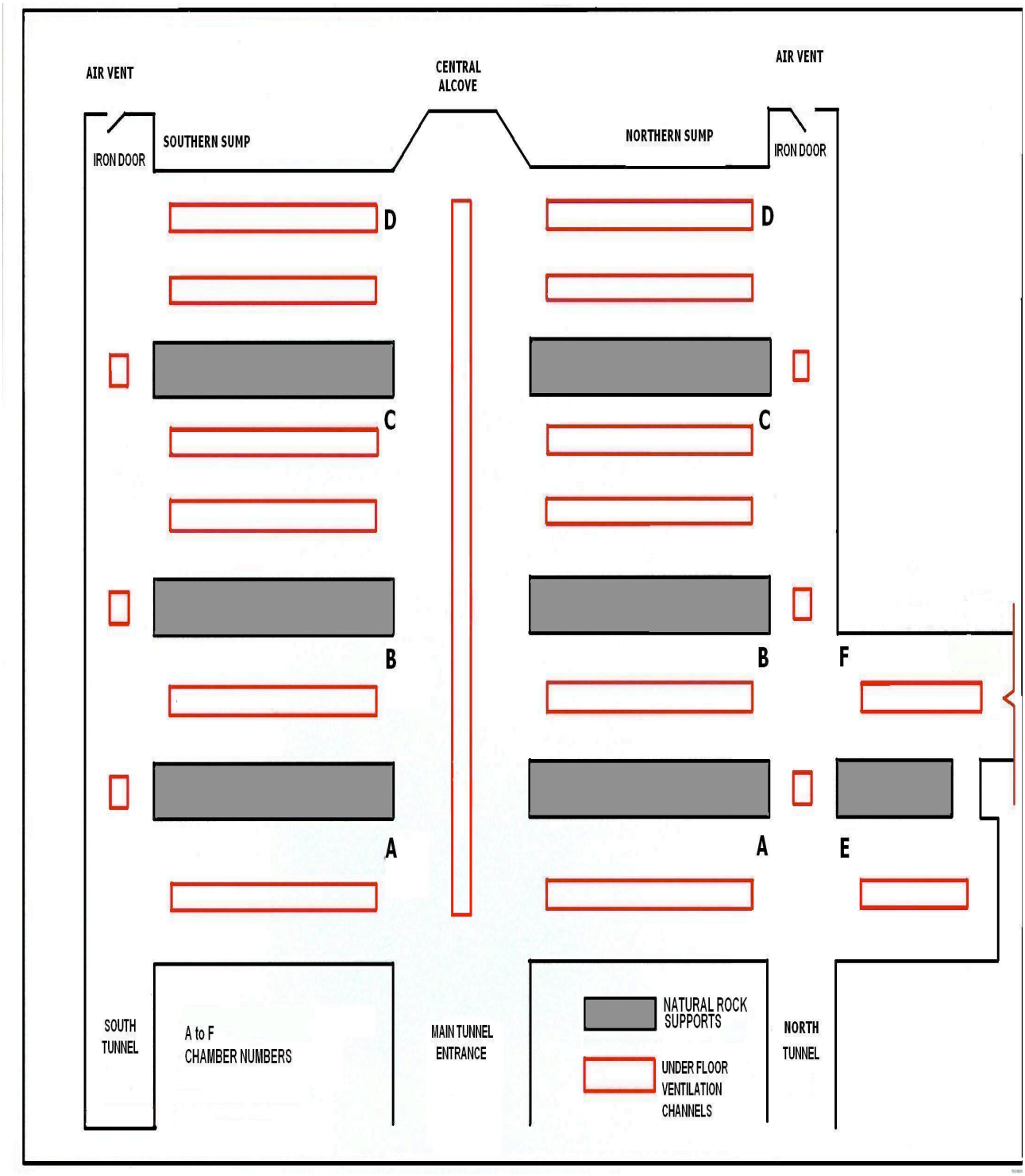
A Short History of the Tunnels and Storage Complex at M.S. Valley 1939-45



By: Colin Barber with much help from Eddie Lloyd-Davies and Sando Citra

Glossary of Terms

Vesicant – A blistering agent used in chemical warfare.

