



5 July 1978

TO: ~~Lou Doelp~~

FROM: Norm Brock

Enclosed please find a report covering the ICI engineering design practices for equipment handling vinyl chloride monomer.

It is excellent general information for the two major divisions (Mond and Plastics) of ICI.

Please return when finished.

RECEIVED

JUL 6 1978

CORP. ENGR. DEPT.

A handwritten signature, likely 'Norm', written in dark ink.

AP00015015



Norm Brock

INTEROFFICE
MEMORANDUM

Date 14 May 1975

Subject ICI Equipment Report

To Distribution

(Location, Organization, or Department)

From J. T. Barr

Valley Forge

(Location, Organization, or Department)

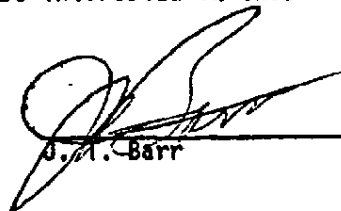
Distribution

N. H. Brock	J. D. Kramer
S. Cordaro	D. V. Lowe
J. L. Cost	T. J. Medovich
W. E. Dunning	E. A. Primeau *
D. H. Francke*	G. B. H. Speed
R. E. Jones	W. C. Wilde*

• No attachment

The attached report received from ICI is being distributed separately from the trip report because of its interest to a different group of people.

Please pass on to anyone whom you think may be interested in this information.


J. T. Barr

JTB/bas

Attachment

(320)

AP00015016

Page 1

IMPERIAL CHEMICAL INDUSTRIES LIMITED
PLASTICS DIVISION - HILLHOUSE WORKS

VCM EQUIPMENT INVESTIGATION

Author: R Drabble

Circulation:

R N Hodge	Runcorn	Mond
D O Hagon	"	"
D P Duffield	"	"
R P Crook	Hillhouse	"
H L Stowell	Welwyn	Plastics
K H Gee	"	"
D Wilson	Darwen	"
Members of Sub Committee		

For information:

AE&CI	} Via J H Wilson, Welwyn
ICI Australia	
Electroclor	
Solvay	

J S Secker	Hillhouse
W F Madden	"
W O Jones	"
F J Young	"
C Wright	"
T Taylor	"
W Howarth	"
A G S Stalker	"
W Fothergill	"
D H Cassie	"
S Bowker	"

RD/MR/1 August 1974

ICI PLASTICS DIVISION

HILLHOUSE WORKS

At the request of the Mond/Plastics Division Liaison Committee on VCM Investigation the following sub-committee was established to exchange information on the performance of engineering equipment used for handling VCM, with particular reference to potential leakages.

Chairman	R Drabble	Plastics Division
	S Matthews	" "
	N S Johnson	" "
	A S Monk	" "
	R C Taylor	Mond Division
	C Layland	" "
	M L Tucker	" "
	T C Ramsdale	" "

The discussions were based on the premise that a broad range of agreement could be reached on the most suitable equipment, bearing in mind the differing conditions under which Mond and Plastics plants operate and without cutting across the various Division and Company Standards/Codes of Practice.

All the recommendations are aimed at desirable equipment and practices for future plants handling VCM which also can be used to consider improvements to existing plants, or in areas where problems become apparent.

The survey is presented in three parts and covers pipework systems, valves and fittings, pumps, compressors and special equipment.

Part 1 covers all the equipment discussed, with brief recommendations. Part 2 covers the general discussion notes and Part 3, leakage data on VCM plants and a visit report to the HCN plant at Cassel Works.

It is clear from the general discussion stages that contact between engineering personnel of the various Divisions handling similar products is stimulating, rewarding in ideas and information, all of which promote efficient processes, and improved safety standards.

In the case of the VCM Equipment Investigation Sub-Committee it was soon apparent that there were large areas of common ground and the personal contact brought about understanding of the various equipment problems.

This contact must not be lost in the future and VCM equipment development programmes of the two Divisions should not be carried out in isolation.

From the attached recommendations there are initially two major items, ie improved glanded or glandless pumps and valves, each of which require urgent development and could form the nucleus of future mutual improved equipment investigations.

Finally, and as Chairman of the Sub-Committee, I take the opportunity of thanking all the above Sub-Committee members for their interest and contributions to the discussions, the taking of minutes, visit report writing and, on the plant, investigation of VCM levels. Considering the short time allotted for this task each of the personnel involved concentrated considerable time and effort into its completion.

R Drabble

AP00015018

PART 1

VCM EQUIPMENT INVESTIGATION (Brief Recommendations)

1 PIPEWORK

- a) Although there have been no reports of serious difficulties with flanged joints, it is thought necessary to reduce joints to a minimum wherever possible by the use of continuously welded pipe.
- b) Pipework should be fabricated to Class 1 standard which include 100% radiography of all butt welds followed by a hydraulic test.
- c) After erection pipework should be leak tested in accordance with ICI Specification B80 'Pressure testing of erected metallic pipework'.
- d) After maintenance and re-assembly pipework should be subjected to a nitrogen or air leak test using soapy water, again in accordance with * Specification B80.
- e) At present tafted pipe ends should not be used with thin wall stainless steel pipes for jointing purposes. ** new method available* Plastics Division Metallurgist is currently reviewing tafted pipe end systems.
- f) Pipework branches should not be less than 1" nominal bore, to avoid mechanical damage.
- g) Wormto or other compression joints should be avoided if possible and not used in any circumstances above 1½" diameter or involving galvanised pipe.
- h) All small bore instrument lines which use screwed or compression fittings should be attached to an initial 1" flanged branch with a flanged isolating valve upstream.
- i) Small relief valves venting pipelines subject to liquid expansion must not vent to atmosphere.
- j) When relief valves are required to vent pipelines, generally >15 m³ capacity, they should vent to a stack or low pressure storage system and be protected by a suitable bursting disc - NB Risk of freezing.
- k) 'Slip on' or weld neck raised face flanges with CAF gaskets should be used.
- l) VCM pipework systems should be self draining as far as is possible.
- m) Bolted flanges are considered satisfactory to cover electrical conductivity of pipework systems when fixed to earthed plant structures and/or vessels.
- n) At the design stage of any pipework system a cost comparison should be made between carbon steel pipe painted and stainless steel pipe unpainted, to combat external corrosion.
- o) Pipework systems should be clearly identified by a 'painted on' coding system. 'Stick on' identification tapes are not recommended due to evidence of corrosion under the tapes.

