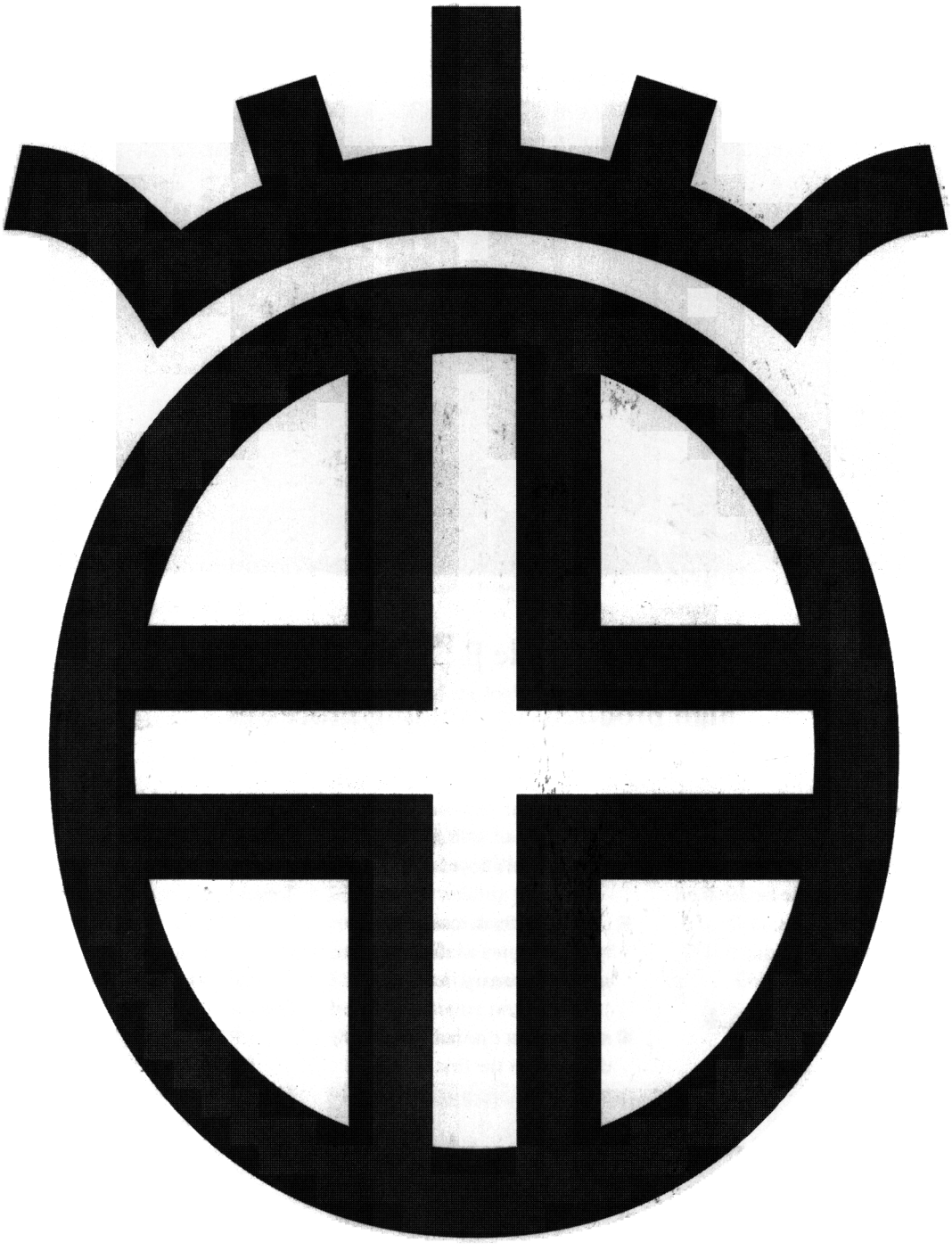


STEELS FOR SHIPBUILDING:

NEW GRADE E FOR HIGH PRODUCTIVITY WELDING PROCESSES

THE PETRONAS LNG TANKERS

DILLINGER HÜTTE GTS

New Grade E : Steels for high productivity welding processes

The Petronas LNG tankers

On the 13th of February 1991, Petronas Marine, the national oil company in Malaysia, ordered to Chantiers de l'Atlantique (GEC Alsthom group) five LNG tankers.

Each carrier ship has 4 tanks allowing the transport of 130 000 m³ of liquified natural gas under a pressure close to the atmospheric pressure and at a temperature of -163°C. The tanks are of "INVAR membrane" type according to the patented process of the french company Gaz Tansport.