F.F.D.s - Forward Filling Depots. Units where mustard gas was shipped for charging chemical munitions.

C.I.D. - Chemical Inspection Department.

D.I.P. – Department of Industrial Planning.

M.S. – Mild Steel

Runcol, HT – Types of mustard gas.

Pyro, HB, HBD and Pyro M – Types of mustard gas.

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The sources for the following article unless otherwise stated were:-

SUPP 5/1011 – A History of M.S. Valley 1939-45 (viewable at the Flintshire County Records Office, Hawarden or in The National Archive)

I.C.I. Internal Management History (Courtesy of Mr E.Lloyd-Davies)

Development.

At the end of 1938 the Government decided that the question of storing large quantities of Pyro and Runcol (Mustard Gas) in bulk with complete protection from bombs should be considered and I.C.I. was asked to submit proposals for dealing with a capacity of 1,500 tons. The general requirements were that in addition to safe storage, it should be possible to provide charging facilities on the site and if necessary to add manufacturing facilities later.

The scheme was to provide adequate cover for bulk storage, bonding and storage of charged weapons, and the selected site should be near enough to Randle Works for the transport of material to be carried out easily with an adequate area of ground available for the manufacture of Pyro and Runcol but not the intermediates such as Thiodiglycol, Sulphur Chloride etc. Other important points considered included rail and road access, water supply, effluent disposal and reasonable concealment from air and sea.

The requirements of an ideal site having been set out, the Department of Industrial Planning, the Geological Survey and the Special Products Division of I.C.I. (General Chemicals) Ltd co-operated in a search for suitable sites. Preliminary investigations were made of a number of sites and five were selected as being most suitable. Of these sites, Valley Site at Rhydymwyn, near Mold, showed the greatest number of advantages; the only possible disadvantage being that the effluent had to be pumped through a pipeline approximately 6 miles long to the Dee estuary.

The Valley site consists of a narrow valley about 1½ miles long with hills on the east and west sides. There is an area of about 60 acres of level ground on the valley floor suitable for the construction of chemical and charging plants. Layouts were discussed by the D.I.P. in April and June of 1939. The initial survey was carried out in April 1939 and orders were placed during September 1939

It was originally proposed that the hill on the west side of the site should be tunnelled for the storage and for part of the charging facilities. The excavated rock was to be used for road making etc. It was also proposed to divert the course of the River Alyn running through the valley so that it ran close to the edge of the west bank of the valley, leaving the valley floor free for the remainder of charging and manufacturing units. The wider part of the valley at the north end was to be used for the manufacturing plants, and the narrower part at the south end was to be used for assembly and for such charging operations as were not to be carried out underground. This site is long compared with its width and it approximately follows the valley bottom of the River Alyn. The ground is a mixture of gravel and clay and has a good bearing value. Piling was not necessary and standard strip and block foundations could be used.

On 27th August 1939 approval was given by the Treasury for the following sections of Valley Works:-

(i)	Purchase of site	£ 6,000
(ii)	Bulk Storage	£ 90,000
(iii)	Charging facilities and storage of charged weapons	£340,000
(iv)	One 50 ton Runcol plant	£105,000

Civil work on the site commenced in October 1939 when contracts were placed on a Prime Cost plus fixed fee basis and the main building contractor started operations. J.B.Edwards & Co. was selected on account of the satisfactory manner in which previous work had been carried out at MS factories.

