

NOT FOR PUBLICATION

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VINYL CHLORIDE: TOXIC HAZARDS AND PRECAUTIONS

R&S 132494

INTRODUCTION

PROPERTIES OF VINYL CHLORIDE

HEALTH HAZARDS

RESPONSIBILITIES

CONTROL LIMITS

ALARM LEVELS

ASSESSMENT

CONTROL MEASURES FOR MATERIALS, PLANT AND PROCESSES

Design and operation

Local exhaust ventilation

Venting

General ventilation

Cleaning and waste disposal

AIR MONITORING

Discontinuous methods

Continuous methods

Measuring equipment

Location of sampling points for fixed analysers or automatic
sequential fixed point sampling systems

Accuracy and calibration

Leak detection

Alarm systems

Recording of results

PERSONAL PROTECTIVE EQUIPMENT

Respiratory protective equipment

Protective clothing

PERMITS-TO-WORK

Confined spaces

Maintenance operations

MAINTENANCE OF CONTROL MEASURES

EMERGENCY PLANNING

REGISTERED WORKERS

HEALTH SURVEILLANCE

INFORMATION, INSTRUCTION, AND TRAINING

Washing and changing facilities

Arrangements for eating, drinking and smoking

NOTIFICATION TO THE HSE

RECORDS

- APPENDIX 1: Properties of vinyl chloride
- APPENDIX 2: Sampling strategy flow chart
- APPENDIX 3: Model letter to the family practitioner of a vinyl chloride worker on his leaving employment with vinyl chloride
- APPENDIX 4: Model form of consent for disclosure of a worker's medical records relating to vinyl chloride to Appointed Doctor
- APPENDIX 5: Records
- APPENDIX 6: Legal requirements

R&S 132496

INTRODUCTION

1 Vinyl chloride is a colourless, highly flammable gas at room temperature and atmospheric pressure. It is normally stored and handled under pressure as a colourless liquid. It has a slightly sweet odour detectable at concentrations above 2000 ppm. In the UK virtually all vinyl chloride is used as starting material for the production of polyvinyl chloride (PVC) homopolymer; a small amount is used for copolymerisation with vinyl acetate. PVC is used extensively in pipes, flooring, home furnishings, electric cable insulation, blow moulded containers, packaging and records.

2 This Guidance Note has been prepared on the basis of joint discussions between representatives of the Confederation of British Industry, the Trades Union Congress and the Health and Safety Executive within a Working Group of the Health and Safety Commission's Advisory Committee on Toxic Substances.

3 This Guidance Note provides practical guidance for employers, self-employed persons and persons in control of vinyl chloride monomer manufacture and polymerisation plants to assist them in complying with the Control of Substances Hazardous to Health Regulations 198- and Approved Code of Practice for the Control of Vinyl Chloride at Work. References in this note to 'employers' should be taken to include self-employed persons. This Guidance Note may also be helpful to safety representatives in fulfilling their statutory functions under the Safety Representatives and Safety Committees Regulations 1977. The guidance will be used by Inspectors of the Health and Safety Executive (HSE) as part of their criteria for assessing compliance with the Health and Safety at Work Act 1974 and other relevant statutory provisions.

4 The Control of Substances Hazardous to Health Regulations 198- apply to all toxic substances used at work, including vinyl chloride. The Directive of the Council of the European Communities (78/610/EEC) on the approximation of the laws, regulations and administrative provisions of the Member States on the protection of the health of workers exposed to vinyl chloride monomer applies to the protection of those workers who:-

R&S 132497

- (a) are employed in works in which vinyl chloride is produced, reclaimed, stored, discharged into containers, transported or used in any way whatsoever or in which vinyl chloride is converted into vinyl chloride polymers, and
- (b) are likely to be affected by exposure to vinyl chloride in a working area.

5 VINYL CHLORIDE IS HIGHLY FLAMMABLE AND PRESENTS A CONSIDERABLE FIRE AND EXPLOSION HAZARD; THIS GUIDANCE NOTE DOES NOT GIVE ADVICE ON SUCH RISKS. Vinyl chloride comes within the group of substances defined in Class 2 of Part II of Schedule 1 of the Notification of Installations Handling Hazardous Substances Regulations 1982. It also comes within the definition of a flammable gas as set out in Schedule 1(c)(i) of the Control of Industrial Major Accident Hazards Regulations 1984. Some of the requirements of these Regulations overlap with certain sections of this Guidance Note. Where this occurs reference is made in the text and the Regulations should be consulted for further details.

6 This Guidance Note does not give detailed advice on the control of emissions of vinyl chloride to the atmosphere. HM Industrial Air Pollution Inspectorate is responsible for the control of air pollution arising from industrial processes involving the production of PVC and copolymers from vinyl chloride monomer. For detailed guidance on the control of emissions, reference should be made to the HSE Note on Best Practicable Means BPM 3/79 : Petroleum Works (PVC Polymer Plants).

PROPERTIES OF VINYL CHLORIDE

7 The properties of vinyl chloride are set out in Appendix 1.

HEALTH HAZARDS

8 Vinyl chloride is a gas at room temperature and atmospheric pressure and the most common route of absorption into the body is by inhalation.

effects, the severity of which increase with exposure. At exposures of 50-500 parts per million (ppm) in air for 7 hours no apparent acute effects have been found in humans. However, exposure to 20,000 ppm (2%) for 3 minutes resulted in dizziness and disorientation. Incapacitation occurred at concentrations above 80,000 ppm (8%) over 5 minutes. Exposure to concentrations of 300,000 - 400,000 ppm (30-40%) is rapidly fatal.

10 Chronic exposure to vinyl chloride has been associated with angiosarcoma of the liver, liver or spleen fibrosis (similar to the perilobular fibrosis known as Banti's Syndrome), circulatory disorders in the hands and feet (similar to Raynaud's Phenomenon, also known as white finger), scleroderma (a degenerative lesion characterised by stiffness of the skin and soft tissues) and acro-osteolysis (a deterioration of certain bones, most commonly the terminal phalanges of the fingers). Such effects have usually occurred after chronic exposure to levels in excess of 100 ppm (see para 12). Vinyl chloride is a proven human carcinogen with no known threshold of effect.

11 Other effects have been reported as occurring in workers chronically exposed to vinyl chloride monomer at similar levels of exposure, although such reports have been disputed by others. These include tumours of the brain, lung, haemo-lymphopoiatic system, and skin (malignant melanoma), lung function disorders, thrombocytopenia and immune complex disorders. Effects on reproduction have also been reported.