2 VALVES

- a) Ball valves are preferred to lubricated plug valves due to the lubrication problem and stiffness in service of the latter. Plastics Division prefer top entry Wilmot Broadon ball valves because of their Division approved anti-static device and ease of maintenance. Mond Division will use Serck Audco and Worcester ball valves which are on ICI contract and are fitted with Company approved anti-static devices.

Measurements of leak concentrations show that most ball and plug valves have good gland sealing performance, and there is little to choose between various manufacturers from this point of view.

- b) Gear operated 'Hindle' ball valves have shown in some respects that they are more complicated for maintenance and the geared drive type does not positively retain the spindle when it is removed and used, albeit temporarily, as a hand valve.
- c) Stainless steel ball valves should be used for PVC autoclave isolation to prevent body corrosion.
- d) Ball valves fitted to all other VC services must have stainless steel balls fitted.
- e) PTFE lined plug valves are satisfactory for obtaining good gland sealing performance. The preferred type is 'Tufflin'. Plug valves, however, can become stiff to operate in service and work is continuing to eliminate this problem. 'Durco', a similar type of valve, is not acceptable because it does not include approved anti-static device.
- f) Packed glanded valves such as the mushroom valves and screw down valves used on the older Plastics Plants, and the control bonnet spindle type, should be regularly checked and repacked as necessary, because they have been found to exhibit excessive leaks in service. However, they should eventually be replaced by ball valves where pressure and temperature conditions allow.
- g) Gate and Globe type valves have proved suitable for use with virgin VCM but are not recommended for general use in PVC plants. Results of tests given in Appendix indicate there are leak problems with packed glands which is a feature of this valve type.
- h) Bellow sealed valves similar to Newman Hender and Serck Glocon, fitted with back-up packings, are preferred for instrument control applications and should be considered for all other critical applications.
- i) All valves should be manufactured from non-brittle materials, ie forged or cast steel, to avoid fracture from physical or thermal shock. Cast iron valves must not be used in any circumstances.

3 BURSTING DISCS

- a) Bursting discs are not generally a problem if the material and type of carrier are chosen from ICI Division or Company standards to suit the particular VCM duty.
- b) bursting discs fitted to critical VCM containing vessels should be tested cold in their carriers before fitting to a minimum of 90% of their lower tolerance bursting pressure. It is suggested that wherever possible spool pieces should be provided to allow for easy removal and testing of bursting disc assemblies.

4 SIGHT GLASSES

These are not recommended and should be avoided wherever possible. They are prone to leakage and mechanical damage.

5 CLAMPED TYPE VALVES

Valves and instruments which are clamped between pipe flanges are not recommended and raised face flanged equipment should be used.

6 NON RETURN VALVES

These are very rarely 100% effective, especially where build-up problems are likely to exist. If used, they should be manufactured in carbon steel or stainless steel materials. Where springs are part of the design, these should in all cases be from stainless steel. The simple flapper or swing check valve gives the best reliability and is more effective if installed in vertical pipelines.

7 PRESSURE GAUGES

- a) They should preferably be of the flanged type, eg 'Budenberg' with stainless steel diaphragm to ICI Standard IH301.
- b) Pressure gauges should be installed on 1" flanged branches with a flanged isolating stop valve immediately below it.
- c) All pressure gauges should be fitted with orifice plates below the isolating valve to restrict flow in the event of breakage.

8 FLOW METERS

- a) Flow meters should be of the glandless type, Foxboro Target 188 or Ropp and Keuter oval gear.
- b) Orifice plate systems with DP cells are not recommended because of the small bore pipes with compression or screwed fittings attached to them and which are prone to damage and blockage.

9 LINE BLIND VALVES

- a) This equipment needs regular maintenance, frequencies of one month minimum are recommended to check seals, lubrication and clamping effectiveness.
- b) One piece body type valves with renewable seats are preferred; the two-piece body type are not recommended. Current evaluation trials are in progress to select the most acceptable manufacturer/design.

10 COUPLINGS AND HOSES

- a) Articulated arms are preferred to flexible hoses for tanker loading/unloading, Cam-lock or Evertite Quick Release couplings with Viton 'A' seals give good leak-free service.
- b) Metallic convoluted and braided hoses are not recommended.

- c) Hoses by 'Compoflex' type 951 with wire whipped resin sealed flanged ends are recommended, but care should be taken to minimise mechanical damage.
- d) All flexible connections should be purged with N_2 to a stack or safe area, prior to disconnection.

11 RELIEF VALVES

- a) These should be protected by an upstream bursting disc with the space between monitored for pressure.
- b) Relief valves should be vented to a common stack of sufficient height and diameter, or alternatively individually to a safe area.
- c) Where relief valves vent into a common stack system a downstream bursting disc should be fitted to prevent corrosion by back diffusion.
- d) It is recommended that all VCM relief valves are fitted with stainless steel seats and springs.

