Evaporator D

Evaporator D Facts & Figures

- Batch evaporator required to volume reduce highly active liquor
- Operational Life 25 years
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- Building with over 23,000 tonnes of concrete
- Over 22,000m of pipework
- Contains over 500 plant items

Introduction

Highly active evaporators play a pivotal role in the delivery of reprocessing, historic clean up and hazard reduction missions across the Sellafield site. Evaporator D, a new Highly Active (HA) Liquid Evaporator will provide additional evaporator capacity to support the sites existing evaporators. It is designed to deal with current liquor arisings as well as being able to deal with liquors of a higher solid content that are expected to arise from post operational clean out (POCO) of Sellafield facilities.

Reprocessing involves extracting elements of the fuel assembly that can be recycled and then safely storing the remainder. The highly radioactive fission products make up approximately 3% of spent nuclear fuel and are not useful products. At this stage the liquor is relatively dilute and in order to minimise the volume to be stored and vitrified into glass form the liquor is concentrated by a factor of between 40 and 100 by evaporation.

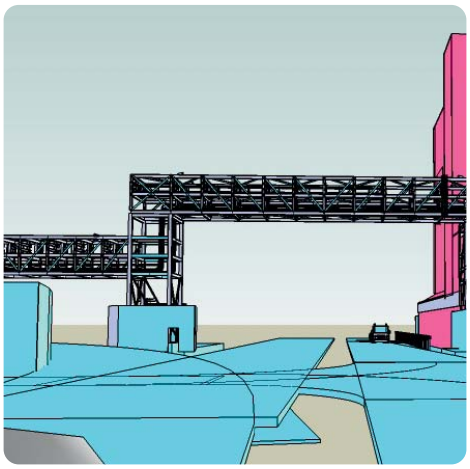
The main issue that has made the construction of Evaporator D a challenging task is the location of the building – it is both adjacent to operational facilities and on a restricted foot print. This has led to innovation such as the modularisation of the plant, enabling fabrication and testing of the majority of the plant equipment off-site. The Evaporator D building will be made up of 11 primary cells which will be installed 11 prefabricated modules of varying sizes ranging from 60 to 500 Tonnes. The modules are then linked together and, following testing, connected to the current facility.

Welding of the Riser Section of the Evaporator Coil

Lower Section of the Evaporator Vessel

Primary Contractor COSTAIN

Module Fabrication at Ellesmere Port



Artist impression of the high level pipebridge over one the of main Sellafield roads

Modularisation

Modularisation means the movement of up to 500 tonne sections of the plant from Ellesmere Port to Sellafield. This would be impossible to achieve by road or rail and hence some modules will be delivered by sea. This has required the project to construct a temporary beach access, which has been successfully tested, and bridge across a tidal area, as well as the removal of bridges and equipment from the Sellafield Site itself.