12 The general consensus of opinion is that polymerisation workers between 1940 and 1975 might have been exposed to levels of vinyl chloride of the following order:-

1945-55	1000 ppm
1955-60	400 - 500 ppm
1960-70	300 - 400 ppm
Mid-1973	150 ppm
1975	5 ppm

R&S 132499

Throughout the world there will have been variations around these figures because of differences in plant design or process operation.

RESPONSIBILITIES

13 Employers must do all that is reasonably practicable to safeguard the health of their employees and others who may be affected by work activities involving vinyl chloride. In particular, they have a duty to comply with the provisions of the Health and Safety at Work etc. Act 1974, the Control of Substances Hazardous to Health Regulations 198- and the ACoP on Vinyl Chloride. Employers may also have a responsibility to comply with the Factories Act 1961 and other associated health and safety legislation (see Appendix 5).

14 Section 2(3) of the HSW Act requires employers, with certain exceptions, to prepare, and revise as appropriate, a written statement of their general policy with respect to the health and safety at work of their employees and the organisation and arrangements used to carry out that policy and to bring the statement and any revision of it to the notice of all of their employees. The arrangements within the organisation for a formal system of joint consultation between management and employees and their representatives on all aspects of the Approved Code of Practice on Vinyl Chloride should also be set out in the safety policy.

15 In the safety policy, a member of senior management should be given responsibility for ensuring that the matters covered by the Vinyl Chloride ACoP, the Health and Safety at Work etc. Act and the Factories Act, etc are implemented. These include the responsibility for safe systems of work, safe places of work, training, monitoring, emergency procedures, joint consultation etc. He should be provided with appropriate support as may be necessary.

16 Responsibility for implementing particular aspects of the Approved Code of Practice and this Guidance Note should be allocated at each appropriate level within the organisation with a clear line of communication from plant operatives to the person in overall charge. Steps should be taken to ensure that individuals understand and accept their responsibilities.

safety precautions and in making proper use of the equipment and facilities provided for their protection. They should report immediately to their supervisors any suspected faults or material defects in plant or deficiencies in the control measures taken to contain vinyl chloride and reduce exposure.

18 Safety policies need to be reassessed at regular intervals to ensure that they are still appropriate and effective, particularly when significant changes in plant or work activities occur. Such assessment should include, of course, the organisation and arrangements for complying with the legislation, code of practice, etc relevant to vinyl chloride.

CONTROL LIMITS

19 The Control Limit for occupational exposure to vinyl chloride vapour in air is an Annual Control Limit of 3 ppm and is the value which should not be exceeded by the concentration, averaged with respect to time, of vinyl chloride monomer in the atmosphere of a working area over a period of one year. Only periods of plant operation including, where necessary, any maintenance time should be taken into account. Periods during which alarm level concentrations are measured need not be taken into account when assessing compliance with the Annual Control Limit. In practice, the atmosphere of working areas should be monitored regularly (see paragraphs 37-62) and the results summarised on a shift and monthly basis. A 'rolling average' time weighted average concentration of vinyl chloride-in-air can then be calculated and over any period of 12 successive calendar months it should not exceed 3 ppm. In this way, past compliance with the Annual Control Limit can be checked and trends noted. This Annual Control Limit is supplemented by an 8 hour time weighted average (TWA) Control Limit of 7 ppm for personal exposure with the proviso that the Annual Control Limit is not exceeded. These Control Limits have been judged after detailed consideration to be reasonably practicable for the whole spectrum of work activities in Great Britain and should not normally be exceeded.

20 For substances, such as vinyl chloride, for which there are no known thresholds below which adverse effects do not occur not only should exposure be kept below the Control Limits but it should also be reduced still further until the point is reached where the costs of further control measures are not justified in terms of the additional reduction in risk.

R&S 132501

21 In vinyl chloride monomer manufacturing and polymerisation plants there should be a system for the automatic detection of high levels of airborne vinyl chloride in places where these may occur (see para 54). The following concentrations of vinyl chloride in the atmosphere of a working area should be treated as alarm levels, signalling the need for evacuation and remedial action:-

- (a) 15 ppm when measured over a period of 1 hour, or
- (b) 20 ppm when measured over a period of 20 minutes, or
- (c) 30 ppm when measured over a period of 2 minutes.

Where a continuous multi-point analyser (see paragraphs 40-41) is used, two successive readings above the appropriate concentration will determine the existence of an alarm level, ie 15 ppm over a period of 1 hour and 20 ppm over a period of between 20 and 30 minutes.

ASSESSMENT

22 Under the Control of Substances Hazardous to Health Regulations an employer must not carry on any work which may expose his employees to any substance hazardous to health unless he has made an adequate assessment of the risks to health created by the substance. The assessment involves identifying the nature of the substance, the risks to the health of persons who may be exposed, the nature and degree of exposure which may occur during the course of work and the steps to be taken to avoid risks to health. In order to ensure effective control of exposure to vinyl chloride, it is necessary to collect and assess adequate data on the circumstances under which exposure may arise. In existing plants, most of these data will already have been obtained. All work activities which may involve exposure should be assessed to identify actual and potential sources of emission of vinyl chloride vapour into the working atmosphere. The nature and degree of exposure should be studied in each case. In Appendix 2, a flow chart sets out a sampling strategy for the assessment of exposure to toxic substances. Assessment permits the formulation of plans for the development and introduction of effective engineering, operational and other measures for the prevention or control of exposure, for the maintenance

R&S 132502

of such measures and for the long-term monitoring of their effectiveness. It also indicates activities where the only reasonably practicable method of preventing exposure is by using respiratory protective equipment. In existing plants, operating experience and monitoring data should already have led to the introduction of most of these control measures.

23 The employer should ensure that whoever carries out the assessment is competent for the purpose and has received adequate information, instruction and training.

24 Examples of work activities which may give rise to exposure to vinyl chloride include:-

- (a) transport, storage, discharging into containers, breaking down from bulk, polymerisation, reclamation and sampling of vinyl chloride or materials, including waste, containing it in residual or unreacted form;
- (b) the operation, cleaning, maintenance and repair of any apparatus or process plant used in the production and conveyance of vinyl chloride or in its polymerisation and the handling and storage of freshly polymerised material.

25 An employer should consider not only the exposure of his employees engaged upon work with vinyl chloride but also that of:-

- (a) other of his employees not directly involved with vinyl chloride who could be affected by that work activity;
- (b) other people who may be exposed while on the premises, eg the employees of outside contractors engaged on maintenance;
- (c) members of the public who may be affected by emissions and discharges from the workplace.

