CHAPTER 28

SHIP STRUCTURE AND FITTINGS

CONTENTS

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2801. General

The greater part of a warships structure is steel plating, welded and held to shape by steel frames, beams and longitudinals. The structure is designed to provide:

a. Strength to withstand all the forces acting on the ship under all conditions of service.

b. Buoyancy and stability.

c. Space, protection and accommodation for machinery, stores, equipment and personnel.

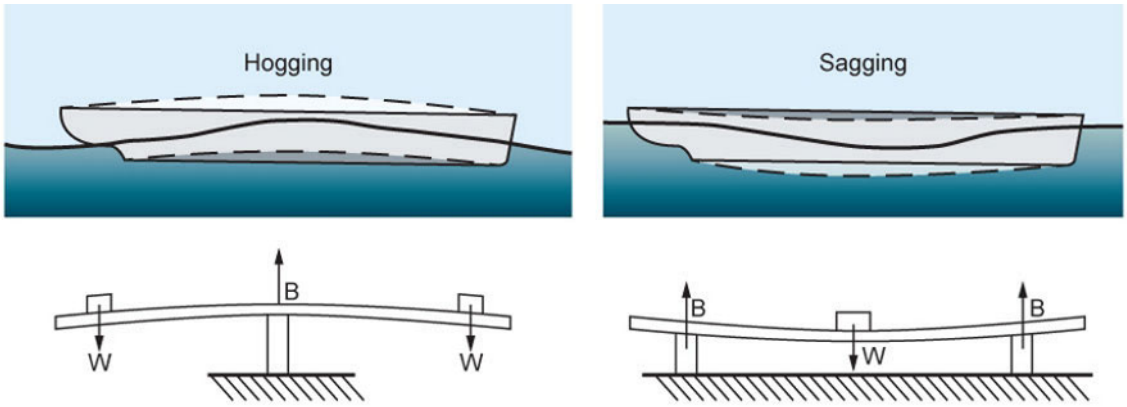
d. Habitability under all conditions of service.

2802. Stresses In Service

The most important stresses met in service by warships are:

a. **Longitudinal**. Stresses in the fore and aft line are caused by the variation in the buoyant forces acting on the ship as a result of the wave action along its length. These cause conditions known as 'hogging' and 'sagging' (see Fig 28-1). The greatest stresses occur in the topmost continuous deck (usually 1 Deck), the vertical and flat keels and the adjoining strakes of plating (garboard strakes) together with the topmost strakes of shipside plating (sheer strake). The bending stresses are usually greatest in the middle of the ships length.

Fig 28-1. Hogging and Sagging

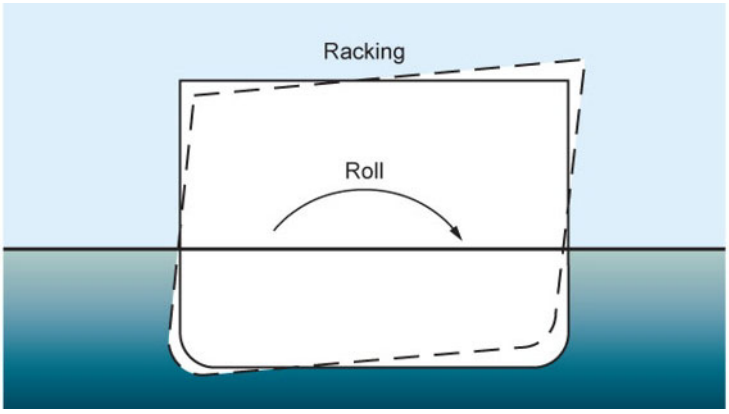


B = Buoyancy **W = Weight**

b. **Racking**. Heavy rolling causes stresses which tend to alter the transverse shape of the ship (Fig 28-2) and are resisted by the main transverse bulkheads and framing.

c. **Local**. Local stresses are imposed by heavy weights eg machinery, weapons, etc, by propeller thrust, the firing of weapons, the landing and movement of aircraft, berthing and docking.