On Site Installation

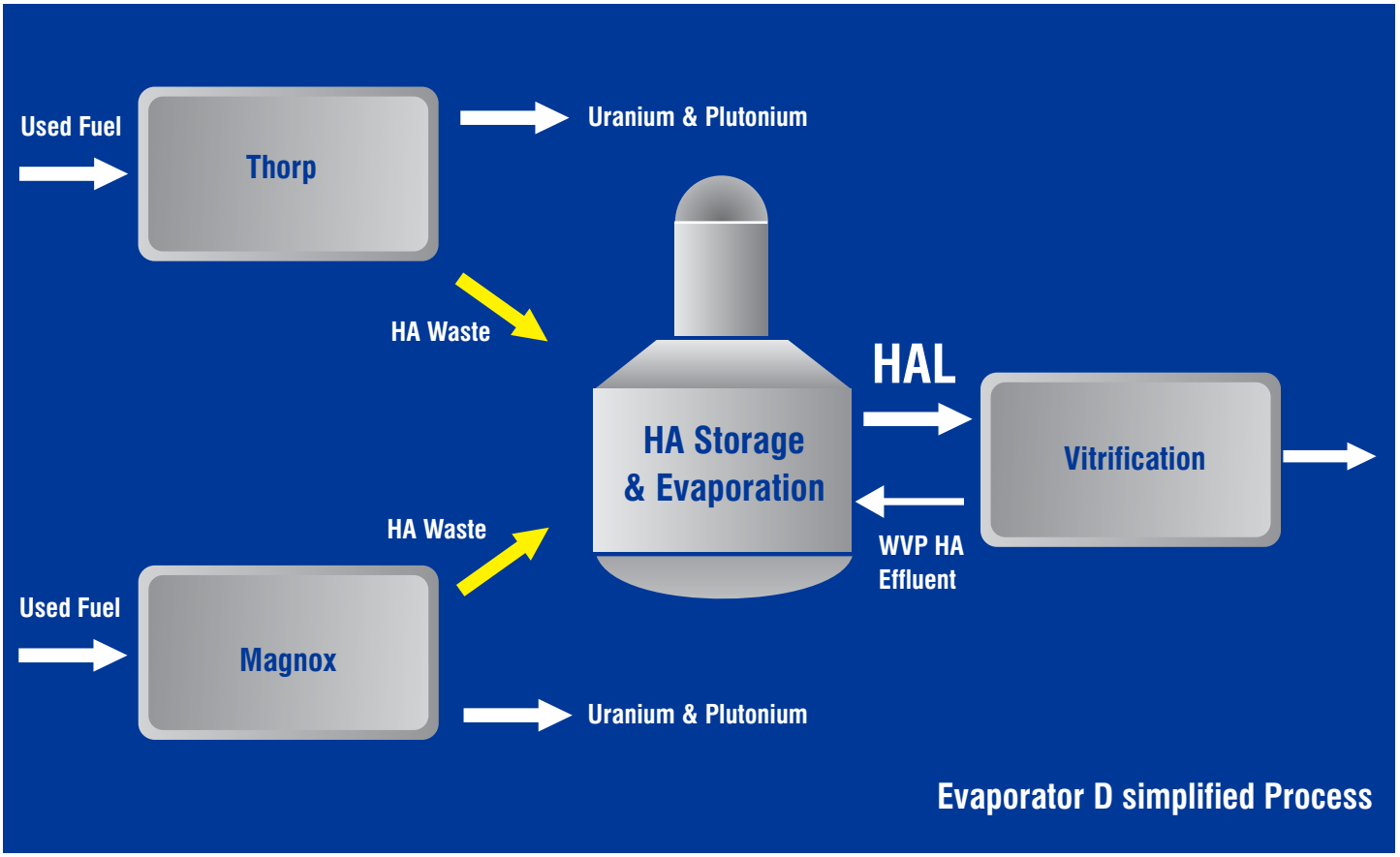
In addition to connection of the modules once they are installed in the building there are significant amounts of mechanical, electrical, instrumentation and ventilation systems and equipment to install in Evaporator D building. As civil construction is completed in areas of the building the teams start installation of the equipment. Facts and Figures include : 10,000m of Pipework with 5,000 welds, 500 tonnes of support brackets, over 100 tonnes of ventilation ductwork , 25,000m of Electrical cable and 105,000m of Instrument cabling together with 6,000 instruments.

Services

In order to provide services to the new Evaporator D building, a development of cooling towers, sub-stations, compressed air plant, switchroom and diesel generator is being built. The layout has been designed to minimise impact on road and rail access in the area. This development (approx. 1600 m^2) is not directly adjacent to Evaporator D and will be linked by a high level pipebridge over one the of main Sellafield roads.

Interfaces with current Highly Active (HA) Liquor Facilities

Evaporator D is essentially being built as an extension to the current HA facilities at Sellafield. Although it will have its own services development for e.g. power, steam, water, it will be connected via the current facilities to receive/despatch the process liquors. In addition, the ventilation system for Evaporator D will be connected to those of the current facilities.



Evaporator D simplified Process

Marine Access Development

River Ehen Bridge

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In order to safely deliver modules by sea to Sellafield, a temporary development has been constructed adjacent to the Sellafield Site near to the Sellafield Rail Station. The development will provide a steady incline between the beach and railway level crossing by the construction of a ramp across a section of the Sellafield beach, the cutting of a section from the Ehen Spit, and the erection of a bridge across the River Ehen.

There were two key considerations to be made when deciding on the feasibility of sea delivery to the Sellafield Beach – environmental impact and practicalities of construction in such a remote location. The overall effect of the development on the environment is considered to be minor, very localised and of a temporary nature.