12 FILTERS AND STRAINERS

Filters manufactured from carbon steel castings, and fitted with Viton 'A' joint rings give reliable and leak-free service.

13 PIPE EXPANSION BELLOWS

Where it is necessary to use expansion bellows, Teddington or Parsons type are recommended, but they can cause difficulties if particles ingress behind the expansion seals. Particular attention should be given to correct installation and to instructions regarding the direction of flow.

14 SAMPLE POINTS

- a) It is recommended that the number of sample points be kept to an absolute minimum, also the number of samples taken from any system containing VCM.
- b) Sample points should be connected to a 1" flanged branch with a 1" flanged isolation valve. Thereafter pipe sizes may reduce to that determined by the sampling method.

15 PUMPS

- a) Pumps should be manufactured from non brittle materials.
- b) They should not be fitted with packed glands.
- c) Screwed vents or drain points should not be fitted. If necessary they should be flange jointed.
- d) Preferred pump seals are product flushed Crane 1A, Crane 109 or Flexibox mechanical seals, in that order. Ceramic seats are preferred to tungsten carbide but seals fitted with PTFE wedge rings should be installed on a separately sealed shaft sleeve to prevent fretting.

- e) All pump shaft seals are prone to leak significantly more than any other sealed equipment such as valve stems. Consideration should be given to glandless pumps, or situating mechanical sealed pumps in the open air. If this is not possible local extraction systems should be installed.
- f) All pumps should be fitted with double block and bleed arrangements, both upstream and downstream. N₂ purge and vent stack connections should be provided for maintenance purposes.

16 PRESSURE VESSELS

- a) All vessels used for containing VCM should be constructed to Class 1 specification.
- b) Flanged branches, minimum size 2" nominal bore are preferred to flush fitting pads with stud or set bolt connections.
- c) CAF and raised face flange joints are recommended up to 8" diameter, above this size consideration should be given to spigoted connections or spiral wound gaskets.
- d) when flush-fitting pads cannot be avoided and the joint broken at frequent intervals for process or maintenance reasons, they should be fitted with helicoil thread inserts which must be regularly inspected and replaced as necessary. Detailed training of craftsmen is necessary to ensure correct assembly and fitting of studs/set bolts.
- e) All stainless steel vessels should be regularly checked for stress corrosion cracking of welds in addition to any statutory/Company requirements.
- f) Because of corrosion problems, inspection frequencies of carbon steel monomer recovery vessels (Plastics Division) must not be given extended frequencies unless carefully considered.
- g) All instrument fittings attached to vessels should be subject to a formal scrutiny at the design stage to check their pressure rating and design.
- h) PVC reaction vessels should preferably be fitted with mechanical seals.

17 GAS HOLDERS

- a) To prevent overfilling, all VCM gas holders should be fitted with high level alarms, and suction control instruments.
- b) The peripheral seal of a gas holder should not be allowed to 'blow', the bell should be fitted with a dip pipe complete with flow alarms and discharged to a safe area.

18 MAINTENANCE PROCEDURES

- a) It is clear that improved maintenance procedures in general will involve greater effort by both monthly/weekly paid staff. This work should not be allowed to stagnate because of maintenance cuts, lack of available effort and adequate training at all levels.

- b) Although increased scheduled maintenance on pumps, valves, piping and vessels can have advantages, the system in general is inclined to be wasteful in effort. A system of scheduled inspections is therefore recommended on top of a scheduled maintenance base load, involving regular monitoring and gas testing of equipment at frequent intervals.
- c) A formal testing of VCM containing equipment prior to handing back to production department should be carried out. This to include pressure testing and gas leak testing with soap and water when back in service.
- d) Widespread provision of N_2 for purging purposes with vent lines to a common stack or safe area should be provided to ensure vapour free equipment before any dismantling is attempted. This, however, is not always possible and the wearing of breathing apparatus will be necessary in cases of doubt or from experience of certain equipment types.

Plastics Division often have the facility for pipeline and vessel evacuation by means of installed vacuum pumps, this is considered a suitable alternative to common stack venting.

PART 2

VCM EQUIPMENT INVESTIGATION (General Discussion)

1. PIPEWORK SYSTEMS

1.1 Mond General

Mond use carbon steel piping schedule 80 up to and including 1½", schedule 40 above 1½", 200 psi and 20-60°C. Originally Table E flanges were used but on new plants as plant modification ASA 150 flanges are adopted. Slip-on flanges with CAF joints (untrapped) are standard. Small bore instrument (½") piping is quite common and satisfactory, using Ermeto or Brownhalls fittings. Where Mond Division use small bore (¾") instrument piping with Ermeto or Brownhalls fittings then the recommended safe practice is to install a larger flanged valve upstream of any such system to allow isolation should leaks develop in the instrument piping. Liquid expansion within plant boundaries is not specially catered for on the grounds that sufficient flanges are present which will 'spring and breathe'. Outside plant boundaries but within works boundaries any line containing more than 15 cu ft between valves is fitted with a bursting disc and relief valve back to storage. Outside works boundaries any size line which could trap VC is fitted with disc and relief valve. Piping fabrication specifications are Class 2, ie 10% radiography. No tafted piping is used. It is preferred that branches on process vessels are not less than 2" N/B; on pipe lines not less than 1" N/B. Vessels are to Class 1 standards.