26 To estimate the degree of exposure to vinyl chloride by inhalation, it is usually necessary to carry out a comprehensive personal atmospheric sampling survey. However, vinyl chloride in air estimations need not be carried out in every individual case, particularly when sufficient information based on

activity or where it may be possible to group employees on the basis of similarity of degree of exposure and type of work done to enable an adequate assessment of likely exposure to be made. It is important to study the pattern of exposure of workers in different jobs and locations over whole workshifts and to identify when and where the highest exposures are likely to occur taking into account the possibility of unusual circumstances such as plant breakdowns or emergencies.

27 It is important to carry out sufficient sampling to enable accurate 8 hour time-weighted average concentrations to be calculated. However, shorter term sampling may assist in the assessment of the performance of engineering controls. The survey of exposures should be extended over sufficient workshifts to ensure that the variability of exposure is adequately studied. Further detailed information and advice is available in HSE Guidance Note EH 42 - 'Monitoring Strategies for Toxic Substances'.

28 It is recommended that the results of the assessment be recorded and a copy provided on request at any reasonable time during working hours to employees and/or their representatives at the place of work.

29 The assessment should be revised whenever there is evidence or reason to suspect that it is no longer valid, as a result of, for example:-

- (a) a significant change in the work activity; this could be a change in plant, processes or methods of work that might affect the nature or degree of exposure, such as the raising of process temperatures or changes in engineering controls;
- (b) results of air monitoring at the work place revealing an increase in exposure;
- (c) data arising from health surveillance;
- (d) new information on health risks becoming available.

CONTROL MEASURES FOR MATERIALS, PLANT AND PROCESSES

30 When considering appropriate control measures for reducing exposure to a toxic substance, the first strategy to examine is substitution with less

using or producing toxic intermediates. Users or potential users of vinyl chloride and polyvinyl chloride should consider the use of a less toxic substance but if that is not possible control measures should be applied as far as is reasonably practicable, irrespective of the size of the plant, to minimise exposure of personnel to vinyl chloride.

31 Control may be considered adequate when exposure to vinyl chloride is effectively controlled to the occupational Control Limits and as far below them as is reasonably practicable in the particular circumstances. The objective in applying materials, plant and process control measures is to ensure adequate control of exposure without recourse to personal protective equipment so far as is reasonably practicable.

Design and operation

32 Equipment and processes should be designed and operated to eliminate or minimise the risks of leakages and spillages of vinyl chloride and to minimise the need for maintenance or other work which requires the breaching of and/or entry into plant in which vinyl chloride is liable to be present.

General ventilation

33 Good general ventilation should be provided for rooms and buildings in which processes involving vinyl chloride are carried on and as far as possible plant should be sited in the open.

Local exhaust ventilation

34 Vinyl chloride should be handled in enclosed equipment provided with local exhaust ventilation at any points where the emission of vapour cannot be eliminated by improved design or maintenance. Local exhaust ventilation should also be provided at specific locations in process plant to ensure that maintenance operations can be carried out safely.

Venting

35 HM Industrial Air Pollution Inspectorate and HM Factory Inspectorate should be consulted on any points relating to plant or storage where there is the potential for the emission of vinyl chloride into the atmosphere to ensure that both the public and the workforce are not at risk.

R&S 132505

Cleaning and waste disposal

36 Waste polyvinyl chloride slurry containing significant levels of residual vinyl chloride should be stripped of vinyl chloride prior to suitable treatment of the liquid waste for general disposal. Solid polyvinyl chloride waste should preferably be dried before disposal. Wastes arising from vinyl chloride processes should be handled and disposed of in accordance with the Department of Environment Waste Management Paper No 15: 'Halogenated Organic Wastes - A Technical Memorandum on Arisings, Treatment and Disposal including a Code of Practice'.

AIR MONITORING

37 The objectives of monitoring concentrations of airborne vinyl chloride in working areas are:-

- (1) to verify that any technical measures and working procedures maintain adequate control of exposure;
- (2) to detect abnormal increases in vinyl chloride-in-air levels which may occur as a result of failure or malfunction of some part of the plant or apparatus, with references to the short term alarm levels for vinyl chloride;
- (3) to provide adequate records of the exposure of individuals for the purpose of epidemiology.

38 The arrangements for monitoring require careful planning to achieve effective and efficient use of resources. A formal air monitoring plan should be drawn up and made known to all employees working in areas where vinyl chloride is liable to be present. The plan should contain details of the air monitoring procedures and equipment that are to be used to meet the objectives set out in para 37, including details of:-

- (a) the parts of plant, working areas and occupational groups of employees to be monitored;
- (b) the type of air sampling to be carried out, eg personal air sampling, fixed point air sampling;

equipment;

- (d) the types of sampling and analytical equipment to be used;
- (e) arrangements for the testing and calibration of sampling and analytical equipment;
- (f) the statistical analysis and presentation of the air sampling results.

The information obtained from the initial and any subsequent assessments should be used when planning or revising the details of the monitoring procedures.

39 Static sampling will be the main method used routinely for assessing compliance with the Annual Control Limit and detection of alarm levels in vinyl chloride monomer production and polymerisation plants. In order to assess compliance with the 8 hour TWA Control Limit personal monitoring will be necessary.

40 Static sampling may be either by discontinuous or continuously operating sequential systems, except at vinyl chloride polymerisation plants sited within buildings where only the latter methods should be used.

41 Where discontinuous air sampling techniques are used, the frequency of measurements should be sufficient to predict with a confidence coefficient of at least 95% that there is compliance with the Annual Control Limit, in other words that the Control Limit value falls above the upper 95% confidence limit for the true annual arithmetic mean for the working area. The required frequency will thus depend upon the variability of concentrations with time.

42 Where vinyl chloride is handled intermittently, monitoring of exposures by personal sampling should be done sufficiently often to ensure that technical control measures and working procedures are adequate to keep exposure below the Control Limits.

43 Large working areas will normally require more than one monitoring point and in such cases the average value of the measurements recorded should be considered as the representative value when assessing compliance with the Annual Control Limit.

R&S 132507

44 The sensitivity, range, selectivity and speed of response of an analytical device should be appropriate to the duty it is required to perform. Electrical equipment in flammable atmospheres should be suitably constructed, protected and installed; guidance is available in BS Code of Practice 1003.

45 The following techniques are among those suitable for detection and measurement of vinyl chloride:-

- (a) gas chromatography
- (b) infra-red absorption analysis
- (c) flame ionisation detection

Flame ionisation detection is not specific for vinyl chloride and may therefore give readings which are greater than the actual concentration.

