

Chemistry at the Octel site

Blowing out towers (BOTs)

The sea water intakes for the Blowing Out Towers (BOT) are located on the western edge of the Amlwch site.

For BOT1 a sea water inlet pond is used to provide some shelter from the elements and protection against large pieces of flotsam etc. Sea water from the intake is feed to the inlet of the sea water pumps via a 3 metre diameter tunnel cut in the rock to the BOT1 pump house located in the centre of the site. From the pump house 3 axial pumps lift the sea water up into the BOT1 sea water pond.

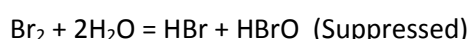
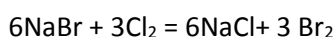


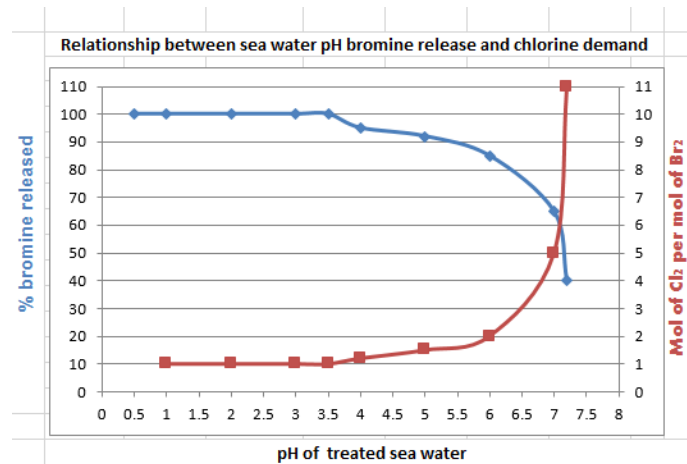
The sea water in the pond is then filtered using 3 rotating fine mesh screens for material such as fish or sea weed which has passed through the sea water pump. In times of storm these screens would on occasions become blocked and the BOT would have to be shut down to allow the day process team to clean them.

From the sea water pond the water flows by gravity via a 6 foot diameter rubber lined sea water main to the distribution valves on the top of the BOT.

The pH of the sea water is adjusted between the sea water pond and the distribution valves. This is necessary to ensure that the majority of the bromide in the sea water can be converted to bromine. The pH of the main is adjusted using waste dilute acid from the dilute acid tank. This acid is basically the recycled scrubbing waters from other areas of the plant. The acidity of the dilute acid is controlled by the addition of 98% sulphuric acid as required. The 98% sulphuric acid is produced in the acid plant by burning sulphur to produce SO₂ which is then converted to sulphuric acid using a catalyst in the "contact process".

The pH of the sea water needs to be adjusted down to around 3.5 to allow the maximum amount of bromide to be released as bromine by the addition of chlorine. At this pH the hydrolysis of the bromine to bromate is suppressed and bromine is released.





The distribution main has 144 Saunders valves which the operators adjust to allow the water pattern across the top of the BOT to be set. The distribution has to be adjusted depending on the flow of air from the blowing out fans. The ideal is to maintain a constant ratio of sea water to air in each section of the BOT. Modification of the sea water pumps and distribution valves are required to maintain a constant height of water in the sea water ponds and the required sea water flow to the BOT.



The acidified sea water passes the valves and is let into wooden distribution boxes inside the BOT. Traditionally these were large coffin shaped boxes with a number of smaller ceramic distributors in their base. The boxes distribute the bromine rich sea water into a ceramic packed tower. A counter current of air flows up the packed section and this blows the bromine vapour back up through the packing and around to the inlet of the BOT fans. The stripped sea water falls out of the bottom of the packing and is directed back to the sea water out fall. Here it soon mixes with the coastal water.