1.2 Plastics General

Plastics also use schedule 80 and 40 carbon steel piping extensively but also have some stainless steel requirements. Slip-on flanges, tafted ends stub fittings, etc, have all been used in the past depending on the application. CAF (trapped joints) have been used; all welded lines where possible with trapped joints where necessary are to be used on 'Corvic' 8. Tafted ends will not, in future, be used on stainless steel VC lines in view of cracking problems experienced at Runcorn. Small bore piping is used extensively on older plants and tend to quickly block due to polymerised VCM. No general rules on liquid expansion apply, small relief valves venting to atmosphere have been used but are now not generally favoured. Bursting Disc and Relief vent to low pressure storage is recommended. Ermeto couplings should only be used up to the 1½" size on MS and stainless piping. Ermeto couplings are not recommended for use with galvanised pipework in any circumstance. Piping standards are Class 1 with 100% radiography.

1.3 Testing of Pipework

Up to the present time both Mond and Plastics arrange for full pressure testing of fabricated pipework including a nitrogen or air leak test after erection. This closely follows the B80 Company standard covering 'Pressure testing of erected metallic pipework'.

Questioning the need for more stringent testing in view of VC leakage/toxicity problems, after some discussion it was agreed that the Company's standard B80 should be followed. Further advice is to be sought from the hydrogen cyanide and phosgene plants on this and other related topics.
ACTION: R C Taylor/S Matthews/N S Johnson.

1.4 Earthing of Pipework

Mond practice differs in detail from Plastics. Both have ceased using bonded across flanges, the consensus being that the flange bolts/studs give adequate earthing routes. Plastics earth the plant structure.

Mond earth individual vessels in addition to the structure, cabling the earthing path back to an earthing point in the switch room. Codes of Practice will be consulted before further discussion.

1.5 Painting of Pipework

External corrosion of carbon steel pipework is becoming an increasing problem on some of the 12 year plus aged Plastics Plants and leaks have been a direct result. Mond appear to spend a larger proportion of their maintenance budget on routine painting than Plastics, in an attempt to keep the problem at bay.

A cost exercise on the use of stainless steel piping in lieu of mild steel piping for all liquid VC lines on 'Corvic' No 8 Plant, and so reduce routine painting and attendant corrosion problems, shows an increased capital cost of some £3-4,000, which is a small increase on an approximate total plant cost of 3.5M. The exercise was based on £5/foot for 4" N/B carbon steel against £7.50/foot for 4" N/B schedule 10 stainless steel pipe.

2 VALVES AND FITTINGS

2.1 Mond General

Mond are moving from the use of lubricated Plug valves (typically Audco) to Ball valves and having tried out a number of makes have decided on price, delivery and experience basis to opt for Serck Audco or Worchester Ball Valve. The Runcorn VCM Plant have very recently had some problems with the Worchester valve. Problems with Hindle geared drive ball valves have been found, in that the spindle is not retained in the casing if the geared drive bridge piece is removed during maintenance and the valve used in this stage as a hand operated valve. A serious leak of HCl occurred on an 8" valve when attempting manual operation after removal of the geared drive.

2.2 Plastics General

Plastics have already installed a large number of ball valves and, unlike Mond, are not happy with the Worchester valve, which requires 'tailor-made' seats on re-furbishing and this might explain Mond's recent problems. Fire safe and anti-static studies have been extensively carried out and the Wilmot Breedon Ball Valve is now the preferred ball valve; there has been evidence of excessive corrosion on carbon steel bodies of WB ball valves at Runcorn. This is understood, however, to be a fault in the initial material choice and they are now being replaced in stainless steel. The use of Tuffin PTFE coated plug valves is now seriously under consideration for 'Corvic' 8, having been in use on trial for approximately one year on VC at the Hillhouse PVC plants.

2.3 Valve Gland Leaks

There is a lack of evidence of whether valve glands leak and if so by how much. A survey of valve glands and types including pump seals will be carried out on 'Corvic' and VC plants to provide basic evidence.

Mond VCI plant Instrument Section strongly suggested Serek Glocon bellows sealed valves with a back up packing for use on control instrument applications. Newman Howler are the general Company standards and far less expensive bellows sealed valve for normal line valvery. The design of these valves makes them very unlikely to leak VC. It was suggested that the Saunders diaphragm valve should be a good contender against leaks if suitable diaphragm materials could be found, although these bring problems of flow restriction which is important with the build up problems of Plastics, in addition to the low pressure rating of these valves and normal CI construction. Mond Division, however, do not support this and would not use these valves on VCM. Plastics Division use them on low pressure VCM gas lines only.

Tuflin valves appeared to have good design features in respect of leakage; there was evidence of stiffness in operation of Tuflin valves after a period of time and there seemed to be some doubt on the fire safe features of the Tuflin. A suggestion that VC swells PTFE (1-2%) is to be confirmed.
ACTION: T C Ramsdale.

Subsequent information on the special techniques required to fit sleeves in PTFE lined valves to obtain a good seal included softening by heating or allowing the PTFE to swell after removing initial wrapping. Some liners show less creep due to inhibition by fillers such as glass fibre.

Because both Mond and Plastics have experience of valves becoming increasingly stiff to operate in service, Welwyn Research have been asked to organise test rig trials with Tuflin valves, after confirming that VCM swells PTFE/Teflon. The manufacturers are also to be involved.

It was unanimously agreed that valve bodies should be made from non brittle material - ie forged or cast steel and not cast iron.