Bridge abutments

Key Environmental Issues Considered

Migrating Fish: It is known that the lower River Ehen is used by salmon and sea trout migrating to reach the headwaters of the river to spawn. Advice from the Environment Agency was sought that identified an unrestricted in-river working window from approximately mid November to end of January, with no restrictions on work at low flow in the river.

Sea Trout

Primary Contractor COSTAIN

Honeycomb reef worm

Natterhack toad

Ehen Spit Excavation

Isle of Man Cabbage: The Ehen Spit (the land between the coast and the River Ehen) comprises made ground of historically tipped material from the Sellafield complex and provides a suitable environment for Isle of Man Cabbage (Coincya monensis spp. Monensis). This is a Priority Species within the UK Biodiversity Action Plan because of its endemic status. Although no plants have been found in the construction area it has been agreed (with Natural England) that any species found can be relocated to a suitable area outside the planned development.

Honeycomb Reef Worms: The Sabellaria spinulosa reefs have been recorded in the area. The location of these reefs have been included on project drawings/plans and are outside the area where the barge lands on the beach. Since the reefs do move (albeit slowly) they are being monitored as part of the project.

Reptiles and Amphibians: Small numbers of natterjack toads (Bufo calamita) have been recorded in the vicinity of Sellafield Station and the pipebridge and are known to breed at Braystones to the north and at Sellafield approximately 1km to the south. A licence has been granted by Natural England to manage any toads found whilst undertaking the construction or module moves. Additionally adders (Vipera berus) and slow worms (Anguis fragilis) are also known to be present within the project area – in addition to clearance of vegetation to made the area less suitable, reptile proof fencing has been erected.

Sellafield Beach Preparation

Beach Ramp – in order to provide a suitable incline the beach will require areas to both be excavated (cut) and material added (fill). This is expected to be in the region of an additional 1 metre (above the current beach level) at its highest point and with an estimated and will stretch approximately 80 metres.

Ehen Spit Cutting

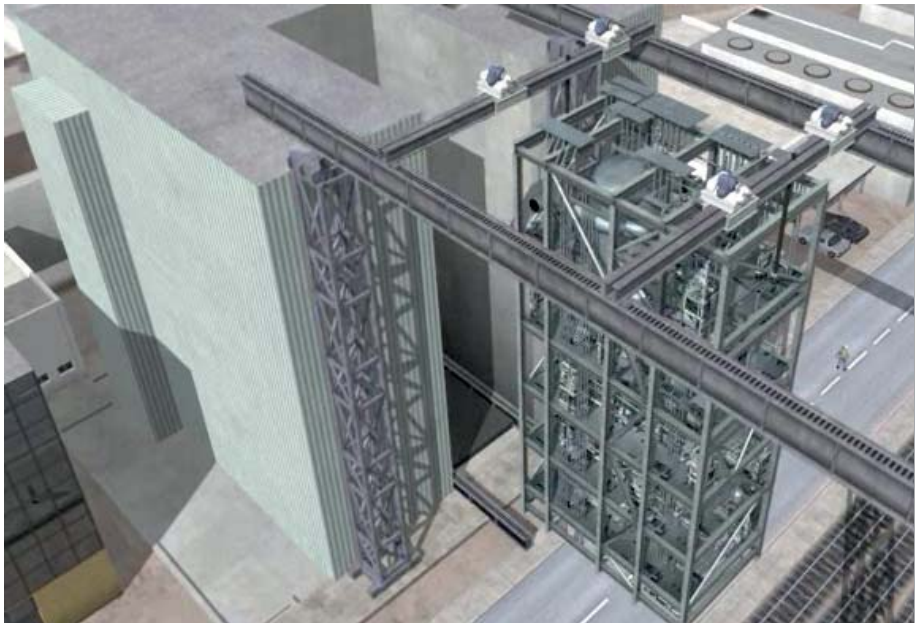
In order to provide a suitable incline the Ehen Spit has been excavated. This has involved the removal of approximately 3,000 m^3 of spoil (equivalent to 300 wagon loads of material) to provide a cut area of approximately 55m of the Ehen Spit at a width of 10m – this material is now stored at the south end of the Ehen Spit.