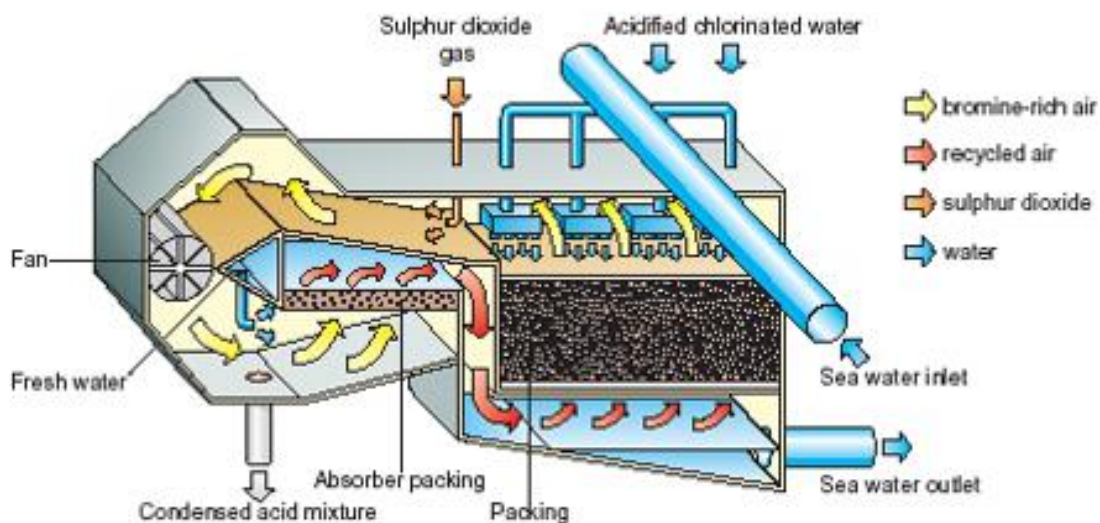
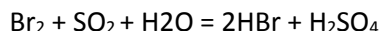


Figure 7 Inside a blowing-out tower.

This bromine vapour is then fixed by reacting with SO₂ gas injection and fresh water from sprays. This reduces the bromine back into bromide in an acidic mist. The liquid in the mist is knocked out by a small fibre glass absorber pad and is collected as Primary Acid Liquor (PAL). This material is pumped to one of 5 large PAL stock tanks on site.

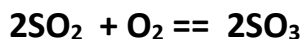


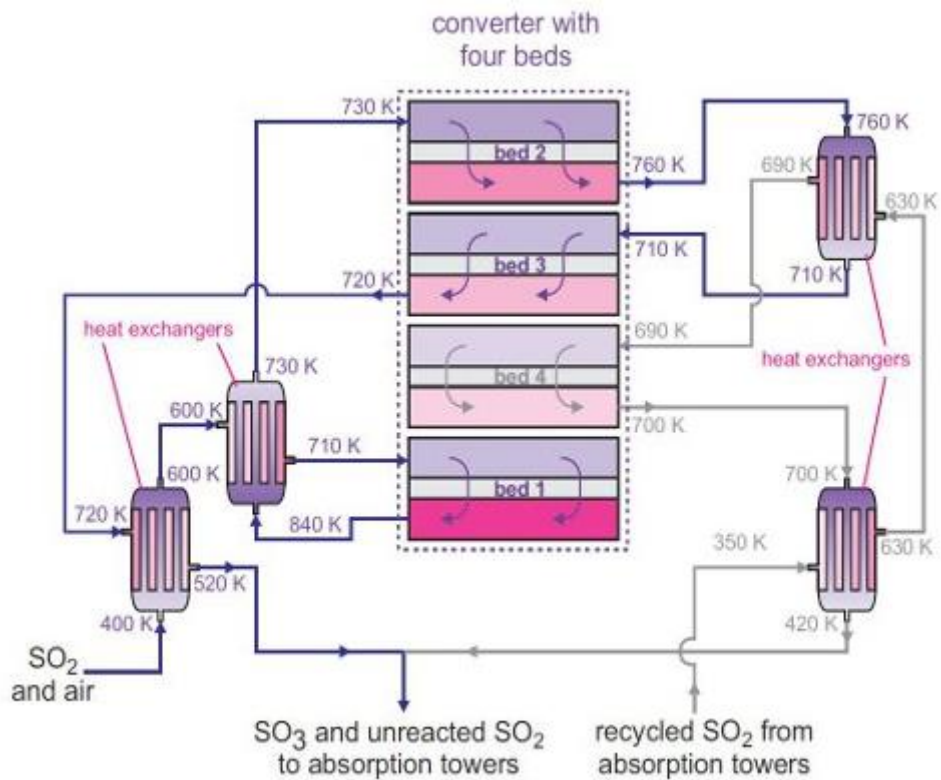
The concentration of bromide in PAL is around 13% compared to the 65 ppm in sea water. The correct control of SO₂ injection is important to ensure that all the liberated bromine is fixed to minimise the loss of halogen to the sea water outfall. This is achieved by measuring the sea water eH.

