

J-5125

February 1980

CHEMICAL INDUSTRIES ASSOCIATION/INSTITUTE OF PETROLEUM

HEALTH PRECAUTION GUIDELINES FOR BENZENE EXPOSURE

IN THE PETROLEUM REFINING AND CHEMICAL INDUSTRIES

INCLUDING BULK DISTRIBUTION

© Chemical Industries Association Limited and Institute of Petroleum 1980.

All rights reserved. Except for normal review purposes no part of this publication may be reproduced, utilised, stored in a retrieval system or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or by any information, storage, or retrieval system without the written permission of the publisher.

February 1980

CHEMICAL INDUSTRIES ASSOCIATION/INSTITUTE OF PETROLEUM

HEALTH PRECAUTION GUIDELINES FOR BENZENE EXPOSURE
IN THE PETROLEUM REFINING AND CHEMICAL INDUSTRIES
INCLUDING BULK DISTRIBUTION

C O N T E N T S

INTRODUCTION	Page No.
PART 1 - OBJECTIVES	1
2 - HAZARDS	1
3 - RESPONSIBILITIES	2
4 - CONTROL OF EXPOSURE TO BENZENE	2
5 - ENTRY INTO CONFINED SPACES	3
6 - SPILLAGE AND WASTE DISPOSAL	3
7 - PREVENTIVE MAINTENANCE	4
8 - IDENTIFICATION AND MONITORING OF EMPLOYEES WHO MAY BE EXPOSED TO BENZENE	4
9 - MEDICAL SURVEILLANCE	5
10 - MEDICAL, BIOLOGICAL AND EXPOSURE RECORDS	5
11 - EDUCATION AND TRAINING	6
APPENDIX 1 - BENZENE HYGIENE STANDARD	
2 - PROPERTIES OF PURE BENZENE	
3 - RELEVANT LEGAL REQUIREMENTS	
4 - RESPIRATORY PROTECTIVE EQUIPMENT	
5 - PROTECTIVE CLOTHING	
6 - MEDICAL SURVEILLANCE	
7 - AIR SAMPLING FOR BENZENE	
8 - REGISTERS AND RECORDS	

INTRODUCTION

Benzene is a chemical of major value to society. It is produced mainly from petrochemical operations but small quantities are obtained as a by-product of coking operations in the steel industry. The uses of benzene are manifold and have included the manufacture of detergents, polymers, pesticides and intermediates in the chemical and pharmaceutical industries, other essential chemicals and some solvents, adhesives, etc; it is also present to a limited extent in motor gasoline.

It has long been recognized that excessive absorption of benzene vapour may have an insidious damaging effect on the blood-forming organs. For this reason much progress has been made in industry in reducing exposures to benzene to their current extremely low levels where there is no correlation with a statistically significant incidence of blood disorders. Nevertheless, there must be no complacency in the handling of benzene or products containing it, and continuous attention to the subject has to be maintained.

In the United Kingdom both the chemical and petroleum industries have an interest in benzene and have appointed a joint committee to review several aspects of the topic. This committee (listed on the back cover) has formed a number of task forces, one of which (also listed) was asked to codify guidelines for safeguarding the health of persons who might be occupationally exposed to benzene vapour. The following document presents these guidelines. The principal intention of the document is to prevent occupational ill-health associated with benzene by providing guidance on the standard of hygiene necessary in the workplace and how to sustain it; and in particular on the initial assessment of exposures, routine monitoring, the control of exposures where necessary, and the collection of both exposure and medical records. It is considered that the implementation of these guidelines will further ensure the protection of the health of employees in the industries concerned.

Thanks are due to all those members of the two industries, whether named or not, who drafted these guidelines, or who gave constructive advice and criticism.

CHEMICAL INDUSTRIES ASSOCIATION/INSTITUTE OF PETROLEUM

HEALTH PRECAUTION GUIDELINES FOR BENZENE EXPOSURE
IN THE PETROLEUM REFINING AND CHEMICAL INDUSTRIES
INCLUDING BULK DISTRIBUTION

PART 1 - OBJECTIVES

The principal objective of these guidelines is to prevent occupational ill-health associated with benzene. In keeping with the Health and Safety Commission Policy on Toxic Substances, as outlined in HSE Guidance Note EH 18, this should be achieved by ensuring that any exposures are as low as reasonably practicable and within the hygiene standard given in Appendix I. A secondary objective is to encourage, for epidemiological purposes, the collection and preservation of appropriate data relating to the exposure of employed persons to benzene vapour.