River Ehen Bridge

The bridge is a single span (to minimise the impact on the River Ehen) with piled foundations. The bridge deck is pre-cast concrete slabs. Four large beams (38m in length, each 2m wide with a 2m deep) have been installed.

Installation of the bridge beams

Gantry and Module Installation



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Installation of the modules requires a gantry system to move them from their transporter into the final resting position.

The gantry is fundamental to the ability to install modules of equipment required by Evaporator D. If the gantry was unavailable the equipment would have to be installed piece by piece and would have required many more (of the order of 1000's) of lifting operations in the direct vicinity of major nuclear chemical plants.

The gantry will essentially comprise a structural steel lifting frame which will be erected adjacent to Evaporator D and used to lift and slide pre-fabricated process modules of up to 500 te in mass into the pre built reinforced concrete structure of the building.

The gantry is essentially bespoke, it is comprised of existing pre-fabricated component parts, including tracks, tower sections, bracing, top beams and lifting equipment, all assembled onto pre-prepared foundations. The gantry is capable of movement, whilst un-laden, in a North – South direction alongside the Evaporator D building to allow alignment with specific cells.

The first 10 modules to be installed involves lifting the module from its 'roof' and then sliding (some are also slid and then lowered) into its cell. The final module, the Evaporator Module, cannot be transported in its installed position due to its height (at 27m high) so the gantry will first reorient the module into it's upright position.

The Evaporator Module

The largest module is 27 high and approx. 500 tonnes

Gantry Parameters

Dimensions
34.07m high x 38m wide x 18m long

Weight of Structure
450 Te

Design Load Limit
745 Te

Erected using a 500te crane (with the assistance of a 35te crane)

Heaviest parts of the gantry are the primary lifting beams (Kursk Beams) @ 65te

Each of the two foundations for the gantry are 50m long, 4m wide and have a concrete depth of 2m

East Gantry Foundation Reinforcement

'Kursk' beam

Gantry Erection

The gantry will be assembled on two foundations running north-south, parallel to Street 12. Construction of the foundations will involve piling operations and ground excavation followed by installation of the reinforced concrete bases.

The gantry will take approximately 4 weeks to erect. Due to the limited working area adjacent to the Evaporator D site some of the component parts will be pre-assembled near the Sellafield Rail Sidings and then transported for final erection next to Evaporator D.

Artist impression of the Gantry Structure

Modifications to Sellafield Site Infrastructure

Thorp Link Bridge

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In order to move the 11 modules to the Evaporator D site, a number of modifications are required to the Sellafield Site infrastructure. The most notable of these are modifications to Station Gate (to provide enough room to perform security checks prior to acceptance of the modules onto Sellafield) and the temporary removal of sections of the Thorp Link Bridge (to provide enough height on the road to move the modules).

Most of the modules being delivered are wider than a two carriage-way road. This means that there are a number of modifications to be made to road signs and rail gates to enable the wide load to move through the site.

Why move Thorp Link Bridge?

Thorp link bridge is the most significant obstacle within the Sellafield site affecting delivery of modules to Evaporator D. Headroom to the underside of the bridge is approximately 8 metres, which is inadequate for a number of the modules to be transported to the Evaporator D construction site.

Optioneering of the delivery route for the modules was undertaken by the project, with all other potential routes constrained by medium or high active pipebridges, rail lines or road bridges.

Facts & Figures

- When transported the largest module (the Evaporator Module) will be over 30m long, over 14m high and 8m wide.
- Modifications have included removal of approximately 10 redundant lamppost and signs.
- Temporary removal of the following equipment will be required to move each module from it's storage area to the Evaporator D site:
  - 8 'wig-wag' barriers on rail crossings
  - in the order of 30 signs
  - a number (approximately 20) of the lampposts on the route
- The length of Thorp Link Bridge sections to be removed are 5m (short connecting section to Thorp itself) and 29.5m (section over the road). Totalling 34.5m equivalent to just over the length of 3 double decker buses.
- The bridge itself is 2.2m wide.
- The bridge walkway floor is formed from 150mm thick concrete cast in steel trays running the length of each bridge section between support columns. In total over 11m^3 of concrete (equating to over 27Te) is contained in the sections to be removed.

