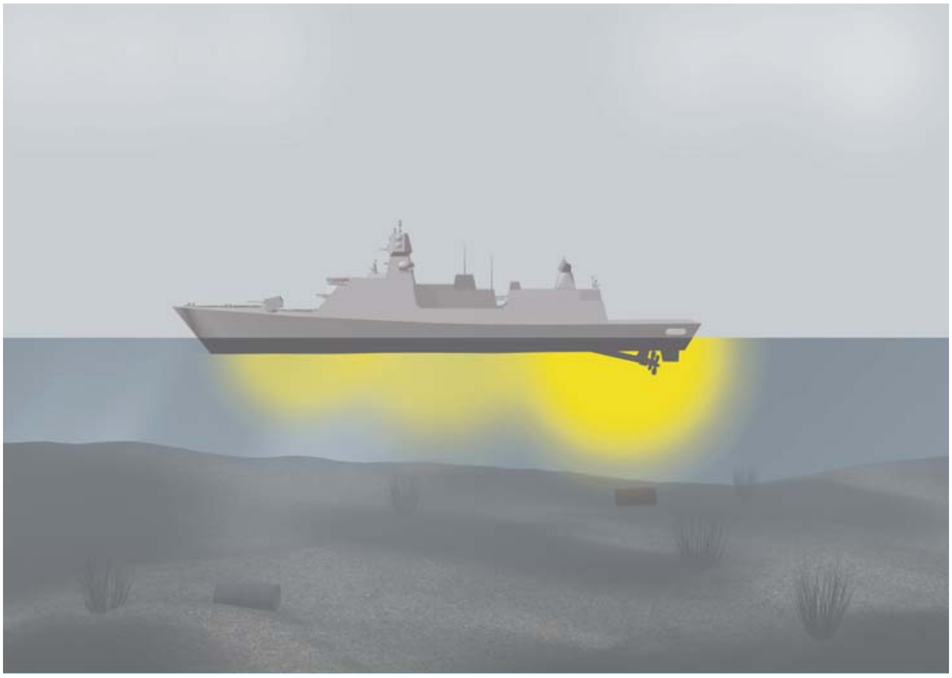
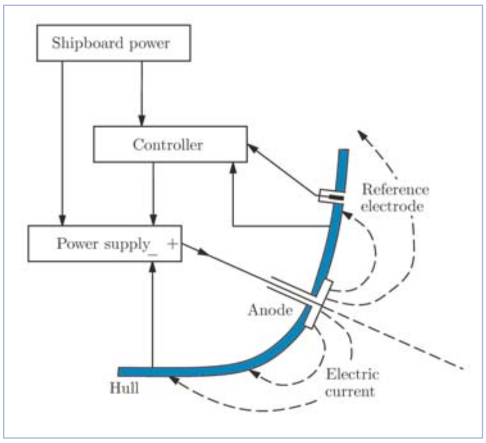
Electromagnetic signature prediction due to the Cathodic Protection System

The cathodic protection system contributes significantly to both the static electric and static magnetic signatures of a ship.
In this study we develop a model to predict the contribution of the cathodic protection system to the electromagnetic signature. In a second stage, this model can be exploited to optimize the cathodic protection system such that the electromagnetic signature is reduced while corrosion protection is maintained.





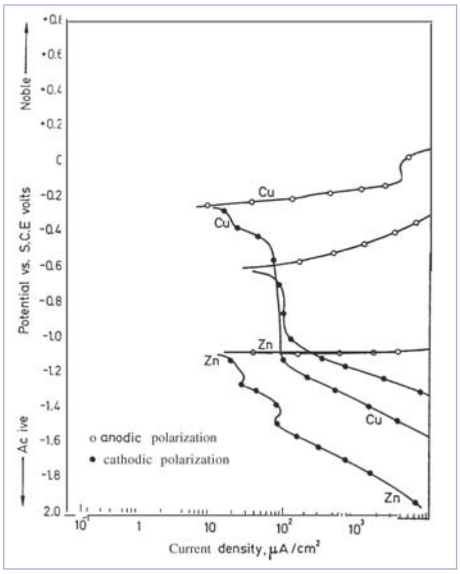
Control system for the Impressed Current Cathodic Protection System