PART 2 - HAZARDS

- 2.1 The chief route of entry for benzene into the body is by inhalation of its vapour. The odour of benzene does not provide an adequate warning of its presence in significant concentrations. The health hazards of exposure to benzene vapour are of two kinds - immediate and long-term:

Immediate

Benzene exerts an acute narcotic action common to many volatile hydrocarbon solvents. Inhalation of very high vapour concentrations can lead to intoxication and rapid loss of consciousness.

Long-term

Prolonged and/or repeated inhalation of concentrations of benzene vapour substantially above the hygiene standard can cause

- (i) Bone marrow damage leading to blood disorders of varying severity, which are usually reversible after removal from further exposure
- (ii) and rarely, leukaemia.

- 2.2 Small amounts of liquid may be absorbed through the skin, but this route of entry is not of great biological importance. Liquid benzene causes local defatting of the skin, irritation and, if contact is repeated or prolonged, may lead to blistering and dermatitis. It is irritating to the eyes and to mucous membranes.

The principal chemical and physical properties of benzene are given in Appendix 2.

PART 3 - RESPONSIBILITIES

3.1 Management

Senior management should assume responsibility for the matters covered by the guidelines with appropriate delegation as they consider necessary. It should be the recognised responsibility of line management to oversee those aspects of the guidelines which relate to their particular situation, to report any difficulties, to progress suggestions from those under their authority and ensure action as and where appropriate.

The general responsibilities of employers to their employees under the Health and Safety at Work, etc. Act 1974 and other relevant legislation are summarized in Appendix 3.

3.2 Employees

All employees should comply with the guidelines as related to their employment and responsibilities, using in the correct manner the facilities and services provided for them in accordance with the guidelines, and report forthwith any material defect or faults to their supervisor.

- 3.3 There should be the normal joint consultation procedures between management and employees on the application of these guidelines.

PART 4 - CONTROL OF EXPOSURE TO BENZENE

- 4.1 No unprotected persons should be exposed to concentrations of benzene vapour greater than the hygiene standard (Appendix 1), nor to avoidable skin contact with benzene.
- 4.2 Steps should be taken to keep concentrations of benzene in the working atmosphere below the hygiene standard (Appendix 1) and as low as reasonably practicable.
- 4.3 When the benzene vapour level in the working atmosphere is such that the hygiene standard may be exceeded, respiratory equipment should be worn to the standard outlined in Appendix 4 of these guidelines.
- 4.4 Access to areas where it is reasonably foreseeable that exposure to benzene vapour could be above the hygiene standard should be restricted to persons whose duties require them to enter such areas, which should be defined in a clearly recognisable manner.
- 4.5 Where equipment used to handle benzene or benzene-rich solutions must necessarily be breached as a routine operation, for example, when sampling, loading or during routine maintenance, etc., then procedures should be adopted which ensure that benzene or its vapour is not released into the working atmosphere in quantities

which may cause the hygiene standard to be exceeded. Such procedures could include provision of closed loop or automatic sampling systems, remote drainage operations, steam, inert gas or water purging, high level venting or, in certain circumstances, local exhaust ventilation.

- 4.6 Where the opening of equipment may release benzene to the atmosphere and it is foreseeable that the hygiene standard may be exceeded, then respiratory protective equipment should be worn to a standard outlined in Appendix 4 of this guide. Precautions should be taken to ensure that other personnel are not exposed to levels of benzene above the hygiene standard because of release of benzene into the atmosphere during such operations.
- 4.7 Where skin contact with liquid or solid benzene is foreseeable, protective clothing should be worn to the standard outlined in Appendix 5.
- 4.8 Plant and equipment should be so designed as to ensure appropriate containment of benzene, and where vents/reliefs are provided they should be positioned so that their outlets do not produce unacceptable concentrations of benzene in neighbouring locations where work may be conducted. Design of equipment should also conform to any requirements of H.M. Alkali and Clean Air Inspectorate relating to the dispersal of emissions.
- 4.9 No clothing, including footwear, contaminated with benzene should be left in buildings or lockers. It should be put in segregated, well ventilated storage specifically for contaminated clothing, or left to dry in the open air away from personnel and sources of ignition and suitably marked until decontaminated.