The construction work for the tunnels to accommodate the bulk storage tanks was also started in October 1939. The tunnelling contractor (Halkyn and District United Mines) were selected by reason of their great experience in tunnelling and mining work in limestone in the near vicinity of the factory and because they were already operating and had plant immediately available. For instance, air compressors of an ample capacity were already installed in their own mine workings and compressed air for use on the tunnel excavations and for the site generally was available within a few days of the contractors receiving the instructions to commence work, this being achieved by laying approximately one mile of 5 inch mild steel main across fields. The application of the existing plant to the tunnelling work resulted in considerable saving of time and expense.
The exact location of the tunnels was decided following an extensive geological survey of the site. The location chosen was such that the roofs of all tunnels would fall within a bed of solid rock and for this reason no additional reinforcement was required.
Construction work on the tunnels was commenced by first driving three pilot headings (A, B&C) each 6ft x 6ft at right angles to the hillside. This enabled the information from the trial boreholes, which had been made during the early negotiations for the site; to be verified and ensure that the cross storage chambers were

located in the best parts possible, having regard to the geological formation of the limestone. These three headings were then enlarged to full size whilst further 6ft x 6ft pilot headings were driven on the centre lines and at roof level on the cross chambers. When the pilot heading of each chamber was completed to its' full length the excavation was extended to full width and down to floor level until the final chamber dimensions were achieved. This method of working made possible the examination of the roof for loose stones and faults as the work proceeded and it also helped in the ventilation of the workings. While the pilot headings for the chambers were being made vent shafts were being sunk from the surface of the hill to connect with the end of headings A and C. By driving the pilot headings in the manner indicated many faces became available at one time, 1,000 tons of limestone was being excavated per 24 hours – work was carried on continuously except for one 8 hour shift on Sunday. Gelignite was used and all charges were fired electrically.

Description of the Bulk Storage.

By the end of November 1940 sufficient excavations had been carried out to enable storage tanks to be manoeuvred into position in D Chamber South. The general layout consists of three parallel tunnels driven horizontally into the hillside, the centre one being big enough to allow tank wagons to pass up it. The side ones are smaller and each terminates in an iron door leading into a steeply sloping wind tunnel at the top of which is a powerful electric fan with an exhaust chimney some 40 ft high.

At the request of the Ministry of Supply a scheme was prepared for doubling the bomb-proof storage capacity. This was to be affected by widening C chamber of the underground storage and lengthening A and B chambers by approximately 60 per cent and installing twenty four additional lead-lined MS storage tanks in C chamber. This scheme was agreed by the Ministry in May 1940 and Treasury sanction amounting to £105,000 was received.

Storage capacity for 3,120 tons of toxic material in bulk was provided by 48 homogenously lead-lined tanks each holding 65 tons nominal. These tanks were situated in two underground chambers in the hillside on the west side of the site 12 each side of the chambers end to end. The nearest and furthest underground chambers A and D respectively were approximately 110 and 139 feet respectively below the rising surface of the hillside.

Access to the underground chambers is provided by three tunnels driven into the hillside at right angles and at the level of the valley floor, one tunnel joining the north end of the chambers, one joining the centres and one joining the south ends of chambers C and D.

Running at right angles to and connecting with these tunnels are six chambers, referred to as A, B, C, and D; two of these chambers, A and B, having extensions on the far side of the north tunnel (annotated as E and F).
In C and D chambers were 48 x 65 ton tanks, 12 each side of the two chambers, end to end. The remaining chambers were used for bonding and storage of weapons

In the A, B, E, and F chambers, two-ton electric cranes were provided (two per section of chamber) for handling weapons.

A mild steel plate false ceiling covering the entire gallery of tunnels and chambers was installed. This ceiling was fitted with 7in. diameter diffusers, each diffuser being fitted with an adjustable cover plate which was set to give the various air rate changes specified.

The following air extraction ducts were constructed in the concrete flooring:-

(a) In the outer tunnels ducts were laid on the inner side with three metal grills over entry ports.
(b) One open central air duct ran the length of the central tunnel. It was covered with a metal grill.
(c) In tunnels A, B, E, F a central duct was cut and covered with mild steel grills.
(d) In tunnels C and D two ducts were laid either side of the chambers with mild steel grill covers. The four rows of 65 ton storage tanks were located over these trenches.
(f) All of the floors of the wind trenches and tunnels are inclined to channel any liquids into two sumps at the inner ends of the north and south tunnels.
(g) All of the air extraction ducts are connected to feed out of the tunnel complex via two underground concrete channels into the ventilation shafts.