The SO₂ required to fix the bromine inside the BOT is generated by burning molten sulphur in the SO₂ burner on site. The chlorine vapour is generated by heating liquid chlorine held in stock tanks on site using a steam evaporator.

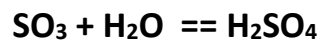
To produce SO₂ and sulphuric acid, molten sulphur is sprayed into a furnace in a blast of dry air at around 1300K. The sulphur is converted to SO₂ and emits a blue flame. The exit gas is around 12% sulphur dioxide and 10% oxygen and this mixture is cooled to around 700K using a water heat exchanger which in turn raises steam for the rest of the plant.

Some of the SO₂ is directly used in the BOT as described above. The rest is converted to sulphuric acid using a catalyst in the "contact process". This is achieved by passing the hot gases through a fixed bed reactor containing up to 4 separate beds of Vanadium Oxide on silica pellets with a caesium sulphate promotor which ensures the catalyst is molten at 700 K. This allows for 99.5% conversion of the sulphur dioxide to sulphur trioxide.





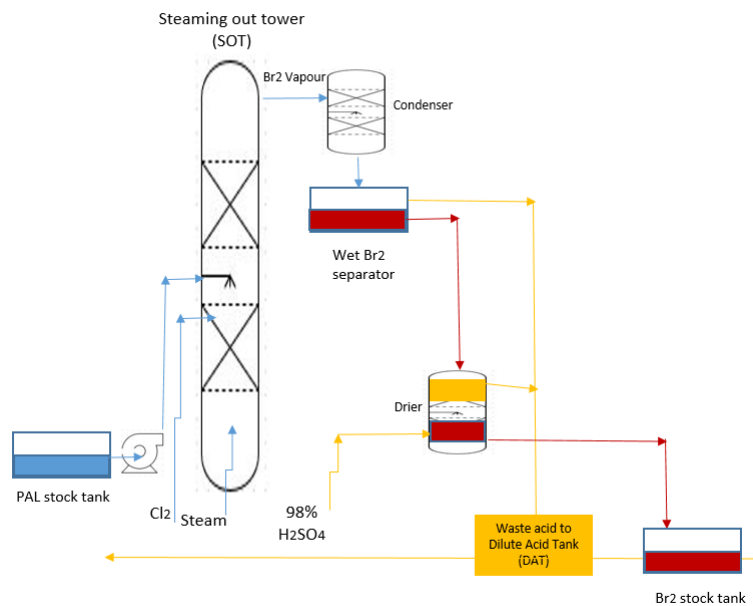
The direct reaction of sulphur trioxide with water would be too energetic and produce acid mist. The final stage is the reaction of sulphur trioxide with water remaining in 98% sulphuric acid to produce more sulphuric acid. The concentration of which is adjusted by adding more water.