Primary Contractor COSTAIN

Modifications to road signs and rail gates

History of Thorp Link Bridge

The bridge was erected during the mid/late 1990's to provide an enclosed elevated pedestrian access route between the Thorp Management Centre and changing rooms in the Thorp plant building.

The link bridge crosses railway sidings and one of the main Sellafield Site roads. It is approximately 103m long and comprises 4 independent sections of steel lattice girder framework supported by 5 concrete columns.

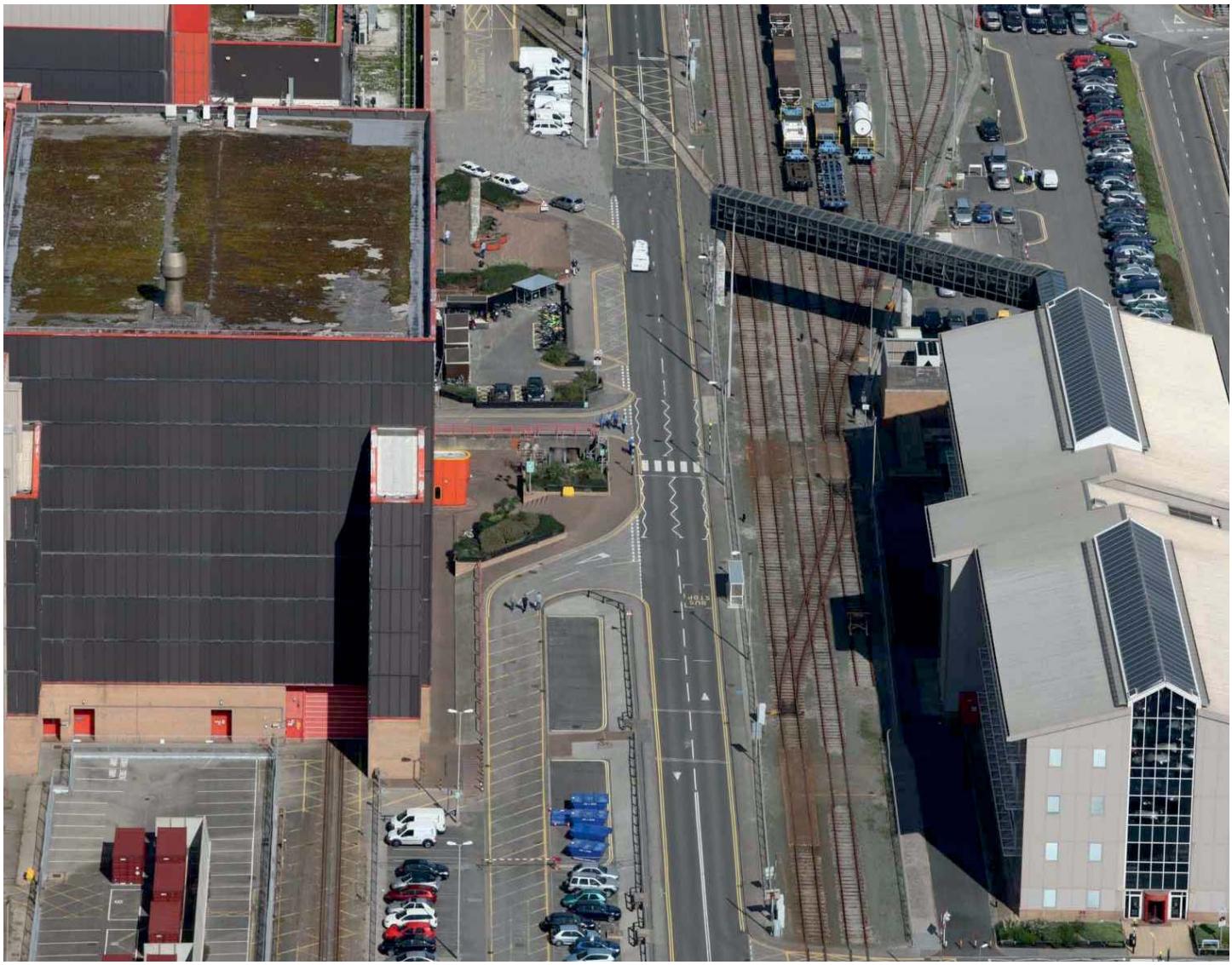
The bridge framework is enclosed by a curtain wall glazing system, which provides weatherproofing, natural light and an aesthetically attractive appearance.

