

APPENDIX 4.3  
(referred to in paragraph 4.21)

**Naval construction standards and the differences between  
merchant and warship hull structures**

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1. The requirements for the design of warships differ substantially from those for merchant ships because of their very different roles. Merchant vessels operate in general outside war zones and are optimized for maximum economy in their operations, carrying their cargoes in peaceful conditions where hostilities arise primarily from the weather and the ravages of the sea. Warships not only have the weather and sea to contend with but also the effects of weapons of war and are optimized for their ability to fight and survive in those hostile conditions. Consequently many aspects of warship design have to comply with a different set of standards from merchant vessels.

2. The most obvious example is the structure of the hull. A common expectation is that warships are constructed of very heavy steel plate with thick armour to withstand the impact and explosive power of incoming weapons. In the early part of this century there were ships in the Royal Navy so constructed—battleships and cruisers. In the same period there were also warships with structures more akin to those found throughout the fleet today—destroyers and frigates, which were not armoured and had quite a light steel structure.

3. The requirements for warships have changed considerably with the changing technology of the weapons systems against which they must defend themselves and which they must also be designed to carry for their own fighting functions. Old-style massive armouring of the whole hull is no longer appropriate and consequently the hull is no longer armoured in any vessel currently in the fleet. Great emphasis is now placed on stealth, speed and manoeuvrability, resistance to nuclear and chemical weapons and resistance to underwater explosions in addition to the basic requirements for survivability such as watertight subdivision and damage control. A modern form of armour (not necessarily steel) still has a limited role in protecting certain critical areas in the ship from the effects of high velocity fragments but now adds only a small amount to the weight of the hull.

4. Most modern warships need to be designed to minimize the weight of the hull structure and to reduce its size and its detectability as much as possible. Hulls are closely subdivided to enhance the ship's ability to withstand damage both above and under water and to remain afloat and stable. Hulls are designed to withstand the effect called 'whipping' which results from attack by modern torpedoes and can lead to the ship breaking its back. Account must be taken of the effects of the shock wave from underwater explosive attack from torpedoes and mines. Superstructures are designed to withstand the blast over-pressures produced by nuclear explosions and the launching of the warship's own weapons.

5. The strongest and lightest structures to achieve these aims are complex constructions of stiffeners and relatively thin plating (typically 10 mm to 20 mm thick in frigates) supported by closely spaced bulkheads all built to precise specifications for the materials, the welding and the structural details. Whilst the shape of the hull is simplified as much as possible to enable some use of automated construction methods, the requirements for sea-keeping (minimizing motions in rough seas) and stealth (reduction of underwater noise and above-water radar detectability) result in complex hull geometry making most of it unsuited to the mass production methods and tools used for merchant ship construction where large flat panels predominate.

6. The requirements for warship hull design and construction are laid down in a series of MoD documents which call up established commercial standards wherever appropriate but inevitably contain special requirements as illustrated in this hull example. These documents form but one section of a whole range of specifications covering all aspects of the warship's special requirements for design, construction, testing, setting to work, upkeep and support referred to generically in this report as 'naval standards'.