- 2.3a Levels of Leakage v Valve Types (Investigation) Part 3A
ACTION: R C Taylor/N S Johnson

2.4 Pipe Fittings

2.4a Bursting Discs: Plastics seem to have more difficulties with bursting discs than Mond, probably because of build up problems. Divisional standards appear different in detail and this is to be examined further. Mond generally test bursting disc assemblies before installation; Plastics only selectively do this. This is a typical example of one of the main differences between the two Divisions; Plastics with batch processes have to change discs, operate valves, open pipe lines, etc, much more frequently than Mond with their continuous process.

2.4b Sight Glasses: These are universally disliked and Mond are aiming to remove the very few remaining ones on their plants. Similarly, Plastics are aiming to eliminate sight glasses but again the process consideration on the older Plastics plants creates a bigger problem in achieving the goal.

2.4c Clamped Valves: There are some valves and fittings (eg the 'Camflex' valve) which clamp between pipe flanges using long studs. This type of fitting is seen as undesirable because of the difficulty of making/maintaining adequate joints and the manufacturer's recommended use of special stud bolt material types.

2.4d Non Return Valves: The general feeling is that only occasionally are NR valves of any real value because of build up problems and their installation must be carefully considered. Plastics have had continuous difficulties with Emato NR spring devices fitted in horizontal lines; the flipper type favoured by most people works best in a vertical line and hence the need for careful consideration at the design stage.

2.4e Pressure Gauges: It was agreed that the best approach was to install 1" N/A stubs with valved and flanged ends to receive flanged gauges (typically Hudenberg gauge with S/S diaphragm to DH 301). This would give a very robust and secure type of fitting. In addition an orifice plate insert to restrict flow in the event of a breakage was a desirable feature, unless build up is suspected.

2.4f Flow Meters: In general it was agreed that glandless meters be used wherever possible. Typically, Mond use Foxboro Target 18B meters and Plastics Bopp & Reuter Oval gear meters, both of which satisfy the glandless requirements. Orifice plates with DP cells are not recommended for VCM services because of the small bore pipes involved and attendant screwed or Ermeto fittings.

2.4g Line Blind Valves

Plastics generally use Triangle type valves with one piece bodies. Recently a similar type of valve has been located, manufactured by Hindle of Leeds which is to be evaluated in the next few months.

The main problem with line blind valves of the Tringle type is the difficulty in maintaining the Fluon seats which are not replaceable on site. Factory replacement and overhaul costs are approximately 60% the cost of a new valve.

Mond have no experience of Line Blind valves, because their processes are conveniently covered by conventional replacement spade systems.

2.4h Couplings and Hose Connections

Both Mond and Plastics Division recommend 'Cam Lock' or 'Evertite' types of quick release coupling, but in all cases coupling jointing materials must be Viton 'A'. The Evertite coupling has a safety catch which cannot be released when the coupling is under main pressure.

Mond Division propose to install articulated arms for all VC tanker loading, these to be in lieu of large size (3" and over) flexible hoses which are prone to mechanical damage and not so manoeuvrable as the articulated arms when connecting to inaccessible points (Mond Ref - Hazard and Reliability Study No 14, 295/5 dated 6 July 1973).

Mond find Compoflex Hose type 951 prone to leaks after very few occasions of use and it has been found necessary to treat the whipped ends with special resins - sea to road tanker connections mainly.

Plastics use flexible hoses for all VC tanker off loading and are 3" nom bore Compoflex type 951 with wire whipped flanged ends and incorporating a separate bonding wire within the hose walls. These hoses have given satisfactory service but are prone to damage if not carefully handled.

The venting of articulated arms and flexible tanker hoses between isolation valves is a potential VC leak area. It is therefore important that before breaking any coupling the residual VC between the valves should be swept by nitrogen to a local stack.

Plastics Division also use convoluted stainless steel braided hoses, up to approximately 2" nom bore for connections to weighed tanks. These have been found difficult to inspect and predict pin holing failure. The plant are considering the replacement of this type hose by Compoflex 951 or alternatively using metered systems direct from stock tanks whenever possible.

2.41 Relief Valves

At Mond Division all relief valves used on VCM services must be protected by a bursting disc manufactured from a suitable material, and all vessels or systems which because of process reasons are difficult to take out of service are fitted with twin relief devices. In addition all spaces between the discs and relief valves are continuously monitored and tested on a regular basis. Nearly all Mond plant vents are piped to a scrubber system and thence to a 200 ft stack. NB: This system covers all vents in a VCM complex, and downstream bursting discs are provided to prevent corrosion by back diffusion from the common vent system. Sphere reliefs are direct to atmosphere and considered safe by position.

All new relief valve installations by Mond Division are now subject to approval by a central division authority and registered at that time. In general ASME valves are preferred in an effort to standardise.

Plastics Division also protect all VC service relief valves with bursting discs, but do not provide twin relief valves, monitoring of the space between discs and relief valves as covered by sample pressure points. Relief valves are all individually vented to atmosphere at the most convenient highest point outside the plant.

Relief valves similarly to Mond are subject to approval by a central division authority based at Welwyn Garden City.

2.43 Filters and Strainers

These are very rarely used but should the occasion arise, cast iron construction must be avoided and synthetic rubber joint rings should be in Viton 'A'

2.4k Pipe Expansion Bellows

VC3 and VC4 use Parsons or Teddington bellows which operate well. Problems can occur if grit such as carbon obtains ingress into the sleeves. The units are sensitive to initial strain on installation and particular attention must be paid to 'Flow' direction of the contained product.

2.41 Sample and Drain Points

Mond Division use $\frac{1}{2}$ " min pipe connections in stainless steel with flanged joints and double ball valve isolation. A standard sample system is also provided comprising a specially designed sample bomb (81% filling ratio max) which is fitted as required into the pipework system. Venting is to an enclosed system or pump suction point.