Fig 28-2. Racking



All these stresses are accentuated if the ship is structurally damaged or subject to shock or whip (see Chapter 14).

2803. CBRN and Damage Control (CBRNDC) Design Aspects

There are many features of CBRNDC that influence, or are influenced by, ship design and layout. Among the more important are:

a. Watertight, and gastight, subdivision, openings and fittings.

b. Structural protection and the thickness of plating.

c. Dispersal, siting and layout of equipment, systems and power supplies, and the arrangements for isolation, duplication, and resistance to shock.

d. Ventilation, air-conditioning and air-filtration systems.

e. Nuclear ‘hardening’ of certain electrical systems.

f. Chemical hardening of exposed structure and equipment.

2804. Zoning

Certain RN ships and RFAs incorporate a CBRNDC zoning system. The principles of this system are:

a. Zone end boundaries are coincident with main watertight bulkheads to No 1 Deck and continued up through the superstructure as fire barrier bulkheads.

b. The combined length of any two adjacent zones is not less than 30% nor more than 50% of the waterline length.

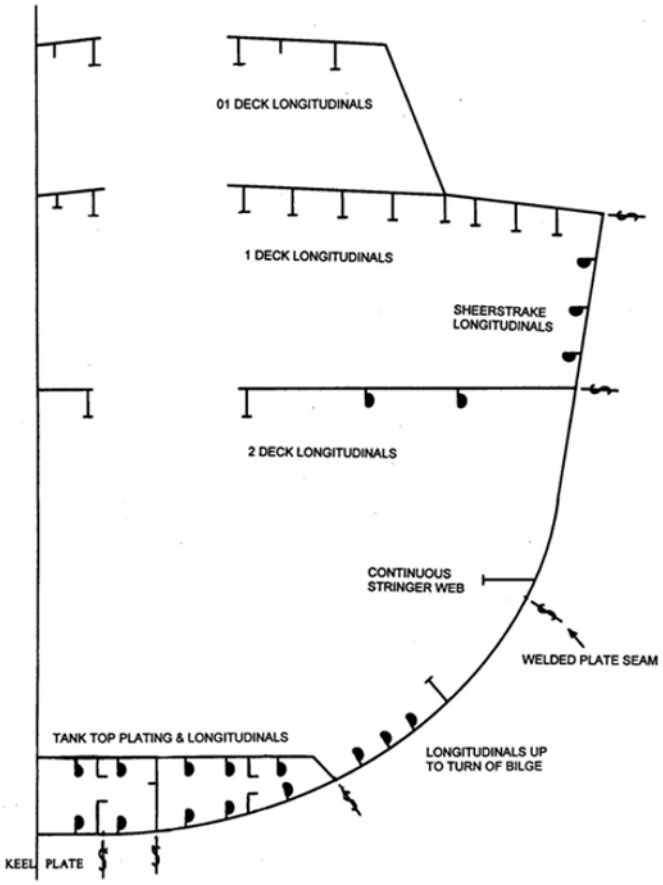
c. If a fire extends over two adjacent zones then essential services (firefighting, sea water, fresh water, chilled water, salvage, electrical power generation and distribution are maintained in the remaining zones.

d. Each zone has its own CBRN filter units (AFUs) and ventilation/air conditioning systems; any emergency cross connections have closures operable from both sides and are normally to remain shut. Smoke clearance arrangements are provided in each zone, crash stopping of fans (AFUs and ATUs) is on a zone basis with restart of AFUs similarly based.

e. Each zone has at least one HPSW pump and the HPSW main has remotely operable isolating valves at zone boundaries.

f. Sufficient domestic facilities are provided in each zone for it to be occupied for prolonged periods in high DC states.

Fig 28-3. Section of a Typical All Welded Frigate



2805. Subdivision

a. Subdivision can be watertight, gastight or non-watertight, as required by the design. Watertight subdivision makes the greatest contribution to the strength of the ship. It is also gastight, though gastight structure is not necessarily watertight. Watertight subdivision localises flooding (and usually fire), preserves buoyancy and provides protection for equipment and personnel. Gastight subdivision is designed to prevent the entry and dispersion of CBRN agents. The amount of subdivision is limited by various conflicting requirements, such as:

(1) Habitability.