At the ends of the outer north and south tunnels two iron doors were built to give access to the chimney stacks and the two drainage sumps and their pumping motors.

All ducts were sloped to drain to one of the two sumps situated in the inner ends of the north and south tunnels. These were emptied periodically by means of electrically driven pumps to the external toxic effluent pit.

Ventilation until March 1942

The ventilation was by two powerful extractor fans, one situated at the end of each wind tunnel. When the doors to the tunnels were closed and the fans were turned on, air was drawn through the air vents above the doors of the central tunnel and along the passage between the false roof and the tunnel ceiling. It was then drawn through the diffusers into the storage area, the amount of air allowed through deciding the number of air changes per hour for that area. Air was then drawn through the air trenches and the passages in the floor into the chimney shafts and was then ejected by the extraction fan.

If the outer tunnel doors A and B were open, a strong ventilation effect was obtained through the chambers as a whole: if closed then a strong current of air was sucked through the wind trenches and grids. In practice, this second method of ventilation was used, as in the event of spillage any toxic vapour was sucked straight into the wind trench.

The third method of ventilation was the 'natural draught' method in which the iron doors were left open and a gentle draught blew up the wind passage onto the exhaust fan. The strength of this draught depended on weather conditions. It was strongest in winter when the tunnels were warmer than the outside air but it could disappear altogether or even be reversed in summer. This third system of natural ventilation was used until March 1942 when the plenum house was completed and the air conditioning system was put in action. The specification of this is attached.

There was a method of isolating the 65 ton tanks in the C and D chambers by lowering three bulkheads located in the tunnels between the B and C chambers. There was also provision for dampers to be lowered at various points into the air ducts of the C and D chambers allowing the ventilation to be focussed on any spills or gas escape.

Installation of The Air Conditioning (March 1942 Onwards)

An air conditioning plant was built just outside the main tunnel and completed in March 1942. Its purpose was to provide a means of regulating the temperature and condensation in the storage areas. As originally planned the ventilating air was to be admitted up the centre tunnel in the arch position above a false ceiling, but the height below this was insufficient to allow large tanks to be transported to the chambers. This false ceiling was omitted and an inclined sliding door placed at the inner end of the tunnel to deflect the air above the false ceiling in the chambers. When the air conditioning was installed the bulkheads in the tunnels between chambers B and C were removed.

Operation From March 1942 Until 1945

The external heating system consisted of two powerful fans in parallel, running one at a time, which sucked air through a steam heater, a water spray, a series of baffle plates and then another steam heater. Air then passed through a fan, which blew it into the centre tunnel. The slanting roller door caused the hot air to rise over the false roof of the chambers and through the holes of this roof, into the chambers themselves. These holes could have been covered up, so as to distribute the heat in any desired manner amongst the chambers. Normally just the air heaters were used and were automatically controlled to give a temperature of 55-57 degrees F on the delivery side of the fan and a temperature of 50-52 degrees F in the chamber.

The designed capacity of the ventilation equipment was not achieved, the maximum steam compensate rate with both batteries working was 8,200 lbs/hr which gave a temperature rise of 37 degrees F. During very cold spells a temperature of 58 degrees F at fan outlet was obtained. The fitting of new pattern steam traps effected no appreciable improvement. As the ventilation air passed over a considerable area of wet rock face, the use of water sprays for humidification was unnecessary in even the coldest weather. During the hot weather the water sprays were utilised to refrigerate and hence dehumidify the air. This was achieved by cooling the air by direct contact with the water drops to a temperature below its dew point and trapping the mist so formed on the baffle plates at the exit of the spray chambers. Simple and positive control of this operation was affected by spraying the incoming air with cooling water whenever a deposit of dew was

visible on the water pipes in the building. Typical results of spraying were to reduce air temperature from 83 degrees F to 73 degrees F and from 70 degrees F to 64 degrees F. Reliable figures for corresponding changes in humidity are not available.