In general, VC sampling is a recognised problem area in connection with leakage and therefore should be kept to a minimum.

VC sampling in Plastics Division is not part of the normal process and therefore does not call for any fixed systems. On older plants, vent connections are $\frac{1}{4}$ " bore mild steel plate reinforced. It is proposed, however, that all future connections of this type should be 1" minimum with orifice plates fitted if considered necessary.

2.4m Valves (General)

Wedgegate and screw-down Globe valves are not recommended for use with VCM, because of leaking packings, jamming and passing. Plastics Division have a special flush fitting mushroom type run off valve fitted to the outlet of autoclaves on the older plants which is prone to leaks through the valve seat and the packings. These are being changed to short pattern ball valves, and piston valves (Yarway) are to be evaluated.

3 PUMPS

All screwed vent connections and drains from pipes and pump bodies have been eliminated on new equipment in Mond Division due to the possibility of corrosion and erosion wear on the plugs and tapped holes. Flanged welded on drain/vents are now used. Atmosphere vents are not recommended and should be stack vented.

Mond make extensive use of double block and bleed arrangement on the upstream and downstream sides of each pump, mainly for safe isolation to cover individual leaking valves. However, this arrangement is also ideal for pump purging when appropriate supplies of N_2 and vent facility to a stack are also provided, either permanent systems or the flexible 'plug in' type.

Mond do not use cast iron pumps and all VCM pumps are fitted with mechanical seals. Crane type 1A single mechanical used (product flushed) for operating temperatures of up to $100^\circ C$ and these have replaced the Crane type 109 whenever possible. Generally the 1A seal has 'V' seats in Ceramic, Monel or Ni-Resist, PTFE bellows and 17 m/m piping for product flushing. These assemblies have achieved a working life of one year.

Above $100^\circ C$ the type 109 seal has remained in service and must be fitted with a replaceable shaft sleeve to prevent wedge ring fretting and it also requires a backing seal.

Mond Division are investigating the use of glandless pumps for VCM duties. The mechanical seal leakage data in part 3 shows the advantages to be gained.

Plastics Division ('Corvic' 7) use Durco pumps on VCM with a single, product flushed, John Crane (American) type 9 mechanical seal running on ceramic stationary seats.

Plastics (Hillhouse) use two types of pumps, Haywood Tyler fitted with Flexibox type BRCPQ45-14L product flushed mechanical seal and Lee Howl fitted with Crana type 109 seals, also product flushed.

Serious leaks are now apparent from various types of seals fitted to both Mond and Plastics pumps. It is therefore clear that whenever pumps are necessary to any VCM process they must be fitted in the open air.

Plastics VCM compressors on the older plants are fitted with packed glands and at 'Corvic' 7 with 1A mechanical seals which have been found to have definite improvements. Similarly to pumps, compressors should be fitted in outside locations.

4 PRESSURE VESSELS

Monod treat VCM containing vessels as Class 1 duty and are all of carbon steel construction. They are subject to the usual pressure tests and regular inspections. Typical duties are distillation columns, drums, filters, storage vessels etc. No corrosion problems have been experienced and as a result some inspection periods have been increased to six years.

Monod prefer welded-on branches, minimum size 2", rather than pads. Joints to such branches are CAF such as Klinger 100. It is preferred that all VC storage vessel connections should have metaflex jointing to cover minor leaks and the fire aspects.

Similarly Plastics Division use Class 1 vessels both s/s and carbon steel construction. Raised faced joints are recommended up to 8" diameter; above this size consideration should be given to the use of spiral wound gaskets or spigoted connections.

For storage vessels, such as on recovery plants, and other general VCM vessels, Plastics Division prefer welded-on branches of a sufficiently large size to resist mechanical damage. It is easier to ensure tight joints with bolted through flanges. Some corrosion of branches and vessels has been encountered on recovered monomer tanks where water and acids can be present. Because of these corrosion problems inspection frequencies of monomer recovery vessels (Plastics Division) should not be given extended inspection frequencies unless carefully considered.

On autoclave reaction vessels (particularly where problems of build-up necessitate flush mounted bursting discs, run off valves and instruments etc), Plastics Division's practice has been to use welded-in pads with helicoil thread inserts. Extra vigilance is required by maintenance to ensure that only studs of the correct material and length are used and that they are sufficiently inserted into the helicoils. Set bolts are not recommended but if unavoidable must be of the correct length to ensure sufficient thread penetration on the one hand, and to prevent ungripped joints arising from complete penetration of the bolts on the other hand. Helicoil inserts must be inspected every two years and replaced as necessary.

Following several minor incidents where leaks of VCM occurred, all instruments and fittings mounted on pressure vessels such as thermocouple pockets, pressure transducers, gauges etc, and their associated joints, pipes and systems are now formally subjected to scrutiny at the design stage for their ability to withstand pressure.

Plastics use process operated manhole lids on autoclaves of the breech block type which are sealed using Viton rubber 'O' rings.

Thorough inspections are regularly carried out on threads, joints, studs etc, as well as the vessel. Stainless steel branches, pads and cladding are examined for cracks following past experience of stress corrosion cracking.

Agitators on reaction vessels have, on the older plants, packed glands or, on newer plants, the preferred balanced double mechanical seals lubricated using a substance which is compatible with the chemical reaction carried out in the vessel. The space between the seal and the abrasive slurry is continuously flushed with water which passes through a labyrinth into the vessels. If bearings fail on the seal cartridge then shut off rings are provided on the agitator shaft to prevent major leaks of VCM.