(2) Economy in weight.

(3) Ease of supply of weapons to their firing point(s), stowage of fuel and stores, ease of movement.

(4) The piercing of structure by pipe, electrical and ventilation systems.

(5) The size of equipment to be installed, and the need for adequate space for equipment and machinery removal routes.

b. Subdivision is achieved by the following structures:

(1) **Deck and Flats.** These watertight structures divide the ship in the vertical direction (a flat being a short non-continuous length of deck). Weather decks are built with camber and sheer to assist in the drainage of water. The position of the lowest continuous deck in a ship is usually governed by the height of the machinery spaces.

(2) **Main Transverse Bulkheads.** These are strong, watertight, structures that continue as high up in the ship as possible. They divide the ship lengthwise into a number of main watertight sections. The foremost bulkhead extends from the keel to the weather deck in smaller ships, and to a suitable deck well above the waterline in larger ships, and is called the collision bulkhead.

(3) **Main Longitudinal Bulkheads.** In DD/FF and smaller ships these fore and aft, watertight bulkheads are kept to the minimum possible to reduce the risk of flooding on one side only of the ship. Larger ships have longitudinal bulkheads as detailed by the design requirements, eg where local longitudinal strength is required or where additional protection is needed for magazines etc.

(4) **Hull and Inner Bottom.** The part of the hull below the waterline is called the outer bottom. In some large ships an inner bottom is constructed which extend, normally, over an area covered by the machinery spaces and up the ships side abreast of them. Where an inner bottom is fitted the space between it and the outer bottom is called the double bottom, and this is divided up into suitably sized compartments by welded transverse and longitudinal framing.

(5) **Minor Bulkheads.** These are fitted between decks, usually fore and aft, as required to subdivide the main sections and so provide compartmentation for accommodation, stores, passageways, offices, workshops, etc. These bulkheads may be watertight or non-watertight as required by the design. Fig 28-4 shows typical arrangements of subdivision in HM ships.

2806. Openings

a. Structure must be pierced to allow access to compartments, movement through the ship and passage for ventilation trunking, pipe systems, control systems and electric cables. Watertight and gastight integrity depend on:

(1) The design of the openings, which must include arrangements for making them watertight or gastight.

(2) Maintenance of openings and the preservation of structure and fittings.

(3) Control of openings, as required by the watertight and/or gastight condition set for the ship.

b. In the design of a ship, the piercing of watertight and gastight structure is rigidly controlled, especially in the Red Risk Zone where immediate flooding is likely after underwater damage (see Chapter 5). Within this zone main bulkheads are not usually pierced for access, and trunks are built through decks so that access may be gained to most of the lower compartments. Where ventilation and other systems must pierce main watertight bulkheads these are taken through, wherever possible, above the Red Risk Zone. Wherever watertight or gastight structure is pierced, provision for maintaining integrity is made by fitting:

(1) Watertight (or gastight) doors, hatches, manholes, escape scuttles, fixed windows and sidelights.

(2) Watertight slide valves, closures and gas-flaps in ventilation systems.

(3) Watertight glands to rod gearing, electric cables, propeller shafts and rudderstocks.

(4) Bulkhead pieces and stop valves in pipe systems near decks and main bulkheads.

2807. Access Openings

Access openings are in 2 categories:

a. Those in general or occasional (routine) use, eg watertight doors, hatches and manholes, the opening of which are governed by control markings or a special routine or order (see Chapter 5).

b. Those normally kept closed, eg bolted manhole-covers to tanks and double-bottom compartments and emergency escape exits.

2808. Care of WT Closures

a. The proper handling of closures to openings helps to maintain safety and efficiency and reduces the maintenance workload. Much useful information is contained in BR 2203 - Ship Husbandry Manual. The following points are important:

(1) Hatch and manhole covers should never be dropped, but should be lowered, onto their seatings.