The final

Steaming out tower (SOT)

When required the PAL is pump fed to the top of a PVDF lined steel column known as the steaming out tower (SOT). This column is packed with ceramic packing. The PAL flows down the tower where it is mixed with more chlorine which oxidises the bromide back to bromine. Steam is also introduced to the base of the tower to ensure that all the bromine leaves the top of the SOT as vapour which is then cooled to produce an aqueous bromine mixture. This material is very corrosive and so is handled in either glass vessels or much later PVDF pipework. The base of the SOT contains significant amounts of acid and any residual bromine which is directed back to the Dilute Acid Tank (DAT).

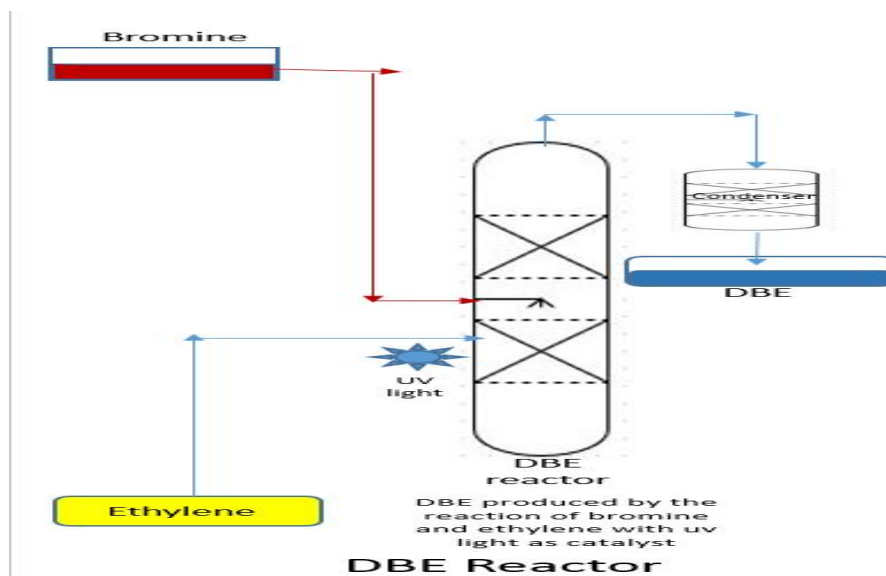


The aqueous bromine from the top of the SOT is first separated by gravity in a settling tank and then the damp bromine is feed into the top of an acid drier. Concentrated sulphuric acid 98% is feed into the bottom of the drier and this strip out the water from the bromine. The spent acid overflow returns to the DAT. The water in the bromine is reduced to less than 30 ppm by the acid and the dry bromine is then stored in one of 6 lead or glass lined stock tanks.

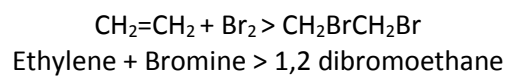
The dry bromine can be loaded into road tankers as required by pressurising the stock tanks with dry air which helps “pad” the liquid bromine across to them. The padding system avoids the need for expensive bromine resistant pumps.



Dibromoethane production (DBE)



DBE is made by the reaction of ethylene gas with liquid bromine in the presence of UV light as a catalyst at 35-85C. The DBE is condensed and neutralised with Soda ash and then kept in stock tanks which contain layer of soda ash which helps neutralise any remaining acid.