The cathodic protection system

To protect a steel-hulled ship against corrosion, the surface is covered with a coating layer. At places where no coating is possible, e.g. the propellor, or where the coating is damaged, an additional protection system is necessary: the cathodic protection system. The cathodic protection system uses electric currents which flow from anodes through the seawater back to the ship's surface and inhibit the natural corrosion process. Two main types of cathodic protection systems are in use: passive and active systems. In a passive system, the anodes are lumps of zinc or aluminum, galvanicly connected to the steel hull. When the lumps are dissolved, divers need to install new ones. An active system uses impressed currents flowing out of platinum anodes. The impressed current cathodic protection system (ICCP) offers full control. It is possible to use fixed current settings but it is usually driven by a control system which uses a reference electrode to measure the potential difference between the seawater and the hull.

Polarization data

Under normal conditions the hull is well protected against corrosion when its electric potential lies in the range [-1000 mV, -800 mV]. In this convention, the potential of the seawater is zero. The non-linear relationship between potential difference and current density at the hull's surface, is described by a so-called polarization curve. The polarization curve depends on the seawater composition and on the type of steel and coating. Moreover, depending on the quality of the coating, the polarization curve may vary along the hull and may gradually shift in the course of time.



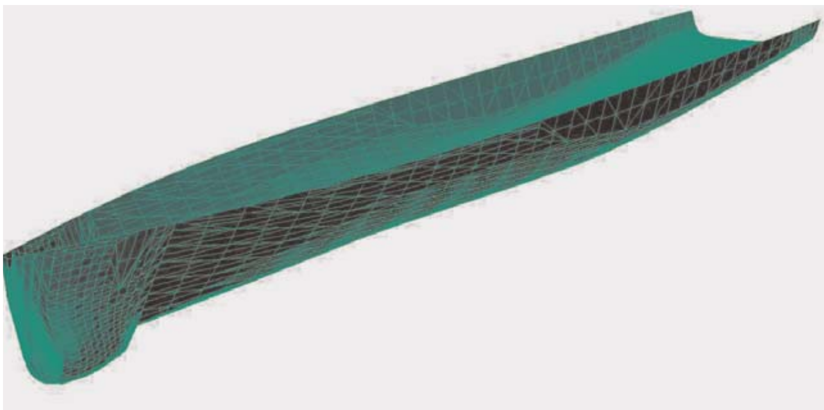
Polarization curves for zinc, steel and copper. Reproduced from Corrosion Vol. 39, No. 5, May 1983. (Published by National Association of Corrosion Engineers)

ICCP signature prediction tool

To model the current distribution outside the ship, the Boundary Element Method (BEM) is exploited. To this end, the hull, the anode and the propellor surfaces are divided into small surface elements. In addition, the air-sea and the sea-seabed interfaces as well as the polarization curves have to be included in the model. An iterative calculation method results in the potential distribution.
In subsequent steps the current distribution and the static electric and magnetic signatures are obtained.

Optimization of the cathodic protection system

The signature prediction tool enables us to consider various designs for the cathodic protection system. Particularly, for a given geometry (hull shape, propellor surface and material choice) and environment (seawater and seabed conductivity and water depth), the number and location of anodes can be varied as well as the individual anode currents. For each design the potential difference along the hull and the electromagnetic signature can be computed. Hence, by introducing an optimization shell, a cathodic protection system can be obtained with minimum electromagnetic signature.



Triangularizaton of the M-Frigate for BEM modelling

TNO Defence, Security and Safety

'TNO Defence, Security and Safety' is the title under which TNO operates as a strategic partner for the Dutch Ministry of Defence and makes innovative contributions to enhancing the security of the Netherlands both at home and abroad. We also use our accumulated knowledge for foreign governments and for defence-related industries.

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