In very warm weather, the liability of moisture condensing on tanks and weapons existed. This was obviated by using the water spray to cool the air down to a temperature below its dew point, so that some condensation took place. The bulk of this moisture was removed by the baffle plates and the air was then warmed up again by the second stem heater. The dew point of the air was lowered by this means and thus prevented deposition of moisture. The water supply was provided by mines water (summer temperature 55-57 degrees F). No advantage was gained unless the wet bulb temperature of the outside air was at least 64 degrees F. During the not very warm summers of 1942 and 1943 this spray was not in use for more than 100 hours altogether.

Following the introduction of the Fuel Economy Campaign throughout the winter of 1943-1944, no heat at all was used in the system except, occasionally, for a few hours for special purposes referred to later.

On November 23 1943 owing to fuel and power economy requirements the plenum fan and heaters were run only during daytime (i.e. when people were working in B chamber). One week later (after the 65lb bomb bonding had been removed from K4A) the plenum house was shut down completely and natural ventilation, as described above, was permitted.

With no steam heating, the minimum temperature recorded in February 1944 averaged 43.2 degrees F. With the introduction of the fuel economy campaign the inlet ventilation fans were stopped and the extract fans on the hill-side were run only during periods of transfer of vesicants. It was necessary to renew the thrust bearings on three occasions on these fans, due to original poor design of lubrication.

In the late spring and early summer of 1944 considerable deposition of moisture on storage tanks, walls etc. in the tunnels was observed especially after long periods without the extraction fan being used.

Emergency bathrooms were installed in the tunnels. Trouble was experienced with the drainage pumps due to the gritty nature of the drainage. The roof of the tunnels and chambers seeped badly in wet weather and it was necessary to pipe this water to the drains in many places. Inspection of the rock faces was made by Halkyn Mines Co. at regular intervals and loose material which showed signs of scaling off was removed. In October 1944, 5 tons of loose rocks were removed from the roof of B chamber. The ends of dividing walls between chambers were reinforced with concrete facings in some places. Prior to the end of 1943, the bonding chambers were used for the bonding of thin cased weapons, but the demand for these having diminished and the risk of bombardment from the air by the enemy having lessened, it was unnecessary to use this area for this purpose.

The storage chambers were used throughout the life of the factory and at various times in 1944 F.F.D. transport tanks were housed here awaiting shipment. Early in 1944 a train-load shipment of those tanks was delivered in heavy frost to an F.F.D. unit near Cambridge. When the material arrived it was impossible to discharge the tanks as the liquid vesicant had frozen. It was considered unwise to allow the tanks to remain in the F.F.D. sidings to thaw out, owing to the risk of bombing and the train was therefore returned to Valley. The tanks were placed in the centre tunnel, the doors closed and warm air from the plenum system was blown through the tunnel. By this means it was possible to thaw out the vesicant in a very short period of time. The control of the air temperature was simple and the experiment demonstrated that the whole plenum ventilation system in the tunnels was adequate to prevent freezing of the products even under the most stringent winter conditions which can be visualised as occurring in this part of the country.

APPENDIX 1

Routine Work Carried Out In The Tunnels

Tunnel Sumps- These were drained once per shift and more often if necessary. The sample of any tank was taken immediately before starting to draw material from it. In the early days of 1941 chlorine gas was passed into the sumps from time to time but no treatment was given. Since then no toxic smell has been detected.

Temperatures- When toxic material was first stored in D chamber a wet and dry bulb hydrometer was installed and read hourly. In March 1942 when the plenum fan was started, wet and dry bulb hydrometers were installed in each chamber. No readings of temperature were taken after the tunnel attendants had been dispensed with but a recording thermometer was installed in B chamber south.