PART 5 - ENTRY INTO CONFINED SPACES

- 5.1 Before a person enters a confined space which could contain benzene vapour, steps should be taken to measure the concentration of vapour and, if necessary, to reduce it to an acceptable level.
(Health and Safety Executive Document GS5 "Entry into Confined Spaces" gives guidance on the management of entry into such spaces.).
- 5.2 Where it is not feasible both to reduce the concentration of benzene vapour to a level below the hygiene standard, and to ensure that it will remain so whilst the person is in the confined space, then suitable respiratory protective equipment and protective clothing should be provided and worn, as outlined in Appendices 4 and 5. Furthermore, due consideration should be given to the explosion and flammability risks associated with such entry.

PART 6 - SPILLAGE AND WASTE DISPOSAL

- 6.1 In work areas where spillage may occur provision should be made for area decontamination and waste disposal.
- 6.2 Waste materials containing benzene should be transferred from the plant in such a manner as to avoid skin contact and to prevent vapour concentrations in the immediate vicinity

exceeding the hygiene standard. The waste material should be disposed of in accordance with statutory requirements. Wherever possible such waste should be segregated and identified. The attention of any person involved in such subsequent disposal should be drawn to the hazards of exposure to benzene.

PART 7 - PREVENTIVE MAINTENANCE

- 7.1 High standards of preventive maintenance in the whole plant and equipment should be provided to facilitate compliance with the hygiene standard.
- 7.2 Surveys for leaks should be undertaken at regular intervals.

PART 8 - IDENTIFICATION AND MONITORING OF EMPLOYEES WHO MAY BE EXPOSED TO BENZENE

- 8.1 Where a potential exists for exposure to benzene, an initial survey should be carried out by personal monitoring of employees who are representative of various job classifications. Where practicable and appropriate, area monitoring should also be carried out to identify where benzene exposures may occur.
- 8.2 After the initial survey, subsequent monitoring of exposures should comply with the following recognized good occupational hygiene strategy (see Appendix 7).
 - (i) Where levels above the hygiene standard (8 hour time weighted average of 10 ppm) are identified, steps should be implemented to reduce exposures. Monitoring should be repeated at frequent intervals as outlined in Appendix 7(iii) until exposures have been demonstrated to be below an 8 hour time weighted average (TWA) of 10 ppm.
 - (ii) Where exposures between the hygiene standard and an 8 hour TWA of 5 ppm are identified, routine monitoring, e.g. quarterly, should be carried out. This is necessary to provide reasonable assurance to both management and employees that the hygiene standard is not being exceeded. Routine monitoring may be discontinued as outlined in Appendix 7(iii) when exposures have been demonstrated to be consistently below an 8 hour TWA of 5 ppm.
 - (iii) Where exposures are found to be below an 8 hour TWA of 5 ppm routine monitoring is not required. However, infrequent periodic reassessment of exposures is desirable to provide reassurance that significant increases have not occurred.
 - (iv) Where changes, which may lead to increased exposures to benzene, are known to have occurred, e.g. operating or process conditions, exposure should be reassessed.
- 8.3 Results of all personal and area monitoring should be recorded and retained as outlined in Part 10 and Appendix 8 and made available to the individuals concerned. Records should include the names of all employees whose job classification indicates exposure in excess of an 8 hour time weighted average level of about 1 ppm. The keeping of records at these very low exposure levels, whilst not being regarded as essential, is recommended as an aid to the further validation of the appropriateness of the hygiene standard.

- 8.4 Where biological monitoring is carried out as part of the exposure surveillance, the results should be recorded and retained as outlined in Part 10 and Appendix 8 and made available to the individual concerned. Appendix 6 gives guidance on the principles for biological monitoring.

