsidiary PNTL, had operated its own purpose built ships constructed and equipped in excess of INF3 standards, since 1979, fourteen years before the adoption of the voluntary code.

2. Development of the purpose built ship

For the early shipments, BNFL chartered general cargo vessels from James Fisher & Sons, which were converted to carry the types of flasks used for this business. Apart from the actual flask-related equipment the vessels were also equipped with powerful radio equipment and additional fuel oil storage tanks.

In the 1970's BNFL decided to develop a design for purpose-built vessels for nuclear transport which provided enhanced protection for the ships and crews, so increasing the safety and reliability of transportation operations. Following wide consultation with Lloyds of London, The Salvage Association and leading salvage companies,and as a result of Japanese standards developed at the same time, today's PNTL fleet was constructed. Since this time extra equipment has been added in line with technological developments and operating experience to maintain high standards of operational safety.

1979 saw the commissioning of the first purpose-built PNTL ship, the Pacific Swan. Not only did her design take into account the requirements of Japanese Ministry of Transport (JMOT) but also a whole host of added safety features were incorporated.

The ships were to have two principal safety features. First, the hull would be divided into a large number of compartments to form a double hull which surrounded the five cargo holds. This would enable the vessel to remain afloat, stable and able to function after sustaining a quite considerable amount of damage. Second, every essential system and equipment would be duplicated to guard against mechanical failure or damage. This is a principle used in the design of nuclear power plant were there is always a back-up to important systems and equipment. A prime objective for a nuclear materials transport vessel is to 'stay afloat' after sustaining damage from collision or grounding.

The ships are constructed with a double hull The inner shell embracing the cargo space is formed by watertight longitudinal and transverse bulkheads. The structure and sub-division of the hull is designed so that the vessel will stay afloat after it has sustained damage, which is in excess of the extent specified for Class I chemical tankers. The wing tanks formed by this construction are used for normal ballast and trimming requirements except for the tanks abreast of No. 5 Hold which are allocated for holding bilge water. This bilge water is not normally discharged directly to the sea.

The wing tank space is also structurally stiffened so as to prevent impact damage being sustained by flasks within the holds in the event of a collision with another vessel. For the purposes of design the colliding vessel is assumed to be about 24,000 tonne displacement travelling at 15 knots and that it will not enter the cargo area.

The wing space is also used to provide all weather passage-ways on both sides of the ship, immediately below deck level for access to the holds and forward plant rooms. These access ways are necessary for checking the flask securing arrangements in heavy weather and for the routine checking of the hold cooling systems, and radiation surveys. The passages also provide convenient routes for segregating electrical power cables, hold cooling system control panels etc. The sub-division of the hull is preserved throughout the passage ways by the use of water-tight doors.

3. Radiation shielding

The segregation between the cargo space and the normally occupied space is provided by radiation shielding (i.e. energy absorbing barriers) in the form of a water tank extending the full width and depth of the cargo hold at the aft end of No. 5 Hold. The tank is formed by two transverse bulkheads separated by 750mm of water space. The radiation shielding is extended forward from the bridge by concrete overlaid on the deck and beneath the hatch covers.

4. Power plant

The ship's power plant has been designed to provide a high degree of reliability. To this end, all the main plant is duplicated and installed in ways which avoid common mode failures. In addition to the main alternators situated aft, two other alternators capable of supplying all main power are located in a second machinery space forward. In addition there is an emergency alternator capable of supplying all essential functions (navigation equipment, lights, steering gear, fire pumps etc). Power cables are divided along different routes (eg along both sides of the ship) to prevent damage in one area severing supplies.

5. Cargo cooling

The ambient temperature in the cargo holds can be controlled within the limits -40°C to +55°C. This has been achieved by providing two forced circulation air chillers in each hold which reject the heat directly to sea. The chilled air is ducted to distributors low down in the hold and extracted at a high level using axial flow fans.

6. Fire Detection/Fire Fighting

All ships are fitted with a fire detection system covering every space. The cargo holds and machinery spaces can be flooded with fire suppressant gases. Also, the cargo holds can be flooded from an array of water sprays in the top of each hold. Pumps to supply firefighting and hold spray systems are located in both the main engine room and the forward machinery space.

7. Emergency response

Another requirement of the IAEA regulations is an emergency response plan. An amendment to the INF Code of 1993 introduced a requirement for a shipboard emergency response plan, but this was already required by existing regulations.
The BNFL/PNTL ships carried detailed emergency response plans and procedures and the amendment caused no extra burden. Another amendment to the code introduced at the same time, required the nearest coastal state to be notified in the event of an incident. BNFL had always considered this to be a requirement anyway, and its procedures contained instructions to ships' Masters to give such notification, so again the amendment had no effect on policy.

Summary BNFL developed ships in the 1970s whose construction and equipment exceeded requirements for what were later to become INF3 ships. Proposals for special requirements for ships carrying irradiated nuclear fuel were made to IMO in 1985. The original Italian proposals gave the initial impetus to the development of what became the INF Code.

The INF Code was adopted as a voluntary instrument in 1993 and became mandatory on 1st January 2001.