In the severe winter of 1940-41 the temperature in D chamber fell to about 40 degrees F without any heating system in use but in the milder winter of 1943-4 (after heat had been cut off) it fell to a minimum of 43-44 degrees F. Midsummer temperatures average 55-60 degrees F.

Sampling- A routine sampling of all tanks in the tunnels was carried out by the C.I.D.(Chemical Inspection Dept.) at intervals of approximately three months.
A surface, middle and bottom sample of each was taken and a routine analysis and a moisture test carried out. In addition a surface sample of any tank was taken immediately before starting to draw material from it.

Tunnel Attendants

When toxic material was first stored in the tunnels, it was considered necessary to have two men per shift permanently on duty in the process area to keep non-process men from tampering with the process material, and as a precaution against sabotage. This continued after construction work had ceased on the tunnels, their duties being to keep an eye on the tanks from a safety point of view, to challenge anybody they thought had no business in the tunnels and to carry out such routine jobs as emptying drainage sumps, taking temperatures and helping on transfers where necessary. With the reduction in labour this was reduced to one per shift in February 1944. In June 1944 the two side tunnel doors were locked permanently and all shift attendant work ceased. All tanks and chambers were now examined each shift by the Transfer Charge Hand and the sumps emptied.

Examination of Tanks

The tanks were examined once per shift to see that no leakage had occurred or pressure developed. This was originally carried out by tunnel attendants, but after their services had been dispensed with, the Transfer Charge Hand patrolled the tanks and chambers at least once per shift to see that all was well

APPENDIX 2

Ventilation Plant House (Type S)

General Requirements

Since it was necessary to deal with a potentially toxic atmosphere, adequate ventilation and certain temperature and hygrometric conditions had to be maintained inside the tunnels. The following rates of air change were provided for:-

Bulk Storage and Bonding areas	-	12 changes/hr
Weapon Storage areas	-	6 changes/hr

To maintain these rates of change approximately 287,000 cu ft/minute of air was required.

It was laid down that the average air temperature inside the tunnel should be approximately 55-60 degrees F and should on no account fall below 43 degrees F. Furthermore the hygrometric conditions of air had to be such that no moisture would form on the surfaces of any weapons stored inside the tunnels.

Air Quantities

261,000 cu ft/min of fresh air was drawn was drawn through a conditioning chamber by means of a fan and delivered through a series of overhead ducts to each of the tunnels. 287,000 cu ft of vitiated air per minute were drawn from the chambers through ducts located below floor level and led to two common outlet ducts. From each of these outlet ducts the air was withdrawn by an extraction fan mounted inside a chimney and subsequently withdrawn into the atmosphere.

Air Conditioning Unit

This was of the spray type, consisting of essentially of a pre-heater, spray chamber and re-heater, together with two induced draft fans (one working and one spare). The air heater had a surface of 2,660 square feet. The spray chamber took the form of a rectangular casing in which were mounted 675 water sprays arranged in two separate banks. The free cross sectional area of the spray chamber was 552 sq. ft. The base of the chamber terminated in a 4ft tank or reservoir, in which was fitted a ball float valve controlling the level of the wash water. An air re-heater of 2,660 sq. ft. was located at the outlet end of the spray chamber.

Circulating Pumps

Water was circulated to the sprays by two centrifugal pumps (one working and one spare). Each pump was capable of circulating 1,350 gall/min when running at 1,400 r.p.m. against a total water head of 75 ft. Pump motors were 40 h.p.

Plenum Fans

Air was drawn through the conditioning unit by a single inlet centrifugal fan, which had a capacity of 261,000 cu. ft./min against a total resistance of approximately 3 ½ inch W.G. (static) when running at 153 r.p.m. The fan was driven by a 260 h.p. motor running at 580 r.p.m. Two fans were installed, one working and one on standby.

Building

The air conditioning unit, pumps and fans were enclosed in a steel framed, corrugated iron sheeted building, which was located at the entrance to the 15’ wide central tunnel. The building was 65’ long, 45’ wide and 34’ high, measured to the eaves. Three overhead runway blocks were installed to facilitate maintenance.