PART 9 - MEDICAL SURVEILLANCE

- 9.1 Medical surveillance should be carried out at the discretion and under the supervision of the medical adviser.
- 9.2 The current aims of medical surveillance are to evaluate clinical responses to benzene exposure and the results of biological monitoring, and to assess other medical conditions which may be relevant to work with benzene.
- 9.3 Medical surveillance should be limited to those who may be exposed to benzene levels above an 8 hour TWA level of 5 ppm. It is recommended that such persons should undergo a medical examination prior to the first employment in situations where they could be so exposed. The frequency and content of subsequent medical examinations should be determined by the medical adviser.
- 9.4 Absences from work of employees who have a potential for workplace exposure should be reviewed medically.
- 9.5 Procedures relevant for medical surveillance are contained in Appendix 6. The selection of the appropriate techniques shall be left to the discretion of the medical adviser.

PART 10 - MEDICAL, BIOLOGICAL AND EXPOSURE RECORDS

- 10.1 Adequate records, as detailed below and in Appendix 8, should be kept on all groups of workers as identified in Part 8.
- 10.2 Full and confidential records should be kept for all workers subject to medical surveillance under Part 9.
- 10.3 Medical records should be preserved and retained for a minimum of 30 years after the worker leaves or retires from employment.
- 10.4 The following records should also be kept for a minimum of 30 years
- (i) Names and job classifications as required by Part 8 and Appendix 8.
 - (ii) Results of any area monitoring of benzene.
 - (iii) Results of personal monitoring of benzene exposure.
 - (iv) Results of biological monitoring.
- 10.5 When a company which has implemented these guidelines closes, careful consideration should be given to the safe keeping of all records. Advice in this matter should be sought from the trade associations for the industries concerned.

PART 11 - EDUCATION AND TRAINING

- 11.1 All employees who may be occupationally exposed to significant levels of benzene should be instructed in the potential health risks and protective measures.
- 11.2 The instruction should include information on the following subjects:
 - (i) the health hazards of benzene
 - (ii) where appropriate, the objectives of the medical surveillance procedures
 - (iii) the principles outlined in these guidelines for the protection of employees
 - (iv) the significance of personal and area monitoring and of leak-testing
 - (v) rules and regulations relating to benzene.

APPENDIX 1

BENZENE HYGIENE STANDARD

1. The hygiene standard for the exposure to benzene of persons at work, is a time weighted average concentration of benzene in air measured over an 8 hour work shift when determined using the standard method of sampling as outlined in Appendix 7.
2. Guidance Note EH 15/78 from the Health and Safety Executive "Threshold Limit Values" indicates that for benzene in air the hygiene standard is 10 ppm by volume (equivalent to approximately 30 mg/m³) time weighted average over 8 hours.*
3. The aim should be to limit a person's exposure to benzene to as low as is reasonably practicable and in any case to levels not exceeding the hygiene standard.
4. Hygiene standards are not sharp dividing lines between 'safe' and 'dangerous' concentrations, and the interpretation of benzene in air values in relation to the hygiene standard should be made by an occupational hygienist or other person who is skilled in interpretation. Infrequent and limited excursions above the hygiene standard are normally regarded as acceptable providing the 8 hour time weighted average limit is not exceeded.**
5. When working out time weighted average concentrations, the following should be used as a guide:
 - (i) If only one sample has been collected throughout an 8 hour work shift, then the employee exposure can be calculated simply by dividing the weight of benzene collected by the volume of air which has passed through the sampler;
 - (ii) Where a number of samples have been collected consecutively throughout the working period, breaks for meals, etc. being taken as periods of nil exposure, then the time weighted average may be calculated as follows:

The duration in time (in minutes) for each sampling period should be multiplied by the benzene concentration found in that period. Then all the totals should be added together and divided by the duration of time (in minutes) for the whole shift.

