



Off to the Caribbean, the largest cruise liner in the world!

by Juha Lukkari, ESAB Oy, Helsinki, Finland

The world's largest, most beautiful, most luxurious and most expensive cruise liner was delivered to her purchaser, the US shipping company Royal Caribbean Cruises Ltd., on 29 October 1999 at Kvaerner Masa-Yards New Shipyard in Turku.

Order for three ships

In November 1996, Royal Caribbean Cruises Ltd. and Masa-Yards agreed on the objective of building one or possibly two cruise liners at the new shipyard in Turku. The contract for the first ship was signed in January 1997 and the option to buy a second ship became a confirmed order in March 1997. At the same time, an option to buy a third ship was agreed on and it was subsequently ordered in January 1998.

The production of the first ship started in September 1997 and the launch took place on 27 November 1998. Now complete, she is already being used for luxury cruises in the Caribbean. The ship was named the *Voyager of the Seas*.

The second of the sister ships, the *Explorer of the Seas*, was delivered in September 2000 and the third, the *Adventure of the Seas*, will be delivered in the autumn of 2001. The total cost of these three ships is an

enormous EUR 1.4 billion (£850 million) and 80% of the materials and labour come from Finland. The family of ships is what is known as an Eagle series.

So the cost of one ship works out at about EUR 0.5 billion (£283 million). The building of the third ship started at the end of August 1999 and her steel work will be ready in December 2000. The direct employment impact of one ship is about 15,000 man-years, the majority of which are being done by Finnish shipyard workers and external small and medium-sized subcontractors.

Huge welding job

If the ship is luxurious, it follows that the welding work is huge. The steel in the ship's hull weighs more than 25,000 tonnes and only accounts for about 10% of her total cost. The ship is made up of about 300,000 individual steel components (plates, beams and so on).



Steel work in the dining room under construction and fully furnished.



Some 450 welders are currently working at the shipyard. The ship is classified by Det Norske Veritas (DnV).

Well over 500 tonnes of welding filler metals were used on the ship with the following breakdown between the various welding processes:

MAG welding with flux-cored wire	67%
Manual metal arc welding	17%
Submerged arc welding	13%
Others	3%

The similar ships involved in the order make up a small series and therefore facilitate production in a number of ways: the same job instructions, fasteners, protective canopies and so on, as well as training and experience in general.

Cored wire rules

Cored-wire welding is the most widely used process, as the consumption breakdown shows. The process is already being used almost to its maximum. All the cored wires are welded with shielding gases, either mixed gas or carbon dioxide, so the principal welding process is MAG welding with cored wire. It is performed both manually and by utilising various mechanised carriers (rail-mounted and tractor carriers), other mechanised equipment and robots.

Submerged arc welding is carried out at a number of large work stations and lines, including one-sided

welding stations, the stiffener welding station, T-beam manufacturing stations and with tractors. The processes used are single wire, twin-arc wire, tandem and three wire. Most of the wires are solid, but some submerged arc welding is carried out with cored wire.

Some stick electrodes are still required, as the consumption figures show. Electrodes are mainly used for all kinds of outfitting welding.

Standard MAG welding with solid wire is not used at the shipyard and in fact never has been. As welding technology developed, the shipyard moved directly from electrode welding to MAG cored-wire welding; the change mainly took place during the 1980s.

Hundreds of tonnes of aluminium were used on the top decks, which were welded almost exclusively using the MIG process. The aluminium alloys are AA 5083 (AlMg4.5Mn) and AA6082 (AlMgSi1).

The most important and widely used ESAB welding consumables were, in order of importance:

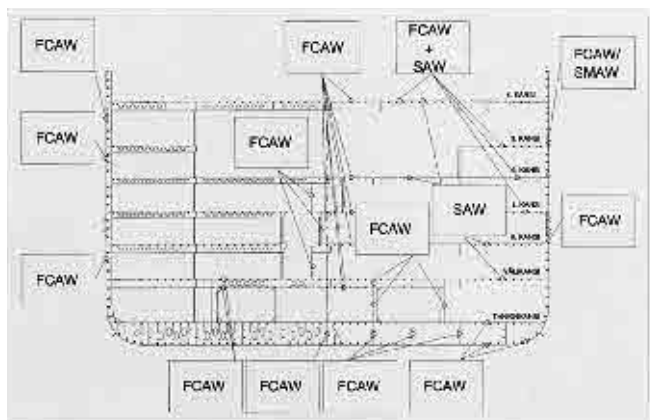
Positional, rutile cored wire	PZ 6113
Metal-cored wire	OK Tubrod 14.12
Stick electrode	OK 48.00
Submerged wire	OK Autrod 12.22
Submerged flux	OK Flux 10.71
Aluminium wire	OK Autrod 18.16