46 Gas samples may be taken by any technique which is recognised and acceptable for the analytical technique to be used.

47 A comprehensive description of the various analytical techniques available for the measurement of vinyl chloride are given in 'The Determination of Vinyl Chloride: A Plant Manual - Analytical Methods for the Control of Vinyl Chloride Concentrations In and Around Manufacturing and Process Plants' published by the Chemical Industries Association Limited, Alambic House, 93 Albert Embankment, London SE1 7TU. Details of one of the personal sampling methods used by HSE are available in MDHS 24 - 'Vinyl Chloride in Air: Laboratory method using charcoal absorbent tubes, solvent desorption and gas chromatography'.

Location of sampling points for fixed analysers or automatic sequential fixed point sampling systems

48 Sampling points should be located within the working area to sample air representative of that breathed by the workers. The probes should normally

be sited at breathing height and at local places where the air movement is representative of the general working area and should not impede the movement of workers, access to or operation of equipment.

49. Other locations for sampling points may also need to be chosen so that any increase in concentration of vinyl chloride arising as a result of leakage or plant malfunction can be detected as soon as possible (see para 54).

Accuracy and calibration

50 If a measuring system is used which records vinyl chloride and other substances without being capable of distinguishing between them, the results obtained should be regarded as representing vinyl chloride only. Special consideration may need to be given to the interpretation of results where there are indications that the Control Limit is being exceeded but it is known that this is due to other substances.

51 The precision and accuracy of the sampling systems used should be investigated over the vinyl chloride in air concentration range of 1-30 ppm. An accuracy of $\pm 10\%$ within this range is satisfactory. The method used and the results obtained should be recorded.

52 Measuring equipment should be calibrated regularly, in accordance with the agreed air monitoring plan, using the most appropriate technical methods. The calibration of automatic air sampling systems should preferably involve the injection of air samples containing known amounts of vinyl chloride into the system at sampling points, rather than directly into the analysing instruments.

Leak detection

53 Leak detection may be carried out by the following means:-

- (a) portable analyser;
- (b) mobile sample line attached to a non-portable analyser;
- (c) ultra-sonic leak detector.

Alarm systems

54 Whatever sampling system is used for routine monitoring, there should also be a system for the automatic detection of high levels of airborne vinyl chloride in places where these may occur, eg in the event of plant failure. The alarm system may be integrated with a continuously operating or permanent sequential system provided for the purpose of air monitoring.

Recording and presentation of results

55 The results of all atmospheric monitoring at fixed points should be available for inspection by personnel working in areas where vinyl chloride is liable to be present and their representatives at any time during a working period. Where continuously operating multi-point sequential sampling methods are employed, the results should be displayed as far as possible within two hours of the end of each shift sampled. Where discontinuous method and/or personal monitoring are used, the results should be displayed within 24 hours of completion of the sampling period where possible.

56 In the areas where continuously operating multi-point sequential sampling and analysing equipment is installed, results should be summarised on a shift basis for each identifiable work area showing the average concentration in the area. Basic details of the position and number of sampling points together with the frequency of sampling and analytical methods used should be included at the beginning of the series of records and thereafter need only be recorded when changes occur in the monitoring procedure.

57 In the areas where sampling is carried out other than on each shift, the individual time weighted average results should be recorded. These should be summarised on a monthly basis showing the average concentration at each location with an analysis of the distribution of the individual results.

58 Records of maintenance and monitoring should provide sufficient information to enable employers, self employed persons, persons in control of premises, employees and/or their representatives at the workplace, and enforcing authorities to:-

R&S 132510

- (a) ascertain whether maintenance or monitoring has been carried out;
- (b) monitor the performance and effectiveness of control measures;
- (c) gain access to information on any defects or matters requiring attention and on the remedial action taken;
- (d) identify exposure trends.

59 The records should contain at least the following information:-

(1) Leakages of vinyl chloride

- (a) description of area or plant inspected;
- (b) date of inspection;
- (c) time of inspection and shift;
- (d) statement of any defects or leaks found that might result in the release of vinyl chloride vapour above the 8 hour TWA Control Limit or alarm levels;
- (e) significant uncontrolled or abnormal emissions of vinyl chloride to the atmosphere reported to HMI/API;
- (f) indication of action taken following discovery of faults;
- (g) name, signature and appointment of person making inspection.

(2) Examinations of ventilation equipment

- (a) location and type of plant;
- (b) date of examination;

R&S
132511

- (c) instruments used and results of instrument readings;
 - (d) defects noted;
 - (e) action taken;
 - (f) name, signature and appointment of person making examination.
- (3) Excursions above the alarm levels as detected during area monitoring
- (a) part of factory to which the record refers;
 - (b) precise location within the factory;
 - (c) date, time and (where known) duration;
 - (d) maximum time weighted average concentrations recorded;
 - (f) result of investigation;
 - (g) action taken;
 - (h) name signature and appointment of person making inspection.
- (4) Personal monitoring
- (a) name of employee;
 - (b) date;
 - (c) time and duration of exposure;
 - (d) time weighted average concentrations recorded;
 - (e) precise duty and working area within factory;
 - (f) nature and nominal efficiency of respiratory protective equipment (if worn).

R&S 132512

The results of personal monitoring should be summarised on a monthly basis by job category in each plant in addition to shift results.

60 If respiratory protective equipment is worn by any personnel during air monitoring exercises, this should be recorded together with the nature and nominal protection factor of the equipment to enable an estimate of the 'actual' exposure to be made.

61 Records may be kept in any suitable form, including microfilm, computer or similar techniques, provided they satisfy the foregoing requirements and can be retrieved readily when required.

62 Records of air monitoring should be kept for at least 30 years. In the long term, air monitoring results may be kept in the form of monthly summaries, but in this case the detailed shift records on which they are based should be kept for at least 1 year. Records of leakages of vinyl chloride and examination of ventilation equipment should be kept for at least 2 years.

PERSONAL PROTECTIVE EQUIPMENT

Respiratory protective equipment

63 Where adequate control of exposure to vinyl chloride cannot be achieved by normal engineering controls and the provision of further control measures for materials, plant and processes is not reasonably practicable, workers should be provided with adequate and suitable respiratory protective equipment. The term 'adequate' with respect to respiratory protective equipment refers to the ability of the equipment to protect the wearer; 'suitable' refers to the correct matching of the equipment to the job and to the person. To be considered adequate and suitable, respiratory protective equipment must be correctly selected and used. It should be noted that the nominal protection factor of respiratory protective equipment can only be achieved if the face fit of the equipment is very good. In the case of vinyl chloride, this means compressed air line or self-contained breathing apparatus of a type approved by or conforming to a standard approved by the Health and Safety Executive.