4.1 Gas Holders

Must not use gas holders to contain VCM. Plastics use them as buffer capacity on the recovery sections. The main cause of leakage is overfilling which can blow the peripheral water seal. One technique to prevent such leaks from affecting personnel is to vent via a dip pipe positioned in the centre of the moving bell which releases gas to a vent stack. In addition instrument interlocks and alarms should be provided as an early warning. In emergencies this will not always be possible because rapid venting of an autoclave into a gas holder can prevent larger quantities of VCM being released directly from the autoclave to atmosphere.

5 MAINTENANCE PROCEDURE

Some procedures relating to specific equipment have, where appropriate, been described in the earlier sections of these notes. This section refers to general matters.

The main problems were thought to be the following:

Practices for Dismantling Equipment that has previously contained VCM

Despite the advantages of providing nitrogen purges and vent lines to stacks or vents to gasholders, those present realised the practical uncertainty of ensuring always that all traces of VCM have been removed from equipment prior to maintenance especially where trapping can occur. In such circumstances, although it is essential to thoroughly purge vessels, pipes, pumps, valves, etc, prior to maintenance and in many cases to carry out accurate gas tests, there is still a significant advantage to be gained by erring on the side of safety and using breathing apparatus for such work. At minimum it was thought advantageous to have a specified list of jobs where it is compulsory for breathing apparatus to be worn with options left open for additional jobs based on a judgment of circumstances at the time.

Polyperoxides can form in all VCM containing vessels and equipment, therefore, before opening up, all vessels should be decontaminated with 10% HCl in water and boiled for a minimum period of one hour. No vessel, pump, pipe or other equipment should be left containing polymerised VC for longer than one week without dismantling and cleaning or decontaminated as above.

Maintaining Equipment Leak Free on a Scheduled or other Basis

Neither Mond nor Plastics carry out a high level of scheduled maintenance on VCM equipment. Mond rely on main shutdowns at appropriate intervals for most maintenance on their continuous plant but have regular schedules at shorter intervals for repacking filters, lubricating plug valves etc. This is supplemented by as-needed maintenance of equipment that is provided with stand-by duplication.

Plastics adopt approximately the same procedure for their continuous recovery sections but, on the batch autoclave sections, tend to carry out opportunity maintenance and some schedules between batches usually combined with breakdown jobs. Rather than increase the level of schedules, it was generally thought to be an advantage to add onto the above existing procedures, regular monitoring and inspection of equipment, including gas tests to check for leaks before they become significant, thus identifying which equipment is required to be repaired (ie scheduled inspections). Any scheduled inspections would need to identify leaks before they reach a defined unacceptable level otherwise this technique would result in some leaks being repaired only after they had become serious. However, the method of scheduled inspections is thought to have real practical and cost advantages over extra scheduled maintenance mainly because, for such items as pump seals and valve stem leaks, such large scatter is experienced in their sealing performance that it is not practical to regularly maintain all equipment at intervals prescribed by the worst performers. Effective checking/testing after maintenance, prior to hand-over, can eliminate some of the latter difficulty and a formal procedure for handing back was thought necessary.

Because of the recent VC in air problem the implications of the above means increased maintenance costs and equipment outage on existing plants and increased capital cost of new plants.

MEASUREMENT OF VC LEAKS ON VARIOUS EQUIPMENT

Leakage concentration levels of VCM adjacent to various equipment were measured at both Mond and Plastics Division plants. The results and conclusions given separately in Part 3A.

7 VISIT TO HCN PLANT AT BILLINGHAM

The conclusion obtained from this visit was that the main method of preventing personnel from being exposed to HCN is to enclose equipment in well ventilated cubicles from which air is continuously extracted and discharged high into the atmosphere. Strict procedures are adhered to for entry into the cubicles which, after obtaining clearance, is always done wearing full protective clothing and a fresh air mask with a second man in attendance.

PART 3A

VALVE MECHANICAL SEAL AND FLANGE LEAKAGE DATA

In an effort to quantify what Leakage rates are being achieved with different types of equipment, readings were taken on several sites producing the data as tabulated below. In the time available it was not possible to standardize exactly on the method of sampling and analysis and it is recognised that further work in this field is necessary.

The preliminary results give the following indications.

A. Valves

Ball valves are suitable for most applications although their leakage rates vary from site to site. Ball valves that are used infrequently perform better than those used several times daily. Worcester valves have given trouble on the Millhouse 'Corvic' plants and this problem is being investigated independently. Although the Audco lubricated plug valves show little leakage they are usually difficult to move due to poor lubrication and are being superseded by ball valves.

Wedge gate valves, globe valves and control valves appear to have much higher leakage rates than ball valves and the conclusions reached were that more attention must be paid to maintenance of the gland area. The use of glandless bellows seal valves should be considered for critical installations.

Mechanical Seals

The leakage rates were very much greater than expected especially since in all cases except one there was no visible leakage. It is recognized that the design of such seals depends on a fluid or vapour film to lubricate and cool but the levels had not been previously known.

One thing is obvious and that is that the actual rate is very small

and localized since its effect soon disappeared within the velocity of the unit. Obviously ventilation is of prime importance and special consideration should be given to siting pumping units. As a result of these findings and from previous work it was agreed that the investigation into the use of glandless pumps being carried out by Mond Division (VC3 and DED) should proceed as quickly as possible and the results be made available for discussion. Consideration should also be given to providing an external back up gland and quench with EDC if available to dilute high concentrations with otherwise satisfactory seals.