Bridge structure, concrete floor and curtain wall framework components awaiting fitment

Removing (and Replacing) the Sections

Firstly the glazing panels will be removed using elevated working platforms. There are approximately 290 panels to be removed ranging from 0.9m to 1.8m high and 1.2m wide.

Once de-glazed the bridge section (weighing approximately 55Te) will be prepared for lifting. The complete (two) sections will be lifted using two 200Te cranes and lowered onto the awaiting transporters (SPMTs).



Disassembly of Thorp Link Bridge

Module transportation

Self Propelled Modular Transporter

Introduction

There are eleven modules to be delivered and installed into the Evaporator D building.

The modules are transported in a number of phases:

- At the module assembly site (Pioneer Point, Ellesmere Port) a self propelled modular transporter (SPMT) will be driven under the module support system and then driven out of the facility.
- The SPMT will then drive onto the barge and the module will be secured. There may be more than one module per barge so this activity might be undertaken a number of times.
- Once all checks have been completed the barge will sail to the beach adjacent to the Sellafield Site.
- The barge will land on the beach and, once suitable ramps are in place, will unload all SPMTs.
- In order to cross the River Ehen a purpose-built bridge has been installed.
- Once a possession order for the West Cumbrian Rail Line is obtained, the module transporter will cross a rail line.
- Security checks will be undertaken at a recently modified gate onto the Sellafield Nuclear Site.
- The module will then be placed in a storage area awaiting installation into the Evaporator D building itself.

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SPMT Facts & Figures

- The transportation route is designed to have a 1:17 incline.
- The SPMT is controlled by an operative using an umbilical cord arrangement and will be moved at walking pace.
- When transported the largest module (the Evaporator Module) will be over 30m long, over 14m high and 8m wide.
- Each wheel on the SPMT can be manoeuvred separately by the operator – for the largest module being delivered (the Evaporator module) this means 124 wheels (the smaller modules only need 64 wheels).
- The axle loading of the SPMT is less than that of a standard HGV.
- SPMTs were used at Sellafield in the early 90's to move the heat exchangers from the AGR to LLW Repository at Drigg.

Terra Marique approach

Manoevering in the Landing Zone

First Panel Removed

Ramps being lifted down

All Ramps Down

Door almost down

Self Propelled Modular Transporter and power pack

Terra Marique

The Terra Marique, is 80m long and 16.5m wide. It is a purpose build vessel designed to handle abnormal indivisible loads (those too large to transport by road or rail).

At sea the Terra Marique is powered by a tug but is fitted with thrusters to manoeuvre, for example, when in dock or when preparing to land on a beach. In order to land in the Sellafield beach it is un-hooked from its tug and moves under its own power to a 'landing strip' on the beach will be marked with a series of coloured buoys and lights to guide the barge into the correct location. The location will depend on the tide but it could be as far as 80m away from the Ehen Spit.

Once in it's landing position the Terra Marique will then start preparations for off-load as the tide recedes. This involves the removal of the watertight door panels and then, once the barge is on the beach, the inner door ramp will be lowered and extension ramps put in place. The sea fastenings on the modules will have been removed during this preparation time – the SPMTs will then drive off the barge and onto the beach ramp.

Trials

A series of trials were undertaken by the Evaporator D Project Team on the Sellafield Beach in December 2009.

This involved the landing of the barge, the Terra Marique, and off-loading of a transporter (SPMT – Self Propelled Modular Transporter).

These trials provided valuable information on the practicalities of working on the beach and the sequencing and organisation of the work.