R&S 132513

64 In particular, adequate and suitable breathing apparatus must be worn:-

- (1) when it is not reasonably practicable to remove vinyl chloride vapour by local exhaust ventilation, e.g. when opening equipment which may release appreciable quantities of vinyl chloride to the atmosphere and during the maintenance or repair of equipment. No such operation should be conducted without a permit-to-work issued by a competent person designated by the employer for this purpose. Precautions should be taken to ensure that other unprotected personnel in the vicinity are not liable to be exposed to concentrations of vinyl chloride above the 8 hour TWA Control Limit;
- (2) during entry into confined spaces which have not been certified by a competent person as being safe for entry without breathing apparatus.

65 Following an alarm, adequate and suitable breathing apparatus should be worn by any person remaining in an affected area until the alarm is over. The source of an escape of vapour should be identified and appropriate corrective action taken without delay.

66 It is recommended that no person should be required to rely for protection on respiratory protective equipment unless he has successfully completed a training or refresher course on the use of such equipment within the previous 12 months and has been issued with a certificate to this effect. The training or refresher course could include the following:-

- (a) principles of operation and use of equipment;
- (b) practical use, correct fitting, etc;
- (c) limitations of the equipment;
- (d) common defects and action required;

(e) company arrangements for issue, cleaning, maintenance, etc;

(f) when it is to be used.

67 A register of authorised personnel trained in the use of respiratory protective equipment should be kept together with a record of each person's training. All breathing apparatus should be maintained in a clean state, in good repair and in efficient working order. It should be inspected every 14 days and defects identified and remedied immediately. The maintenance schedules should specify that the compressed air supplied to the wearer of breathing apparatus should contain not more than 5 ppm carbon monoxide or 500 ppm carbon dioxide or 0.5 mg m^{-3} oil mist and except for these should be free from contamination by dust, dirt, metallic particles or any other toxic or irritant substances whatsoever. The maintenance schedules should also include the source of compressed air, the air line, particularly the connections, and proper cleaning and reissue of equipment.

68 No respiratory protective equipment which has been used should be worn again by another person unless it has been thoroughly cleaned and disinfected.

69 Records of maintenance and inspection of respiratory protective equipment should include the following information:-

- (a) name and description of equipment;
- (b) person issued to, if on personal issue;
- (c) date of inspection;
- (d) description of any defect found and action taken;
- (e) name, signature and appointment of person making inspection.

These records should be kept for at least 2 years.

Protective clothing

70 Under normal circumstances, where vinyl chloride is handled within

clothing by process workers. However, certain circumstances, such as entry into confined spaces or some maintenance work, may require the use of special protective clothing. Such situations should be identified as part of the general assessment. The standard of clothing necessary will depend upon the nature of exposure. For example, where substantial body contact can be foreseen a high standard of protective clothing should be provided, eg completely enclosing air-fed suits (where respiratory protective equipment is also necessary) of wire reinforced PVC, or overalls of PVC-proofed material, completed in all cases by PVC gloves and boots. Where an area is relatively free of vinyl chloride, having perhaps been cleaned by means of high pressure hoses or other methods, overalls of materials such as terylene or cotton, may be adequate.

R&S 132516

PERMITS TO WORK

71 A permit-to-work is essentially a document which sets out the work to be done and the precautions to be taken. It predetermines a safe procedure and is a clear record that all foreseeable hazards have been considered in advance and that all appropriate precautions are defined and taken in correct sequence. It does not, in itself, make the job safe but is dependent for its effectiveness on the persons concerned conscientiously carrying out the requirements of the permit. There should be provision on the permit-to-work for the persons authorising the work to sign to this effect and for the persons carrying out the work to sign the document at each stage of the operation as it is completed. Permits to work should be issued for all entries into confined spaces and for certain maintenance operations. Copies of all permits-to-work issued should be kept for a minimum period of 2 years.

Confined spaces

72 In this Guidance Note the term 'confined space' includes any chamber, tank, vat, pit, pipe, flue or similar confined space such as, for example, a reactor, duct, or bunker in which vinyl chloride vapour is known to be or is liable to be present.

73 Unless adequate precautions are taken, entry into a confined space involves a particular risk of exposure to very high levels of vinyl chloride or lack of oxygen. Concentrations of vapour may even be such as to involve a

risk of persons being overcome with a consequent risk to life, in addition to the possible long-term effects of exposure. Plant should be designed and operated so as to reduce to a minimum time spent in vessels and the number of occasions requiring entry.

74 In order to reduce the potential short-term and long-term risks, entry into confined spaces should be strictly controlled. A permit-to-work system should be operated and other special precautions taken as outlined in HSE Guidance Note GS 5 - 'Entry into Confined Spaces'.

75 Whenever a person enters a confined space for any purpose, a lifeline should be worn or, where this is not practical, some other method should be used, to enable a second person posted outside the confined space to keep in constant contact. The second person should be able to raise the alarm and equipment and trained personnel should be readily available for rescue purposes. All workers involved in any way with work in confined spaces should be fully trained and conversant with the organisation's agreed emergency procedures.

76 Unless a confined space has been certified in writing by a competent person as being, for a specified period, safe for entry without breathing apparatus and the period has not expired no person should enter or remain in the confined space for any purpose unless he is wearing suitable breathing apparatus. The permit-to-work should specify the type and standard of personal protective equipment to be worn and all other necessary precautions to be taken.

77 Entry into a confined space without breathing apparatus should not be authorised by a competent person unless:-

- (a) effective steps have been taken to prevent the entry of any vinyl chloride vapour or other dangerous fume and
- (b) any sludge or other deposit liable to give off vinyl chloride or other dangerous fumes has been removed and no other material liable to give off dangerous fumes is present and
- (c) the space has been adequately ventilated, tested for vinyl chloride and other dangerous fumes and has a supply of air adequate for respiration.

R&S 132517

If there is a possibility that the proportion of oxygen in the air of a confined space has been substantially reduced no person should enter or remain in such a space unless he is either wearing suitable breathing apparatus. Alternatively the space should be adequately ventilated and a competent person should test and certify it as safe for entry without breathing apparatus.

Maintenance operations

78 When a non-routine operation or malfunction may result in the release of vinyl chloride to the atmosphere, adequate and suitable breathing apparatus of a type approved by HSE should be worn. Wherever possible special measures should be taken to prevent emissions of vinyl chloride. Such operations should not be conducted without permission in the form of a permit-to-work from a competent person designated by the employer for this purpose. Precautions should be taken to ensure that other personnel are not exposed to levels of vinyl chloride above the Control Limit.