(2) Clips on doors must be engaged from above downwards onto the door wedges to make sure that they are not shaken off by vibration or shock.

(3) Clips should be tightened in diagonally opposite pairs using only strong hand pressure. Hammers must never be used for this purpose. If a door, hatch or manhole should be slightly distorted and cannot be made to seat firmly, or to open, by hand pressure on the clips, tubular steel 'Samson bar' (normally stowed adjacent to watertight doors on main watertight bulkheads) should be used to apply the extra leverage required.

(4) When gear is being handled through doors and hatches care must be taken to avoid damaging sills, coamings and rubber sealing strips (gaskets) and their fastenings.

(5) The rubber gaskets in watertight (or gastight) doors, hatches, manholes, escape scuttles, flaps and covers must never be painted, as it will cause the rubber to deteriorate, and degrade the integrity of the closure.

b. Some hatches are fitted with manholes to give access without the need to open the hatch. Such manholes have covers that can be operated from above and below. Manholes in hatches must not be confused with bolted manholes (see Chapter 3).

2809. Access Ladders

Sloping steel ladders give access to spaces approached by a hatch and in constant use eg accommodation spaces, workshops, stores etc. Sloping ladders, with hatches beneath them, are constructed such that they can be 'broken' and hinged back so that they hang down, clear of the hatch below.

2810. Emergency Escape Ladders

Emergency escape ladders (flexible) are fitted where permanent steel ladders are not fitted. They are attached to eyeplates at their upper and lower ends. Emergency escape ladders are to be in position and rigged, in all states of readiness, (except for those which would impede progress through the ship which, in State 3 only, are to be rolled up and stowed). All ladders are to be rigged in an emergency, or individually when required for use. When ladders are stowed they are to be secured by 5 mm polyester line and held by a slip knot.