The Modules

Module fabrication at Pioneer Point, Nr Ellesmere Port

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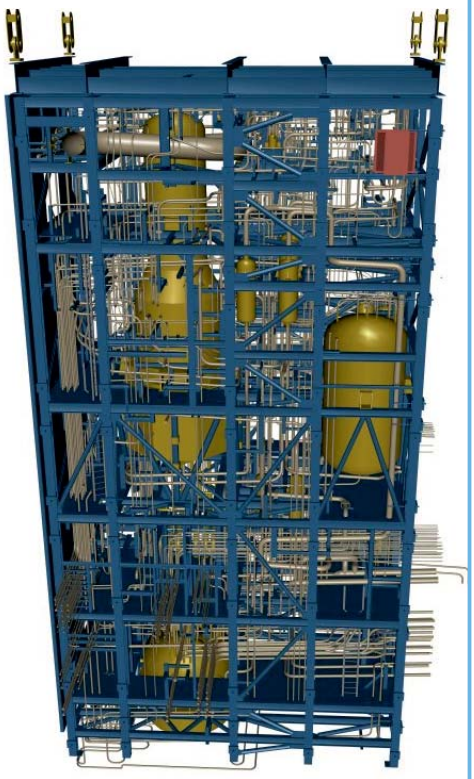
The 11 sea shipped modules are being assembled at Ellesmere Port, Cheshire. A large, dedicated indoor facility is being used with a floor space of 230,000 sq ft which is the equivalent of 3 Wembley football pitches.

Each module will consist of structural steel, stainless steel pipework, vessels and other equipment. Three of the modules have been classified as Highly Active (HA) and as a result, have a stainless steel structure rather than galvanised carbon steel and have Nitric Acid Grade (NAG) pipework.

The list below gives an indication of the size and scale of activities and equipment involved in module assembly:

- 1,000 tonnes of structural steel
- 11,000+ metres of pipe
- 10,000 pipe welds
- 75 vessels
- 50 roof and floor boxes
- 40 ejectors
- 220 actuated valves

The Evaporator Module



The Evaporator Module the largest module

Length = 12.7m x Width = 7.4m x Height = 27m

Primary Contractor COSTAIN

Non Active Drain Module steel erection

Module assembly overview

- Assembly of each module will take place in Pioneer Point facility
- Each module is built on support stools and loadspreader beams to allow clearance from the ground in order for the self propelled module transporter units (SPMT) to lift the module when completed
- The structural steel is erected on top of the loadspreader beams
- Vessels and other large items of equipment will be installed into the module framework
- Pipework is then installed into the module and welded together and to the vessels / equipment
- Following installation of pipework, the electrical, instrumentation and ventilation installation will be completed, as applicable
- When the installation of all equipment is complete, any testing and commissioning activities will take place before the application of the packing materials for shipment

Module Description	Cell Type	Approx Dimensions L x W x H (metres)	Approx Weight (tonnes)	Structural Steelwork Type	Structural Steel Qty (tonnes)	Pipe Quantity (metres)	No. of Pipe Welds	Electrical & Instrumentation
Evaporator Module on East Face	HA	12.7 x 7.4 x 27	480	Stainless Steel	327	5000	1800	N/A
Steam & Pneumercator Module	Non-HA	19.8 x 8.5 x 4.5	82	Carbon Steel	42	1200	2570	Yes
Condensor Module	HA	6.3 x 9.5 x 6.6	80	Stainless Steel	51	300	100	N/A
Delay Tank Module	Non-HA	6.2 x 9.5 x 7.8	66	Carbon Steel	50	200	225	Yes
Distillate Collection Module	HA	6.2 x 9.5 x 9.2	118	Stainless Steel	83	800	235	N/A
Cooling Water Cell 1 Module	Non-HA	10 x 7.4 x 9.6	140	Carbon Steel	101	800	1130	Yes
Cooling Water Cell 2 Module	Non-HA	9.6 x 7.4 x 9.6	118	Carbon Steel	91	750	1445	Yes
Auxillary Cooling Water Cell 1 Module	Non-HA	9.6 x 7.4 x 9.6	95	Carbon Steel	75	550	769	Yes
Auxillary Cooling Water Cell 2 Module	Non-HA	9.6 x 7.4 x 4.3	103	Carbon Steel	69	550	755	Yes
Non Active Drain Module	Non-HA	10 x 7.4 x 10	105	Carbon Steel	85	900	275	Yes
Low Active (LA) Effluent Module	Non-HA	9.6 x 7.4 x 10.3	118	Carbon Steel	71	500	225	N/A