APPENDIX 1 (i)

* Support for the values in this Guidance Note is found in the conclusions of the International Workshop on Benzene held under the auspices of the Permanent Commission and International Association of Occupational Health in Paris, 9-11 November, 1976. These conclusions were:

" From its study of the available information, the Workshop recommended that, in addition to all unnecessary exposure to benzene being avoided, and benzene not being used where substitute materials are available;

1. Benzene exposure should be controlled to levels as low as possible, but in no case should the time weighted average exceed 10 ppm for an 8 hour day and 40 hour week. The average should be based on a single work day. The ceiling value should not exceed 25 ppm based on a 10-15 minute sampling period (1)

- (1) It was recognised that the concept of ceiling value is an imprecise attempt to limit short term exposure and hence should not be given the same weight as time weighted average.) "

** As a guide, an acceptable short term exposure above the hygiene standard would be 20 ppm (approximately 60 mg/m³) as measured over a 15 minute sampling period. The number of times such an excursion is permitted will be governed by the 8 hour time weighted average hygiene standard.

APPENDIX 2

PROPERTIES OF PURE BENZENE

Formula C_6H_6

Appearance: Clear, colourless liquid

Odour: Pleasant - does not provide
adequate warning of hazards

Boiling Point: $80.1^{\circ}C$

Melting Point: $5.5^{\circ}C$

Density at $15.5^{\circ}C$: 0.8845

Vapour Density (Air = 1) 2.7

Vapour Pressure at $20^{\circ}C$ 75 mm Hg

Flash Point (ASTM D56:61) $-11^{\circ}C$

Autoignition Temperature: $562^{\circ}C$

Explosive limits in air: Lower 1.3% v/v
Upper 7.1%

Solubility in water: 0.06 - 0.08%

Miscible with most common organic liquids

APPENDIX 3

RELEVANT LEGAL REQUIREMENTS

The legal requirements summarized below apply to the application of these guidelines in the U.K. In other countries the national legislation relating to the health of employees at work should be observed.

Health & Safety at Work, etc. Act 1974

General Duties of Employers to Their Employees

- 2 - (1) It shall be the duty of every employer to ensure so far as is reasonably practicable, the health, safety and welfare at work of all his employees.
- (2) Without prejudice to the generality of an employer's duty under the preceding subsection, the matters to which that duty extends include in particular:
- a) the provision and maintenance of plant and systems of work that are, so far as is reasonably practicable, safe and without risks to health;
 - b) arrangements for ensuring, so far as is reasonably practicable, safety and absence of risks to health in connection with the use, handling, storage and transport of articles and substances;
 - c) the provision of such information, instruction, training and supervision as is necessary to ensure, so far as is reasonably practicable, the health and safety at work of his employees;
 - d) so far as is reasonably practicable as regards any place of work under the employer's control, the maintenance of it in a condition that is safe and without such risks;
 - e) the provision and maintenance of a working environment for his employees that is, so far as is reasonably practicable, safe, without risks to health, and adequate as regards facilities and arrangements for their welfare at work.
- (3) Except in such cases as may be prescribed, it shall be the duty of every employer to prepare and as often as may be appropriate revise a written statement of his general policy with respect to the health and safety at work of his employees and the organization and arrangements for the time being in force for carrying out that policy and to bring the statement and any revision of it to the notice of all his employees.
- (4) Regulations made by the Secretary of State may provide for the appointment in prescribed cases by recognised trade unions (within the meaning of the regulations) of safety representatives from amongst the employees, and those representatives shall

APPENDIX 3 (i)

represent the employees in consultations with the employers under subsection (5) below and shall have such other functions as may be prescribed.

- (5) It shall be the duty of every employer to consult any such representatives with a view to the making and maintenance of arrangements which will enable him and his employees to cooperate effectively in promoting and developing measures to ensure the health and safety at work of the employees, and in checking the effectiveness of such measures.
- (6) In such cases as may be prescribed it shall be the duty of every employer, if requested to do so by the safety representatives mentioned in subsection (4) above, to establish, in accordance with regulations made by the Secretary of State, a safety committee having the function of keeping under review the measures taken to ensure the health and safety at work of his employees and such other functions as may be prescribed.

- 3 - (1) It shall be the duty of every employer to conduct his business in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not exposed to risks to their health and safety.

General Duties of Employees

7 It shall be the duty of every employee while at work:

- a) to take reasonable care for the health and safety of himself and of other persons who may be affected by his acts or omissions at work; and
- b) as regards any duty or requirement imposed on his employer or any other person by or under any statutory provisions, to cooperate with him so far as is necessary to enable that duty or requirement to be performed or complied with.