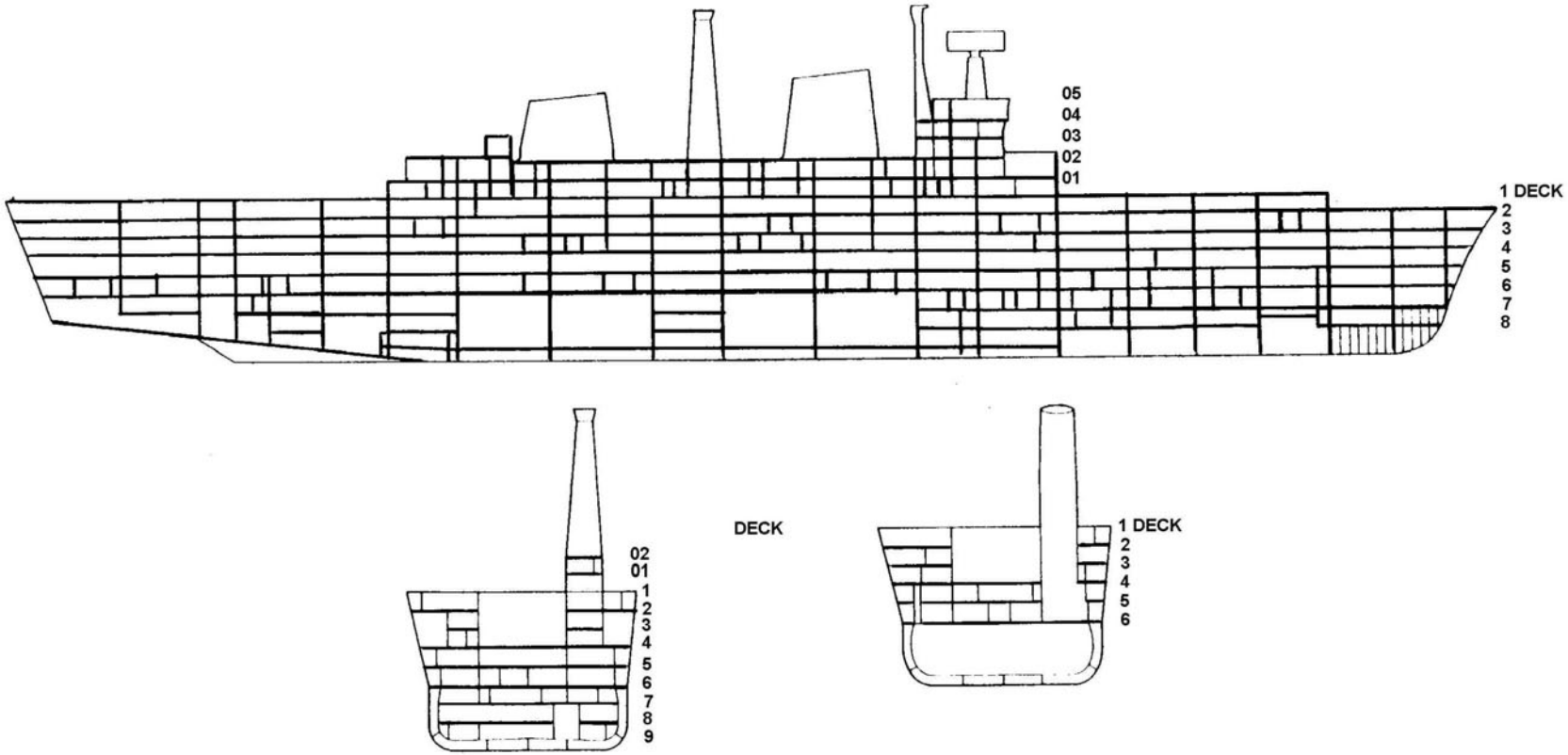
2811. Control of Openings

However efficient the design and maintenance of openings and their closures, watertightness and gas tightness ultimately depends on the strict control over all openings which pose the risk of spread of floodwater or the entry of CBRN agents. The organisation for this control is given in Chapter 5.

2812. Air Escapes

Air escape pipes rise from the crowns of all compartments which contain liquids or are fitted with flooding arrangements; those from adjoining compartments are sometimes grouped together. Air escapes must terminate outside the Red Risk Zone and those from magazines and compartments containing flammables must be fitted with wire gauze filters as a fire precaution. Care must be taken in maintenance to ensure that the perforations at the outboard ends of air escapes are not obstructed, for instance, by paint. As a CBRN precaution, air escapes to freshwater systems and magazines are sited within the citadel. Magazine air escapes have automatic valves that open only when the amount of flood or spray water in the compartment is enough to cause a predetermined increase in pressure.

Fig 28-4. Profile and Sections of Large Warship



2813. Structural Integrity

Watertightness and gastightness can be impaired by:

a. Corrosion.

b. Perished, worn, or painted rubbers on closures to openings.

c. Distorted closures to openings.

d. Defective glands to rod gearing, electric cables and pipes.

e. Unblanked holes such as redundant cable glands, screw and boltholes etc.

2814. Preservation of Structure

The strength, watertightness and gastightness of a ship can be seriously impaired if corrosion is not prevented in its structure. BR 2203 - Ship Husbandry Manual gives detailed information on this subject. However the following points should be borne in mind:

a. Accumulation of water should be prevented, especially where different metals are in contact in the water. Heat accentuates any adverse reaction caused by these conditions.

b. Any liquid flowing from copper pipes must be run clear of aluminium structure and fittings.

c. Strong alkalis, such as caustic soda, must not be used for cleaning structural materials, particularly aluminium.

2815. Structural Protection

The protection afforded by structure depends upon the thickness and composition of the plating. Much of the protection required for equipment is gained by siting it below the waterline, below the superstructure and, in larger ships, behind longitudinal bulkheads. This also applies to the protection of personnel from blast and radiation hazards.