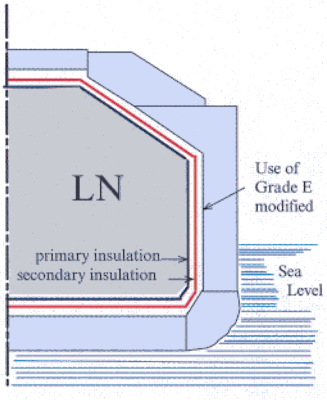
Each tank is completely insulated from the ship's double hull and shows the following structure (from outside to inside):

- a 300 mm thick insulating layer named "secondary insulation" made of plywood boxes filled with expanded perlite.
- a watertight "secondary barrier" made of INVAR strips (36% nickel alloyed steel).
- a 230 mm thick insulating layer, designed as the first layer, named "primary insulation".
- a watertight "primary barrier", designed as the first barrier, is attached to the primary insulation.

Steel plates delivered by Dillinger Hütte GTS

Tons:
77 275
Delivery period:
Dec. 91 to Janv 96
Grades:
LRS-A/B/D/D Z25/E
E modified/CMnLT60-410
Thicknesses:
6 to 65 mm

LNG tanker double hull cross section



Grade E modified

This is a Grade E complying with the Lloyd's Register of Shipping requirements.

Its reduced and optimized chemical analysis leads to an excellent behaviour under high energy welding conditions (3.5 kJ/mm to 27 kJ/mm) enabling the shipbuilder to make significant productivity gains.

Use for the Petronas LNG tankers construction

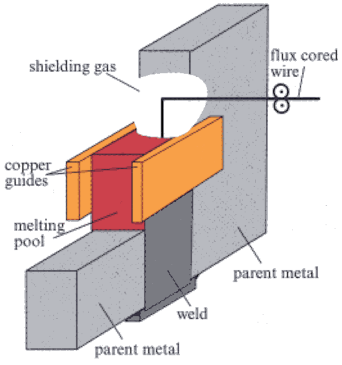
About 7 500 tons of Grade E modified, thicknesses 14 to 19 mm have been delivered by Dillinger Hütte GTS (Dunkerque mill) for the 5 LNG tankers double hull construction.

The Grade E modified has allowed to obtain a heat affected zone (HAZ) with excellent toughness level despite the use of high energy welding.

The welded joint impact requirements were as follows:

- for a 5 kJ/mm heat input: 27 J average value at -33°C.
- for a 9 kJ/mm heat input: 27 J average value at -26°C.

Electrogas welding process (EGW)



Actual savings

The target of the high energy welding process (electrogas type: EGW) was the welding time reduction.

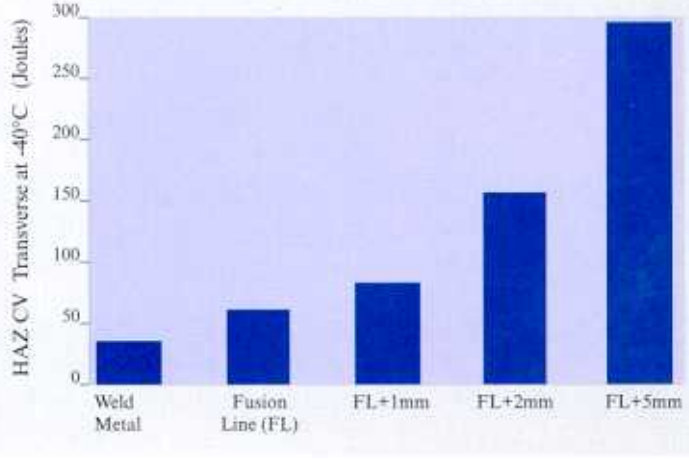
This welding time has been significantly reduced thanks to the high energy welding process enabling to increase the filler metal deposition rate.
For steels not designed for this purpose, a higher productivity would have led to a very important toughness drop in the heat affected zone. This drop is such that for traditional steels, the minimum impact requirements cannot be fulfilled.

Due to the use of Grade E modified, it has been possible to comply with these requirements.
The welding of such steel has allowed Chantiers de l'Atlantique to make substancial savings which are in general about 150 F/t to 350 F/t depending on the thickness range to assembly, and depending on the welding energy and the welding joint length.

Grade E modified - thickness 18 mm

C : 0.080 %, Mn : 1.490 %, P : 0.014 %, S : 0.002 %,
Si : 0.200 %, Al : 0.026 %, Ti : 0.010 %

Electrogas process (EGW) - Heat input = 9.0 kJ/mm
Filler metal : flux cored wire DWS 43 G (KOBE STEEL)



THE FEATURES OF THE LNG TANKERS

Steel plates supplier :	Dillinger Hütte GTS (Dunkerque mill - France)
Shipyard :	GEC Alsthom Chantiers de l'Atlantique (St Nazaire)
Shipowner :	Petronas Marine (National oil company of Malaysia)
Length :	272 m
Width :	43.30 m
Maxi draught :	11 m
Speed :	21 knots
DWT :	62 000 t
Maxi loaded displacement :	90 000 t
Number of crew :	36
Number of cabins :	44
Autonomy :	7 500 nautical miles

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