8 No person shall intentionally or recklessly interfere with or misuse anything provided in the interests of health, safety or welfare in pursuance of any of the relevant statutory provisions.

APPENDIX 3 (ii)

Factories Act, 1961

Removal of Dust or Fume

- 63 - (1) In every factory in which, in connection with any process carried out, there is given off any dust or fume or other impurity of such a character and to such extent as to be likely to be injurious or offensive to the persons employed, or any substantial quantity of dust of any kind, all practicable measures shall be taken to protect the persons employed against inhalation of the dust or fume or other impurity and to prevent its accumulating in any workroom, and in particular, where the nature of the process makes it practicable, exhaust appliances shall be provided and maintained, as near as possible to the point of origin of the dust or fume or other impurity, so as to prevent its entering the air of any workroom.

Notification of Disease

As chronic benzene poisoning is a notifiable industrial disease; the principles of Statutory Instrument 1966 (No. 1400) Factories (Notification of Disease) Regulations apply.

APPENDIX 3 (iii)

ALKALI, etc. WORKS REGULATIONS ACT 1906

(and Alkali, etc. Works Orders 1966 and 1971)

From Section 7 (1)

The owner of any (scheduled work) shall use the best practicable means for preventing the escape of noxious or offensive gases, and for preventing the discharge, whether directly or indirectly, of such gases into the atmosphere, and for rendering such gases where discharged harmless and inoffensive

From Section 27

The expression "best practicable means" has reference not only to the provision and efficient maintenance of appliance adequate for preventing such escape, but also to the manner in which such appliances are used and to the proper supervision, by the owner, of any operation in which such gases are evolved.

From Section 9 (5)

A certificate of registration shall be issued on application being made if the conditions of registration are complied with, and one of the conditions shall be that the work is at the time of registration furnished with such appliances as appear to the Chief Inspector, or, on appeal, to the Local Government Board, to be necessary in order to enable the work to be carried on in accordance with such of the requirements of the Act as apply to the work.

The above references and extracts from regulations, etc. are not intended to present a comprehensive review of all legislation relevant to benzene, but only a brief summary of those having prime interest to the industries covered by these guidelines. Other references, such as the Indiarubber Regulations, 1922, should be consulted as appropriate.

APPENDIX 4

RESPIRATORY PROTECTIVE EQUIPMENT

1. In these guidelines 'suitable respiratory protective equipment' means a full or half mask continuous flow, compressed air line or self-contained breathing apparatus, provided with a supply of air adequate for breathing, and conforming to BS 4667: Parts 2 and 3: 1974. Use has been made of canister respirators for limited periods of exposure to predictably low concentrations of benzene vapour. Before introducing such devices appropriate professional advice should be obtained.
2. The recommendations for use and maintenance of respiratory protective equipment, which are made in BS 4275: (1974), should be regarded as suitable guidance where relevant, with particular attention being given to the compressed air supply, and the setting up of a system for cleaning, inspection and issue of equipment.
3. All respiratory protective equipment must be inspected as required by BS 4275 (1974) and any statutory requirements and records of such inspection kept for 3 years.
4. Management should establish procedures for ensuring the correct use of respiratory protective equipment. Such procedures may include safety audits and where appropriate, measurements of phenol in urine (see Appendix 6).
5. All employees required to use respiratory protective equipment must have undertaken satisfactory training and demonstrated competence in its use. A list of topics for training is given below.
 - (i) Principles of operation and the use of the equipment.
 - (ii) Practical use, correct fitting, etc.
 - (iii) Limitations of the equipment.
 - (iv) Common defects and action required.
 - (v) Company arrangements for issue, cleaning, maintenance, etc.
 - (vi) Circumstances in which use is required.

APPENDIX 5

PROTECTIVE CLOTHING

The type of protective clothing required to prevent skin contact with solid or liquid benzene will vary according to circumstances or degree of risk. The following are examples of such equipment.

1. Where there is a risk of substantial body contact with benzene:

- (i) Completely-enclosing impervious air-supplied suit.
- (ii) Impervious PVC or PVC-proofed overalls, worn in conjunction with gloves, goggles, boots, etc.
- (iii) Impervious PVC apron worn with other items of protective clothing appropriate to the risk.