C. Flanges

The readings indicate that leakage from flanges is very low. So long as flanges are correctly made and pipe lines tested prior to use they do not present a problem.

It is good practice to use continuously welded mains both from economic and leakage considerations. This practice is used on other difficult duties such as HCN at Cassel and should be extended where possible.

Value type	Latitude	State	Log ₁₀ Concentration ppm	Frequency of Operation of	Comments	Site
Salmon	47° 30' N	30° 4'	3 to 4	1/T	Core 1-6	WC3
"	50° 30' N	0.5 to 3	-	1/T	Core 1-6	WC3
White Breeder	70° 30' N	5 to 25	4 to 19	1/T	Core 1-6	WC3
"	30° N	4.1	-	1/T	Core 7	WC3
"	90° 30' N	1 to 9	-	1/T	Core 7	WC3
"	12° N	-	-	1/T	Core 7	WC3
"	14° N	-	-	1/T	Core 7	WC3
"	43° N	-	-	1/T	Core 7	WC3
"	62° N	-	-	1/T	Core 7	WC3
"	65° N	-	-	1/T	Core 7	WC3
"	140° N	-	-	1/T	Core 7	WC3
"	150° N	-	-	1/T	Core 7	WC3
"	215° N	-	-	1/T	Core 7	WC3
Waterfall	40° N	0.8	-	1/T	Core 7	WC3
"	30° N	50	30	1/T	Core 7	WC3
"	30° N	100	30	1/T	Core 7	WC3
"	30° N	500	30	1/T	Core 7	WC3
"	30° N	10,000	200	1/T	Core 7	WC3
Deep Lanco	30° N	5.2	-	1/T	Core 7	WC3

Valve Type and Manufacturer	Size	Leakage Concentration ppm at sample distance			Frequency of Operation or Intrusion	Comments	Site
		"	5"	10 ft			
TRIANGLE WEDGE GATE	5 off 3"	6 to 15	6 to 15	6 to 15	1/T	Corvair 1-6	
"	"	150	150	150	1/T	"	
"	"	200	200	200	1/T	"	
"	"	250	250	250	1/T	"	
"	"	600	600	600	1/T	"	
"	"	1,500	1,500	1,500	1/T	"	
"	"	2,000	2,000	2,000	1/T	"	
"	"	10,000	10,000	10,000	1/T	"	
"	"	16	16	16	1	"	
"	"	30	30	30	1	"	
"	"	100	100	100	1	"	
"	"	150	150	150	1	"	
"	"	350	350	350	1	"	
"	"	500	500	500	1	"	
"	"	> 10,000	> 10,000	> 10,000	1	"	
AUDCO LBS. FLDG	2"	0.3	0.3	0.3	1/T	WC3	
"	"	0.7	0.7	0.7	1/T	"	
"	"	28	28	28	1/T	"	
"	"	0.7	0.7	0.7	1/T	"	
"	"	2.5	2.5	2.5	1/T	WC3	
"	"	1,450	1,450	1,450	1/T	"	
INTEK, BOMBY OPERATED, PACKED SPINDLE C/V/VALVE	3 to 4-5	3 to 4-5	3 to 4-5	3 to 4-5	1	Corvair 7	
"	"	400	400	400	1	"	
"	"	440	440	440	1	"	
"	"	60,000	60,000	60,000	1	"	
ROSKOPF TYPE AUTOCLAVE READERS	33	33	33	33	1/T	Corvair 7	

16 flanges carrying gaseous VC at 60 psig were checked at 'Corvite' 1-6 and the levels at all joints were indistinguishable from the background levels of approximately 5 ppm.

16 flanges carrying liquid VC at 60 psig were also checked at 'Corvite' 1-6, of these only 2 gave levels higher than the background i.e. 20 ppm with a background of 5 ppm.

PIPE FLANGES

Seal and Pump Types	Leakage Concentration ppm				Comments	Date
	1"	1 1/2"	2"	10 ft		
Flexibox RBCP45-14L Seal	10,000	0,000	30	6	NVL. Pump running	'Corvite' 1-6
" "	10,000	10,000	2,000	6	NVL. Pump stopped	"
" "	10,000	10,000	500	25	NVL. Pump running	"
" "	30	25	25	25	NVL. Pump stopped and isolated	"
Crane 109B Seal	10,000	10,000	360	30	NVL. Pump running	"
" "	700	35	30	30	NVL. Pump running	"
" "	10,000	10,000	800	4	NVL. Pump running	"
" "	40	14	8	4	NVL. Pump running	'Corvite' 17
Coal Creek Type 9 Seal	-	-	912 & 4"	-	Leaking. Pump running	"
Butco Pump	520	-	-	-	NVL. Pump running	"
Crane 109B Seal	17,160	-	-	1	NVL. Pump running	VC3
Crane 109B Seal	1,460	-	-	1	NVL. Pump running	VC3
Crane 109 Seal	-	960	14	< 1	NVL. Pump running	VC4
M & P Lysavane Pump	-	310	2	-	NVL. Pump running	VC4
Crane 109 Seal	-	1	< 1	-	NVL. Not running. No Guard.	VC4
..Ditto.. (P504B)	-	130	3	-	NVL. Not running. Guard on.	VC4
Crane 109B Seal	-	7	< 1	-	NVL. Pump running. Perforated Guard on.	VC4
M & P Lysavane Pump	-	-	-	-		
Flexibox RBCP45 Seal	-	-	-	-		
M & P Lysavane Pump	-	-	-	-		
BUCK/EMIA (P650A)	-	-	-	-		