Cruise liner steel plates are thin

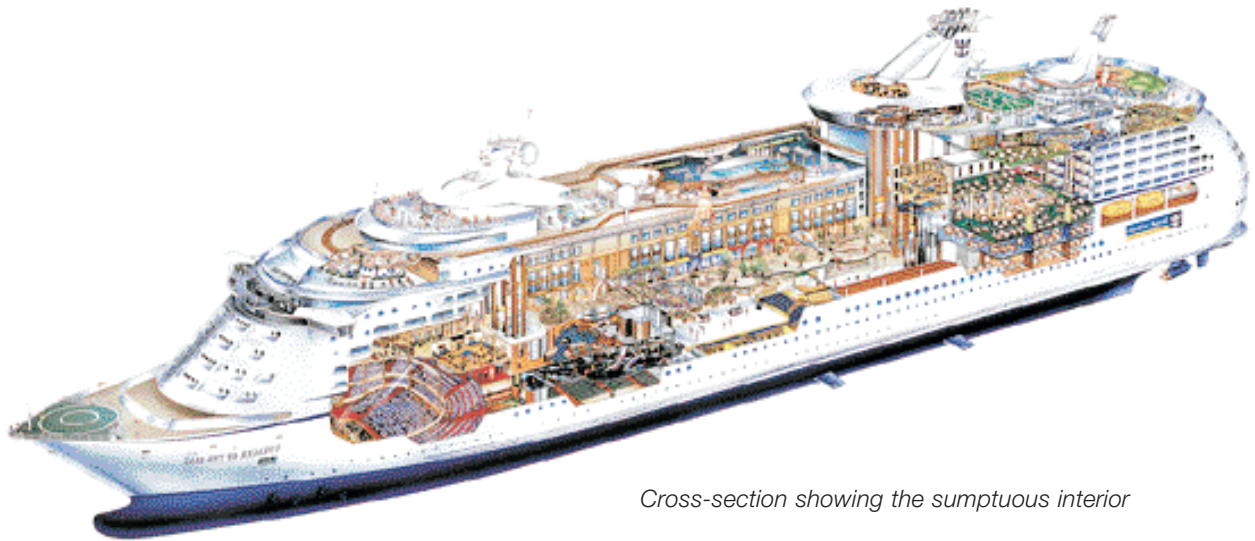
The steel comes from Rautaruukki's steel mill in Raahé and the steel is mainly standard NVA grade ship-building steel with a yield strength of 235 N/mm². At certain points, a stronger NV36 grade steel has been used. The ship has 18 decks, with 15 in passenger use, and their plate thicknesses generally vary between 5.5 and 6.5 mm. The bottom plate of the hull is 25 mm thick, thinning out to 15 mm towards the top.

Welding development

The shipyard has its own welding laboratory, which



Partial plan of the ship's cross-section and the various welding processes used to weld the main deck and structures above and below it. (FCAW: MAG welding with cored wire, SAW: submerged arc welding and SMAW: manual metal arc welding)



Cross-section showing the sumptuous interior

comes under Masa-Yards Technology Unit. It is constantly developing welding and welding processes. Its greatest achievements so far have been made in the development of aluminium welding in LNG tankers, which we have had the opportunity to read about in many trade publications and the media.

The shipyard monitors welding technology development closely and selects any new solutions or processes that are applicable for its operations. Much interest is currently being shown in laser welding in its various forms and in friction stir welding. ESAB also organised a welding seminar at the shipyard in October 1999 which dealt with laser welding and friction welding, of which there is an overview elsewhere in this magazine.

Main specifications of the Voyager of the Seas

Max. length	311.1 m
Max. width	48.0 m
Draught	8.6 m
Max. height	63 m
Gross tonnage	137,300 tn
Ship's total weight	55,000 tn
Passengers	3,840
Crew	1,180
Cruising speed	22 knots

Did you know...

The Voyager of the Seas has

- 5,500 fire alarms
- 15,500 seats
- 50,000 m² of carpets = 5 hectares = over 100 basketball courts or 10 football fields
- an ice rink and a full-sized basket-ball court
- a climbing wall with the top 60 m above sea level
- 757 outside balconies
- the largest cabin of 107 m² with a grand piano
- 65,000 light fittings
- 8 km of neon lights
- about 3,000 books in the library

- 400 game & slot machines
- 31,000 litres of water in her aquaria weighing 56,000 kg
- 3,000 km of electrical cable (compared with the 2,977 m by road from Helsinki via Berlin to Rome (!))
- generator capacity of 110 MW (as compared to the 59 MW power plant in a city with 172,000 inhabitants)
- a length of 311 m, which is equal to a 17-carriage train or four Boeing 747s
- a godmother, the Olympic figure-skating champion Katarina Witt
- the ability to travel sideways at a speed of three knots.

The most expensive day on the ship costs about EUR 1,000 (£630) and even the cheapest one costs about EUR 200 (£115), so cruising does not come cheap. Cruises departing from Miami last one week initially.

Acknowledgements

Many thanks to the management of the shipyard for allowing us to write this article and especially to welding engineer Pasi Hiltunen, who answered all our questions and gave us information about welding the ship.

About the author

Juha Lukkari, M.Sc. (Eng.), joined Oy Esab in Helsinki, Finland, in 1974, after graduating from the Helsinki University of Technology. He has since held different positions and is currently head of technical customer service.