MAINTENANCE OF CONTROL MEASURES

79 All plant, especially that from which vinyl chloride may escape or which is provided for the purpose of controlling exposure to vinyl chloride, should be maintained to a high standard in order to limit the exposure of workers to vinyl chloride. Maintenance procedures should include regular and thorough examinations by a competent person at appropriate intervals of those parts of the plant at which leakages of vinyl chloride may develop over a period of time. A suitable instrument giving a direct read-out of the concentration of vinyl chloride-in-air should be used for leak detection during such examinations. All defects found should be remedied promptly and the results of maintenance examinations and details of remedial action taken recorded.

80 Regular examinations and tests should be made of ventilation equipment and other technical control measures by a competent person, using instruments where appropriate, to check the performance of such equipment as part of a planned preventive maintenance programme. Where ventilation plant is provided in pursuance of Regulation 7 of the Control of Substances Hazardous to Health

R&S 132518

Regulations, maintenance should include a visual check at least once a week to identify obvious defects and a thorough examination and test by a competent person at least once a year. Details of such examinations and tests, defects found and remedial action taken should be recorded.

EMERGENCY PLANNING

81 A procedure for dealing with a substantial escape of vinyl chloride should be prepared and updated as often as is necessary. The objective is to ensure that all employees who may be affected are trained and practiced in the arrangements for dealing with such emergencies. The emergency plan should cover:-

- (a) the definition of the type of situation to be considered as an emergency;
- (b) raising the alarm;
- (c) evacuation of the immediate area and adjacent areas liable to be affected;
- (d) control of the occurrence using site resources;
- (e) plant shut-down and containment of vinyl chloride leakage, and
- (f) obtaining assistance from the emergency services.

The booklet "Recommended Procedures for Handling Major Emergencies", published by the Chemical Industries Association Ltd., Alembic House, 93 Albert Embankment, London SE1 7TU, provides useful information and advice on this subject. It should be noted that the Control of Industrial Major Accident Hazards Regulations 1984 will apply to some vinyl chloride installations and may require the preparation of on-site and off-site emergency plans.

82 Whenever abnormal emissions occur which affect the environment significantly, the District Inspector of HM Industrial Air Pollution Inspectorate and the local authority must be informed immediately. Production should not be continued with emissions outside the limits allowed without

having consulted the District Inspector. Under the Notification of Accidents and Dangerous Occurrences Regulations 1980 the sudden, uncontrolled release of 1 tonne or more of vinyl chloride, eg. by rupture of a bursting disc, must be notified to the HSE immediately.

REGISTERED WORKERS

83 In plants subject to the requirements of the Vinyl Chloride ACoP, any worker identified during the assessment procedure required under Regulation 6 of the Control of Substances Hazardous to Health Regulations as likely to be affected by occupational exposure to vinyl chloride should be designated as a 'registered worker'. A register of such workers should be kept by the employer. Any worker generally spending less than 25% of his working year exposed to vinyl chloride need not be designated as a registered worker. Consideration should also be given to designating other persons working regularly on site, eg contractors' employees, as registered workers where there is the potential for exposure to vinyl chloride on a scale similar to that for an employer's own employees and the assessment warrants such action.

HEALTH SURVEILLANCE

84 Health surveillance of registered workers is intended to detect, as early as possible, any harmful effects associated with exposure to vinyl chloride at work. The initial assessment considers the individual's fitness to work with vinyl chloride and establishes baseline medical information with regard to registered workers.

85 Workers should be subject to periodic assessment to check their fitness to continue working with vinyl chloride. The assessment may also provide additional information which might lead to a fuller understanding of the toxicological effects of vinyl chloride. Such data could also be of value in any future epidemiological studies. Each person should be subject to medical reassessment:-

- (a) at intervals of not more than 12 months;

- (b) if he has reported symptoms which could be attributable to vinyl chloride exposure;
- (c) if, in the opinion of the appointed doctor, he requires further medical assessment;
- (d) when he has been absent from work because of any illness for 4 weeks or more.

86 The medical assessment of each individual is the responsibility of the appointed doctor but it will normally include:-

- (a) a full history, both clinical and occupational;
- (b) a clinical assessment with particular reference to the abdomen, skin and extremities, and
- (c) such further tests, including radiological examination and laboratory tests, as may be indicated by the results of (a) or (b).

87 The employer should ensure that the leaflet "Vinyl Chloride and You" is given to every worker on commencement of his employment. Copies can be obtained free of charge from any office of the Health and Safety Executive.

88 The employer should also ensure that each employee is aware that he has the right to request a written record of the results of any health surveillance procedures. If abnormal findings are present the individual may, if he consents, be referred to his Family Practitioner.

89 Where medical examinations need to be carried out adequate facilities should be made available. The facilities should comprise a room which is properly cleaned, adequately warmed, well ventilated, suitably furnished and provided with a wash basin equipped with hot and cold running water, soap and a clean towel. If it is not reasonably practicable to provide hot and cold running water, a means of heating water should be provided within the room. The room should be suitably quiet and not permit ordinary conversational voices to be heard outside its walls. The room should be set aside for the exclusive purpose of health surveillance whenever it is required.

R&S 132521

Where the number of employees to be examined or assessed is substantial, a suitable waiting area should be provided. An adjacent lavatory with hand-washing facilities should be provided for employees who may be required to provide specimens for biological testing.

90 Arrangements should be made for any employee who is a registered worker to present himself, during his normal working hours, for medical examinations and any additional tests as may be necessary. Employees should cooperate in such examinations and tests.

91 The basic occupational health record of a registered worker's health surveillance should consist of at least the following information:-

surname, forenames, birth surname, sex, date of birth, place of birth, (town and country), permanent address, National Insurance Number, National Health Service Number, date of commencement of present employment, and a historical record of jobs performed whilst in that employment, with appropriate details to indicate likely exposure.

92 These records may be kept in any suitable form provided that they satisfy the foregoing requirements and can be retrieved readily when required. They should be kept in a form compatible with and capable of being linked to those for monitoring, so that it is possible to compare the nature and degree of exposure to vinyl chloride with effects on health. The health record of a registered worker should be kept for at least 50 years from the date of the last entry.

93 Some of the conditions associated with exposure to high levels of vinyl chloride, particularly angiosarcoma of the liver and portal hypertension due to non-cirrhotic periportal fibrosis, may have prolonged latent periods with symptoms not appearing until several years after exposure, possibly after a vinyl chloride worker has retired or transferred to other work. In all cases when a vinyl chloride worker leaves a company, ceases to be a registered worker or transfers to another location, a letter should be sent to his Family Practitioner by the Appointed Doctor. Appendix 3 contains a suggested letter for sending to an employee's Family Practitioner and Appendix 4 a suggested form for the employee to give his consent for the Appointed Doctor to discuss his medical and occupational history with regard to his exposure to vinyl

chloride with his Family Practitioner. Both the suggested letter and form of consent have been approved by the Ethical Guidance Committee of the General Medical Council. Appointed Doctors are recommended to place copies of any letters and forms of consent in the occupational health records of the employees concerned.