Air Inlet Ducting

The duct between each fan discharge and the inlet to the centre tunnel leading to the underground chambers was 15’ wide, 6’ deep and approximately 64’ long. It was constructed of mild steel plate and insulated with 1½’’ thick cork slabs. Inside the underground chambers the air duct was formed by the area enclosed between the roof and a false ceiling constructed of mild steel plate. Air was admitted to the chambers through 7’’ diameter diffusers, each diffuser being fitted with an adjustable cover plate, which was set to give the various air rate changes required.

Air Extraction Ducts

These were formed in the flooring of the underground chambers and the air was extracted through a series of mild steel grills.

Extraction Fans and Chimneys

All vitiated air drawn through the air extraction ducts was discharged to the atmosphere through two fans mounted inside the chimneys. Each fan was capable of handling 143,500 cubic feet of air per minute.

Drainage

All floor and duct drainage was collected in two sumps. Each sump was drained by a motor driven float operated submerged pump fitted with trip gear to operate between specified levels. Each pump had a capacity of 100 gallons per minute and was directly coupled to a 5 h.p. x 960 r.p.m. motor. Pump discharges were led through 4'' bore piping to drainage points located outside the tunnels.

(Source I.C.I. Internal Document courtesy of Mr E.Lloyd-Davies)

Inventory

65ft x 45ft x 34ft high with a concrete floor and fan foundations (2,925 sq. ft.).

2 x MS centrifugal fans each 261,000 c.f.m. driven by 260 h.p. motors.

1 x air conditioning chamber 26ft x 9ft x 22ft high (free area 522 sq. ft.)

2 x centrifugal pumps for water to sprays. 1350 galls/min driven by 40 h.p. motors.

6 x water filters 12ft diameter x 24ft high. Valves and pipe work.

1 x Pre-heater battery. Capacity 261,000 cu. Ft./min from 32 degrees F to 50 degrees F.(steam heated)

1 x Re-heater battery, as above but 45 degrees F to 52 degrees F.

3 x 5 ton blocks. Traveling blocks on 12in. by 5in. RSJ runways.

2 x Harley Boyce compressors with H.P. Motor
2 x Receiving chambers 3ft diameter 3ft 6in high.

(Source V/SP5/30 I.C.I. Inventory dated 30th March 1945 viewable at Rhydymwyn Valley Site)

APPENDIX 3

General History of the Storage Tunnels

On December 11th 1940 the first load of Pyro M ex-Randle for underground storage was delivered to Valley Works and discharged into US tank No 1. The transfer was carried out without mishap but owing to the low temperatures prevailing, braziers had to be kept burning in the vicinity of the tanker, as it had to be left in the tunnels all night due to electrical trouble with the ventilation fan. This practice of lighting braziers around the tanker was frequently used both at Valley and Woodside. Hot water or steam jets were also used for thawing liquor lines and pipes. During the succeeding days further Pyro M was sent from Randle and by December 20th this tank was full.

US 3 was the next tank to be filled and then US 4.

On January 4th 1941, the first load of Runcol was received from Randle and on the same day the first load of runcol from R4 plant was transferred to the tunnels. At first, Runcol from R1 and R2 was kept separate from that from R4 but later the storage position made this impossible and, in any case, no useful purpose was served by this segregation. To distinguish the content of tanks, a yellow band was painted on Pyro M and a red one on Runcol tanks.

When transfers were first started at Valley all making and breaking of joints in air and liquor lines was carried out by shift fitters but to speed up working generally this job was subsequently passed over to transfer men.

In February 1941 a rule was made that liquor lines in the open air must not be disconnected during the hours of darkness. As the amount of work to be done increased it was found impossible to keep to this regulation and a lamp was provided for use when breaking lines in the darkness.

The permanent vacuum pumps in the tunnel were put into use by May 1941. Previous to this, either the tanker vac. pump (where fitted) or a portable vac. pump was used. In each case an extension was fitted to the exhaust leading the fumes into the wind trench.