2816. Fire Barrier Insulation

Bulkheads and decks forming the boundaries of high risk compartments in some ships have a layer of fire barrier insulation applied to them. Care must be taken to preserve the fire barrier properties of these boundaries throughout the life of a ship. Any insulation that is removed or damaged during refit work, etc, must be reinstated as soon as possible.

2817. Classification of Fire Barriers

In RFAs and other vessels built to comply with Safety of Life at Sea (SOLAS) and Maritime and Coastguard Agency (MCA) requirements, the following definitions are used:

a. **Class A Divisions.** These are bulkheads and decks made of steel or equivalent material capable of preventing the passage of smoke and flame to the end of a set time period. Insulated with an approved non-combustible material, the average temperature on the unexposed surface of the panel will not rise more than 140°C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 180°C above the original temperature within the time interval.

The divisions are classed to indicate this interval, eg an A60 bulkhead will not exceed the stated temperature rise in 60 minutes or an A30 bulkhead will not exceed the stated temperature rise in 30 mins.

b. **Class B Divisions.** These need not be made of steel but must be of non-combustible material (with the exception that combustible veneers may be permitted) and must prevent the passage of flame to the end of the first 30 mins of the standard fire test. They are insulated such that the average temperature on the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225°C above the original temperature within the time interval. The divisions are classed to indicate this interval, eg a B-15 bulkhead will not exceed the stated temperature rise in 15 mins.

c. **Class C Divisions.** These are non-combustible materials. They meet neither requirements for the passage of smoke and flame nor limitations to the temperature rise.

d. **Non-Combustible Material.** A material which neither burns or gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C. This does not mean that the material will not combust if subject to higher temperatures.

2818. A60 Structure - Boundary Monitoring and Cooling (Reference: SOLAS Regulations Consolidated Edition 2009).

a. A60 structures are designed to prevent the passage of smoke or flame for a given period. For the RN this means that a lower containment priority can be given to these boundaries than non protected or damaged structures. Other insulated boundaries exist (eg B15) however **'A' rated boundaries should be the only boundary where lower containment priorities are applied.**

b. A60 boundaries are to be clearly marked on ship's drawings and general arrangements. A60 boundaries are to be marked on Incident Boards, Kill Cards and within DSAC/PMS systems, however where this is not the case ship's drawings should be readily available within HQ1 and the Containment HQ.

c. Whilst it remains the decision of HQ1 (and Containment HQ) what the priority boundaries are, A60 boundaries may be directly labelled to assist personnel engaged in boundary cooling with their identification. A sticker in the form of a **RED** rectangle containing 22 mm high **WHITE** lettering 'A60' or 'A60 Behind' (where a bulkhead is obscured by equipment mounted directly on it or on the deck adjacent to it) should be applied (see Table 3-1).

d. **A60 Escape Routes.** Where platforms are fitted with A60 protected escape trunks, such as in RCOPV Main Machinery Spaces, it is important that the capabilities and limitations of these facilities are widely understood and regularly exercised. These facilities may also allow a Re-Entry Team to enter low into a compartment (see sub para f below on Vertical Access Trunks).

e. **A and B Class Definitions.** The overarching regulations for A and B class divisions are at Reference. 'A' class divisions are defined as follows (see Reference):

(1) 'A' Class divisions are those divisions formed by bulkheads and decks which comply with the following criteria:

(a) They are constructed of steel or other equivalent material.

(b) They are suitably stiffened.

(c) They are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature within the time listed below:

- Class A-60 60 mins (against standard fire test).
- Class A-30 30 mins (against standard fire test).
- Class A-15 15 mins (against standard fire test).
- Class A-0 0 min.

(d) They are so constructed as to be capable of preventing the passage of smoke and flame to the end of the one hour standard fire test.

(e) The Administration (International Maritime Organisation) requires a test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code to ensure it meets the above requirements for integrity and temperature rise.