94 When an employee ceases to be a registered worker, but continues to work at the same location and for the same employer, the Appointed Doctor shall offer to continue the employees health surveillance programme as in paras 85, 86 and 88.

INFORMATION, INSTRUCTION AND TRAINING

95 Employers should ensure that employees receive adequate information, instruction and training, so that they are aware of the nature of the hazard, the extent of the risks from exposure to vinyl chloride, the precautions to be observed to minimise these risks and the role of joint consultation. Employers should also ensure that employees of contractors and other persons working in areas involving potential exposure to vinyl chloride have received similar information, instruction and training. The topics covered should include the following:-

- (a) health hazards of vinyl chloride;
- (b) contents of the vinyl chloride ACoP;
- (c) general methods outlined in this Guidance Note and the leaflet 'Vinyl Chloride and You' for protecting persons from the health hazards of vinyl chloride and the need for health surveillance;
- (d) correct operation of the plant with which the employee is concerned;

R&S 132523

- (e) role of the employee in observing safe working methods;
- (f) correct use of respiratory protective equipment and any other personal protective equipment;
- (g) significance of monitoring procedures and results;
- (h) relevant emergency procedures;
- (i) relevant rules relating to vinyl chloride;
- (j) procedures for reporting defects in plant and equipment.

It should be noted that Regulation 4 of the Control of Industrial Major Accident hazards Regulations 1984 requires a manufacturer to provide evidence that persons working on a site are informed, trained and equipped as necessary to ensure their safety.

96 Basic information, instruction and training should be provided on recruitment and should be supplemented at regular intervals by training, "on-the-job" refresher courses, talks, notices, leaflets or other methods in order to create and sustain a high level of awareness amongst employees.

97 Any person who carries out any assessment, air monitoring or maintenance tasks which require the use of instruments should be given additional instruction and training concerning their use including:-

- (a) objectives of air monitoring;
- (b) correct use of the instruments;
- (c) sampling techniques;
- (d) analysis, interpretation and recording of results.

FACILITIES

Washing and changing facilities

98 Adequate washing and changing facilities of a high standard should be provided. All the facilities should be kept clean, warm and in good repair. Washing facilities should include showers for the use of persons whose skin may be contaminated by vinyl chloride. Changing facilities should be designed to ensure that clean clothing and that which may be contaminated by vinyl chloride are kept separate.

Arrangements for eating, drinking and smoking

99 Employees should not eat, drink or smoke in areas liable to be contaminated by vinyl chloride, so suitable facilities for these purposes should be made available.

100 Where a number of employees are involved, suitable facilities for use by persons who remain on the premises during main meal intervals should consist of a canteen, mess-room or other suitable eating area. This should be provided with suitable tables and chairs and facilities for the storage of food and drink, whether the food and drink is supplied by the employers or the employees. If drinking fountains are provided they should be installed so as to prevent the water from becoming contaminated.

101 Smoking should not be permitted except in areas set aside for the purpose because of the fire and explosion risks associated with vinyl chloride.

NOTIFICATION TO THE HSE

102 Employers are requested to notify HMFI at HSE Area Offices and HMI/API at District Offices of proposals for the installations of new plant or modification of existing plant. Such notifications should be made at the design stage. Vinyl chloride comes within the group of substances defined in Class 2 of Part II of Schedule 1 of the Notification of Installations Handling Hazardous Substances Regulations 1982. The Regulations require initial

R&S 132525

notification to HSE of any site handling quantities of vinyl chloride in excess of 25 tonnes with renotification at three times this figure. Vinyl chloride also comes within the definition of a flammable gas as set out in Schedule 1 e(i) of the Control of Industrial Major Accident Hazards Regulations 1984. Notification to HSE is required under Regulation 4 at 50 tonnes of vinyl chloride and for Regulations 7-12 at 200 tonnes for process and storage or 300 tonnes for isolated storage. Notification to HSE is also required of significant modifications to the industrial activity for inventories exceeding 200 or 300 tonnes for process and storage or isolated storage respectively. For further details, reference should be made to the appropriate Regulations (see Appendix 6) and associated guidance published by HSE.

RECORDS

103 There are a number of references in various sections of this Guidance Note to the keeping of registers and records. For ease of reference these requirements are summarised in Appendix 5.

104 Where an employer ceases to operate, it is recommended that the Health and Safety Executive be notified and the records of air monitoring and employees' occupational health records transferred to HSE.

R&S 132526

APPENDIX 1

PROPERTIES OF VINYL CHLORIDE

SYNONYMS

VC, Vinyl Chloride Monomer, VCM,
Monochloroethylene, Monochloroethene

CHEMICAL FORMULA

$\text{CH}_2 = \text{CHCl}$

PROPERTIES

General

Vinyl Chloride is a colourless gas at ambient temperature and pressure with a sweetish odour at high concentrations. It is normally stored and handled under pressure as a colourless liquid

Physical

Boiling Point
Freezing Point
Flash Point
(open cup)
Liquid Density
Vapour Density
Solubility

-13.9°C
-153.7°C
-78°C
0.983 (at 20°C)
2.15 (relative to air at 20°C)
Readily soluble in most organic solvents
but only sparingly in water

Chemical

Vinyl chloride will polymerise exothermically under the influence of light, air, oxygen and initiators such as benzoyl peroxide. Pure vinyl chloride is thermally stable to quite high temperatures, however, peroxides formed by slow reaction with oxygen in air may initiate polymerisation. Stabilisers, such as benzoquinone or p-methoxyphenol, and storage in an oxygen free atmosphere inhibit adventitious polymerisation

Dear Doctor

CONTROL OF SUBSTANCES HAZARDOUS TO HEALTH REGULATIONS 198-
APPROVED CODE OF PRACTICE FOR THE CONTROL OF VINYL CHLORIDE AT WORK

Mr/Mrs/Miss

Date of Birth

Address
.....

is about to leave/has just left employment here where he/she was
registered as a worker potentially or actually exposed to vinyl
chloride monomer (VCM).

Exposure to high levels of VCM has been associated with angiosarcoma
of the liver, portal hypertension due to non-cirrhotic periportal/^{fibrosis}and
acro-osteolysis particularly of the terminal phalanges of the hands.