By the end of June 1941 all the tanks in D chamber had been filled. From time to time a certain amount of material (chiefly Pyro) had been sent back to Randle for charging. On July 22nd 1941 the emptying of storage tanks from the Antelope Field into tunnel storage was commenced and this job was completed on October 5th 1941. On February 17th 1942 the last tank (No 37) was in position in the tunnels and filling was started.

On two occasions water was introduced into storage tanks due to overfilling of vacuum scrubbers with caustic solution. The first case was US 2 containing Pyro M. In October 1941 this was found to have a layer of water 2-3'' deep on top of the Pyro M. The material in this tank was reputedly skimmed through a monel metal tube from either end of the tank into a 50 gallon drum which was subsequently disposed of in the burial pit. This skimming failed to remove all the water but subsequent samples over a period of 2 ½ years showed decreasing amounts of wetness and in June 1944 this tank was reported dry. The second case was US 30 containing Runcol: a considerable layer of water was reported on 12th August 1942; this was extensively skimmed removing most of the water. The tank gradually dried out over the next four months and on January 1st 1943 was reported dry.

Since May 1942 HB and HBD had been stored at Woodside but on account of the fire risk had not been stored in the tunnels. Pyro M from Woodside was convoyed down to Valley to make room for HBD.

In August 1943 permission was granted for HBD to be stored underground. Precautions adopted included the use of non-sparking copper-beryllium spanners and prohibition of all naked lights and smoking materials in the tunnels. Calculations showed that the maximum quantity of benzene that could be deposited into the drainage sump in the course of a day was so small that no appreciable fire risk would result. On 14th August 1943 the first load of HBD was therefore transferred to US 30 and by the end of 1944 8 tanks were filled with HBD. No trouble was experienced due to the inflammable nature of the material. Tanks containing HBD were printed with blue bands to distinguish them from HT and HM (and from the vacuum system).

To obviate the possibility of fire during decontamination of spillages, bleach paste or bleach and sand was prohibited for HB or HBD. 'Green Solution' made by mixing 17 volumes of water and adding 60 volumes of saturated sodium bicarbonate solution to the diluted hypo was the only permitted decontaminant for HB and HBD.

APPENDIX 4

INVENTORY

Underground Storage Area.

The storage area was excavated in a limestone hill, with four chambers at an average depth of 147ft below ground. Their dimensions were:-

(a)	4	chambers	260ft x 30ft x 20ft 6inches high
(b)	1	chamber	272ft x 30ft x 20ft 6inches high
(c)	1	chamber	220ft x 30ft x 20ft 6inches high
(d)	3	chamber	234ft x 36ft x 18ft high
(e)	1	chamber	260ft x 36ft x 18ft high.

They were connected by three tunnels:

(a) 1 central tunnel 564ft x 15ft with a concrete entrance fitted with steel roller shutter doors measuring 12ft x 18ft.

(b) 2 side tunnel entrances 490ft x 12ft wide with concrete entrance and roller shutter doors measuring 8ft4in x 8ft 6in.

All chambers were cut in solid limestone with concrete floors and concrete ventilation trenches (fitted with MS air grids)

2 ventilation shafts 9ft square x approx. 200ft long with MS chimneys 9ft in diameter and 60ft high each fitted with axial flow type extract fans rated at 143,500 cu.ft./min driven by a 52.5 h.p. motor.

Conditioned air from the ventilating plant was circulated through ducts in the tunnel roofs formed by MS false ceiling.

The ceiling comprised three areas of approx 200ft x 15ft wide, 1600ft x 30 ft wide and 1094 ft x 36ft wide giving 90,384 sq ft of area. This consisted of 5,021 x 5ft x 3ft MS sheets.

(Source V/SP5/30 I.C.I Inventory dated 30th March 1945 viewable at Rhydymwyn Valley Site)

If you detect any errors or have additional information please contact me at lixwm@tiscali.co.uk