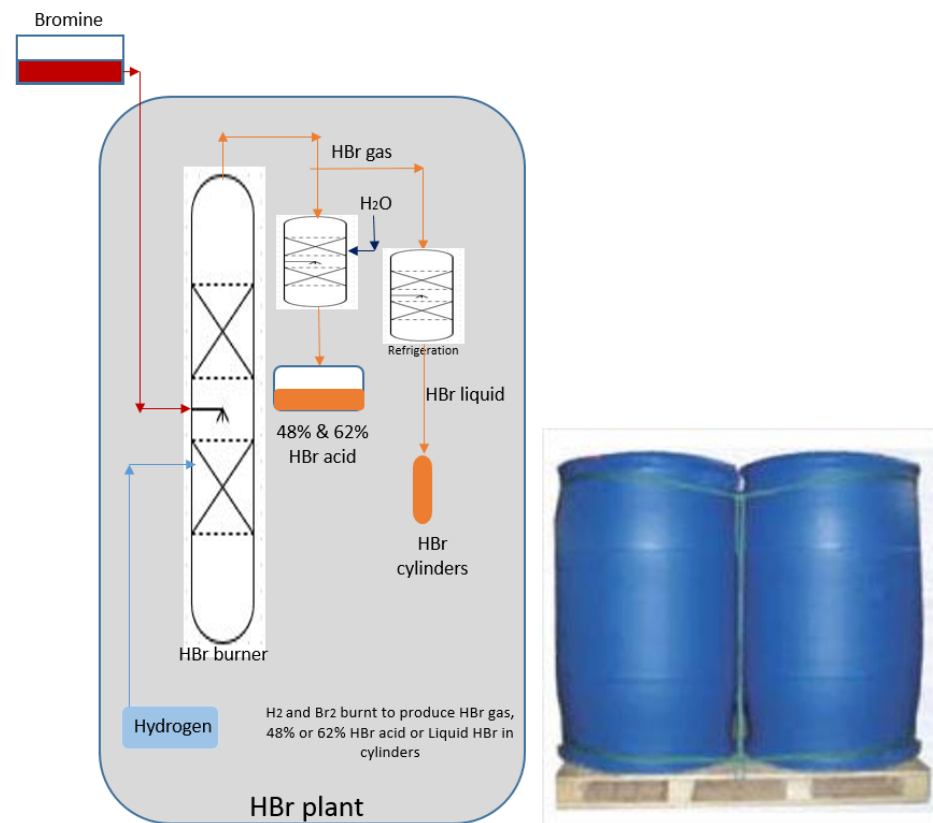
The production of DBE was initially the whole purpose of the site at Amlwch as it was loaded into either rail or road tankers and sent to the main Octel plant at Ellesmere Port. Here DBE was mixed with TetraEthylLead (TEL) or TetraMethylLead (TML) to produce antiknockcompound (AKC).



Hydrogen bromide (HBr)

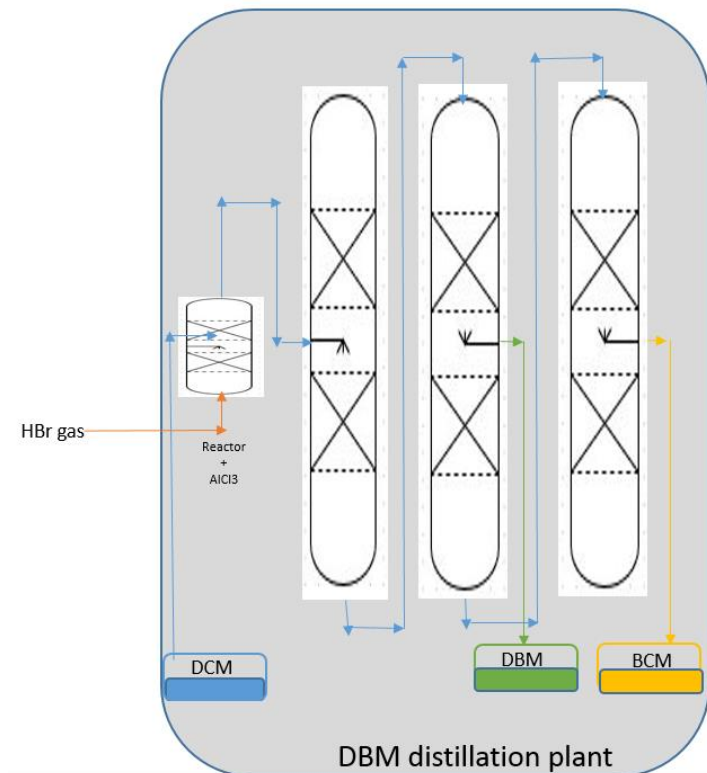
The bromine can also be used to produce a number of downstream products. The first of these is hydrogen bromine gas. Bromine from one of the stock tanks is pressurised with nitrogen and transferred to a heated coil vaporiser to produce hot dry bromine vapour. The bromine is then ignited and burnt in a hydrogen rich atmosphere to produce anhydrous hydrogen bromide gas in one of two HBr burners. This gas can be passed to further downstream plants or dissolved in demineralised water to produce 48 % HBr acid which is stored in a bulk stock tank or drummed off into plastic barrels. If required fuming 62% acid can also be produced.