Note. *The principles in this section can be applied to 'A' rated boundaries. Additionally, it should be noted that some A60 doors in service fail to meet these regulations for preventing the passage of smoke (see specific platform BRd 2170 Vol 7 for further details).*

(2) 'B' class divisions are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following regulations:

(a) They are constructed of approved non-combustible materials and all materials used in the construction and erection of 'B' class divisions are non-combustible, with the exception that combustible veneers may be permitted provided they meet other appropriate requirements of the Reference.

(b) They have an insulation value such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature at any point, including any joint, rise more than 225°C above the original temperature, within the time listed below:

- Class B-15 15 mins (against standard fire test).
- Class B-0 0 mins.

(c) They are so constructed as to be capable of **preventing the passage of flame to the end of the first half hour of the standard fire test.**

(d) The Administration (International Maritime Organisation) required a test of a prototype division in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity and temperature rise.

Note. *The principles in this section should not be applied to 'B' rated boundaries under any circumstances. 'B' rated boundaries do not provide sufficient mitigation to relax boundary cooling requirements and only offer a notional level of integrity sufficient to give time for the establishment of protection in adjacent compartments.*

f. Procedural Considerations when Dealing with A60 Boundaries

(1) A60 boundaries will be fitted with either an A60 domestic type door or a watertight/gastight door (perhaps also with an A60 rating). An A60 boundary has considerable merit as a point of entry to the incident however the following circumstances might guide boundary selection:

(a) Establishing a boundary on an A60 bulkhead where a more appropriate non 'A' rated bulkhead exists could lead to excessive loss of real estate. This may be a conscious decision if to do otherwise might require excessive resources to undertake containment.

(b) If the smoke hazard generated by the incident is so significant that passing of smoke from within the boundary into the FCP cannot be managed (eg when a domestic type A60 door is the point of entry and is passing excessive smoke) a more suitable smoke tight division (ie watertight or gastight door) should be used. Under extreme circumstances, eg where capability would be placed at risk by a FCP re-location, then it may be acceptable to move the FCP but keep a sentry in BA to monitor the integrity of the A60 boundary. Some platforms may apply mitigation to smoke leakage by domestic type A60 doors, such as taping of seals but in general terms this should be discouraged (this is a particular issue on MCM, P and H vessels and is an accepted practice given the small real estate and the impact of loss).

(2) Modern ship designs, eg RCOPV, QEC and T26 have Vertical Access Trunks (VATs) between decks and these may be used as point of entry to the smoke boundary (an effective airlock if managed correctly) however conditions with the VAT should be closely monitored. In the case of VATs and re-entries from the same level, smoke curtains remain vital even when boundary is not being transited.

(3) A60 doors/bulkheads may be considered as low priority by Containment Parties, but should always at least attract a sentry (roving if necessary); with A60 the emphasis becomes boundary monitoring rather than active boundary cooling. The ability to monitor will allow one person to manage several compartments and dependant on the extent of the A60 boundary, 4 Boundary Coolers could be deployed in the monitoring role (one fwd, one aft, one above, one below). However, as many incidents will still require active boundary cooling this approach, by itself, should not be used as justification to reduce numbers of boundary coolers in the HFEP and SSEP. A60 will delay the commencement of active boundary cooling with water such that it may be possible to defer isolation of electrical supplies to navigationally critical or mission essential equipment.

(4) In the initial stages of any incident good communications between the Containment Party I/C, Deck Managers and the Boundary Coolers is necessary to confirm which boundaries are A60. Despite the fact that A60 markings exist on bulkheads and doors, priorities should be discussed, cross referencing markings, Kill Cards and DSAC/PMS (drawings if appropriate) before priorities are agreed. Until these priorities can be agreed active boundary cooling should be assumed.

(5) Due to the requirement to conduct TMS for some incidents, it may be necessary to cut insulation away from A60 boundaries to establish correct boundary temperatures. It should be noted that the aim of TMS is most often to establish conditions internal to the compartment and unless this insulation is stripped back a false reading could result.

Note. *Some platforms (eg RCOPV) have insulation on the inside of the Main Machinery Spaces and TMS procedures require modification to overcome this (refer to specific platform BRd 2170 Vol 7 for further details).*