Other effects have been reported as occurring in workers chronically
exposed to vinyl chloride monomer at similar levels of exposure,
although such reports have been disputed by others. These include
tumours of the brain, lung, haemo-lymphopoietic system, and skin
(malignant melanoma), lung function disorders, chromocytopenia and
immune complex disorders. Effects on reproduction have also been
reported.

Whilst exposure to such levels is unlikely to have been incurred since
1975, the latent period particularly for the first two above mentioned
conditions may be prolonged.

May I therefore suggest that this letter which (together with the
patients form of consent) has been approved by the General Medical

clinical suspicions along these lines arise in the future you might like to consider contacting me or my successor. I hold, and enclose a copy of, your patient's signed informed consent to this which means that you need not hesitate from taking such a step early in your considerations of differential diagnosis from fear of groundlessly alarming your patient.

Should this factory have ceased trading, the Employment Medical Adviser for your area, who can be found in the telephone book under Health and Safety Executive would know the whereabouts of your patient's factory medical and exposure records which are being preserved for 50 years from the end of his/her employment here.

If you would like any further information or explanations, please do not hesitate to contact me now or in the future. I will be glad to assist in any way possible in the interests of your patient's, our ex-employee's, well-being.

Yours sincerely,

APPOINTED DOCTOR

R&S 132529

APPENDIX 4

CONTROL OF SUBSTANCES HAZARDOUS TO HEALTH REGULATIONS 198-
APPROVED CODE OF PRACTICE FOR THE CONTROL OF VINYL CHLORIDE AT WORK

MEDICAL SURVEILLANCE

(Give surname I, born
and full fore-
names, give date of
of birth thus
eg 3 SEPT 36

hereby give consent for the Appointed Doctor or the Area Employment
Medical Adviser to discuss with my family doctor my medical and
occupational history and I also consent to the release to my family
doctor of such records insofar as they relate to my exposure to Vinyl
Chloride Monomer.

I confirm that Dr, Appointed Doctor
has explained to me the reasons for this consent being sought and I
believe that I have understood these reasons. I agree to a copy of
this consent and explanatory letter, which I have seen, being sent to
my present family doctor, Dr
of

R&S 132530

Signed

Date

Witness

RECORDS

The records which should be kept in relation to the control of vinyl chloride at work are summarised below with cross references to the relevant paragraphs of the main text of the Guidance Note.

- (a) Assessment (paras 22-29);
- (b) Atmospheric monitoring (paras 55-57);
- (c) Maintenance of monitoring equipment (para 58)
- (d) Leakages of vinyl chloride (para 59(1));
- (e) Examinations of ventilation equipment (para 59(2));
- (f) Excursions above the alarm levels during area monitoring (para 59(3));
- (g) Personal monitoring (para 59(4));
- (h) Names of persons trained and authorised to use respiratory protective equipment (para 66);
- (i) Inspections of respiratory protective equipment (para 69);
- (j) Permits-to-work (paras 71 and 77);
- (k) Maintenance of control measures (paras 79 and 80);
- (l) Register of registered workers' (para 83)
- (m) Occupational health records of registered workers (paras 91 and 92).

Records may be kept in any suitable forms, including microfilm, computer or similar techniques, provided they can be reviewed readily when required.

Occupational health records should be kept for 50 years after the last entry made in them. Records of atmospheric monitoring should be kept for at least 30 years. All other records should be kept for a minimum of 2 years.

LEGAL REQUIREMENTS

Some additional legal requirements relevant to the handling of vinyl chloride may be found in the following:-

The Health and Safety at Work etc Act 1974

The Factories Act 1961

The Alkali etc Works Regulation Act 1906

The Emissions into the Atmosphere Regulations 1983

The Control of Pollution Act 1974

The Control of Substances Hazardous to Health Regulations 1988

The Notification of Installations Handling Hazardous Substances Regulations 1982

The Control of Industrial Major Accident Hazards Regulations 1984

The Dangerous Substances (Conveyance by Road in Road Tankers and Tank Containers) Regulations 1981

The Dangerous Substances (Conveyance by Road in Packages etc.) Regulations 198-

The Classification, Packaging and Labelling of Dangerous Substances Regulations 1984

The Notification of Accidents and Dangerous Occurrences Regulations 1980

The Reporting of Accidents and Dangerous Incidents Regulations 198-

CHECKLIST OF MAIN CONTROL MEASURES

CONTROL MEASURES FOR MATERIALS, PLANT & PROCESSES (Paras 30-36)

- Plant should be designed and operated to minimise exposure to vinyl chloride
- Plant should be sited in the open wherever possible
- Good general ventilation should be provided in process buildings
- Local exhaust ventilation should be provided where emissions from plant may occur that cannot be eliminated by improved design and maintenance

CONTROL OF EXPOSURE (Paras 19-20)

- Personal exposure to vinyl chloride should be controlled to below 7 ppm 8 hour TWA
- Vinyl chloride in the air of working areas should be controlled to below 3 ppm averaged over a year

R&S 132533

AIR MONITORING (Paras 37-62)

- Personal monitoring is required to check compliance with the 8 hour TWA Control Limit
- A static monitoring system is required for the monitoring of vinyl chloride in the air of working areas

ALARM LEVELS (Para 21)

- Air monitoring system required for the detection of high levels of vinyl chloride and to sound an alarm at the following levels:
 - 15 ppm measured over 1 hour
 - 20 ppm measured over 20 minutes
 - 30 ppm measured over 2 minutes

PERMITS-TO-WORK (Paras 71-78)

- Permits-to-work required for all work in confined spaces and some maintenance
- All personnel involved must be properly trained

RESPIRATORY PROTECTIVE EQUIPMENT (Paras 63-69)

- Required for certain operations, eg entry into confined spaces, maintenance, dealing with leaks of vinyl chloride, emergencies, etc
- Only equipment of a type approved or to a standard approved by HSE to be used
- To be used only by trained and authorised personnel

MAINTENANCE OF CONTROL MEASURES (Paras 79-80)

- Regular and thorough examinations of plant required, especially where leaks may occur
- Regular examinations and tests of ventilation equipment required
- Regular checks of other control measures to be carried out

(Paras 81-82)

foreseeable emergencies

HEALTH SURVEILLANCE
(Paras 84-94)

- All employees should be familiar with relevant emergency procedures
- Registered workers should undergo regular medical examinations
- All employees should receive adequate information, instruction and training on the hazards of vinyl chloride, the precautions to be observed and the role of joint consultation

INFORMATION, INSTRUCTION & TRAINING
(Paras 95-97)

R&S 132534