The anhydrous hydrogen bromide gas from the HBr burner can also be compressed and refrigerated to produce liquid HBr which can be loaded into gas cylinders for sale to customers.



Dibromomethane (DBM)

The HBr gas from the burners can also be feed into the base of the DBM reactor. This is a stirred recirculating glass lined reactor into which dichloromethane (DCM) is pumped. Solid aluminium chloride is added as a catalyst which helps convert the DCM into a mixture of BromoChloroMethane (BCM) and DiBromoMethane (DBM).



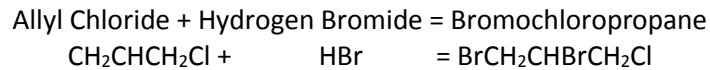
The reaction results in an equilibrium mix of products which is evaporated from the reactor. The mixture is scrubbed with water to produce a water / organic mix. The excess water is separated off and the wet organic phase passed to a distillation column where a DCM/aqueous distillate is removed. The DCM is dried by further distillation and returned to the reactor. The organic mix without the DCM is further separated in two distillation columns to produce pure DBM and BCM which are stored in separate stock tanks. The products are either sold as bulk material or drummed off into polythene lined steel drums.



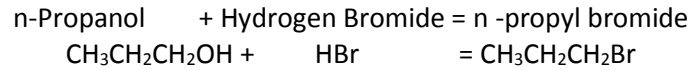
Multi product bromination facility (MPBF)

The MPBF was designed as a batch processing plant which uses either HBr gas or liquid bromine to produce a range of products in glass lined reactors.

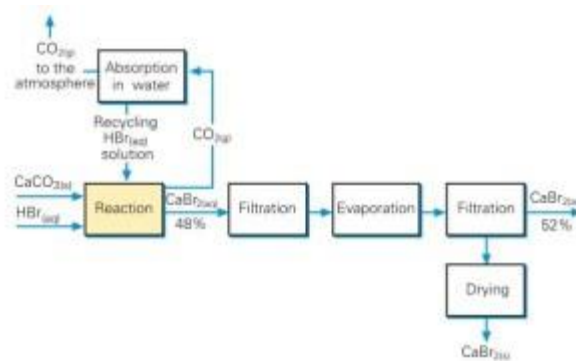
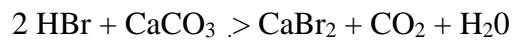
One such product is 1,3 bromochloropropane (BCP) ($\text{BrCH}_2\text{CH}_2\text{CH}_2\text{Cl}$) It is manufactured through free-radical addition of anhydrous hydrogen bromide to allyl chloride.



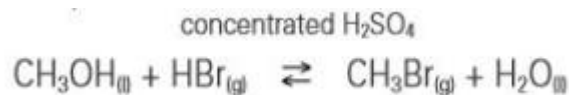
Also n propyl bromide



Another MPBF product was 48% Calcium Bromide which was made by the reaction of hydrogen bromide gas and calcium carbonate. This material was used as an oil well drilling fluid.

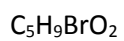
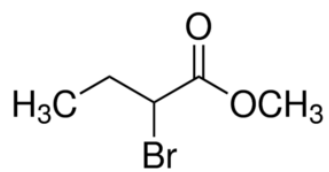


A third product was Methyl Bromide made by the reaction of hydrogen bromide gas and methanol using sulphuric acid as the catalyst.



The MPBF also made a range of brominated esters including:-

methyl bromo butyrate (MBB)



and methyl bromo myristate (MBM).