2. Where there is little or no risk of body contact with benzene, overalls of cotton, polyester, polyester/cotton, nylon, etc., may be worn with other items of protective clothing appropriate to the risk.

3. Items of protective clothing which have proved satisfactory in benzene service include:

- (i) Gloves - PVC or "Plastichrome" type.
- (ii) Goggles - clear plastic to BS 2092 (1967 and subsequent amendments).
- (iii) Face shields - clear plastic.
- (iv) Boots - industrial safety shoes/boots of synthetic rubber, PVC, leather uppers with PVC or composition soles.

Advice from suppliers of the protective equipment should be sought where there is any doubt about the suitability of its use with benzene.

Where serious contamination with liquid benzene or with liquid containing high concentrations of benzene may occur, protective clothing impermeable to liquid benzene should be worn.

APPENDIX 6

MEDICAL SURVEILLANCE

1. Regular Surveillance

Any programme of medical surveillance requires careful planning and specialist medical advice should be sought before instituting one for benzene-exposed workers.

1.1 Urinary Phenol Concentration

The measurement of the urinary phenol concentration provides an index of exposure to benzene in the one to two days prior to sample collection. Variations in the baseline urinary phenol excretion rate limit the effectiveness of the method when the 8 hour time weighted average exposure to atmospheric benzene is below 5 - 10 ppm. (75 mg phenol/litre in urine, corrected to S.G. 1.024 is approximately equivalent to a benzene vapour exposure of 10 ppm 8 hour TWA). Acceptable methods are (i) Van Haaften (Am. Hyg. Assn. 3. 26. pp. 57 5B. 1965). (ii) Sherwood and Carter (Ann. Occup. Hyg. 13. pp. 125-46. 1970).

1.2 Blood Counts

Prolonged exposure to high concentrations of benzene vapour can alter the number and pattern of circulating blood cells. For exposures within the current hygiene standard, experience has shown the value of blood counts is limited by fluctuations caused by non-occupational factors, hence they have no place in routine monitoring.

2. Pre-Exposure Investigations

Prior to first exposure a medical and occupational history, clinical examination and blood count may provide information about abnormalities which might preclude employment in which exposure to benzene is involved.

3. Suspected Over-Exposure

Repeated urinary phenol measurements may be useful as a means of assessing suspected over-exposure.

APPENDIX 7

AIR SAMPLING FOR BENZENE

1. OBJECTIVES

In the context of these guidelines, the objectives of air sampling are to define benzene exposure levels, identify occupational groups, improve process control and ensure compliance with the hygiene standard.

2. SAMPLING STRATEGY

For the purpose of determining exposure to benzene vapour during occupational activities, it is preferable to make use of personal sampling in which the device is worn on the body with the sampling head located near the breathing zone. Area or fixed position sampling, where the device is located in the general area in which workers may be employed, does not usually correlate well with personal sampling results. However, routine area sampling is useful for identifying deteriorating standards of process control.

The extent to which air sampling need be conducted and the frequency with which the tests should be carried out will depend on numerous factors such as the type of operation under study, numbers of workers involved, variation in ambient conditions, etc. Continuous measurements on every worker are clearly impracticable and the strategy and rationale for the sampling programme should be left to competent persons with appropriate training and expertise. Such a person will need to decide where, whom, how long, how many and when, to sample. Guidance on strategy and rationale may be obtained by consulting two recent publications (1)(2) on this subject. The attached flow diagram may also be helpful in this respect.

Personal samples are normally taken over periods ranging from 15 minutes through to a full shift. Ideally, the sampling results should enable an assessment to be made of the exposure time weighted over 8 hours (TWA) and of the pattern of exposures occurring during the test period. However, it is more usual for the sampling to be conducted over a full shift using one or more (consecutive) samples. Identification of significant excursions above the TWA are best identified by obtaining short-term air samples usually under the worst potential conditions of exposure.

Area samples are normally taken in locations where process components require monitoring for leakage and hence risk areas, deteriorating conditions and the offending sources are readily identifiable. The samples are normally taken over extended periods such as a full shift of 8 hours, with the sampling heads located at about 1.5 m above ground or floor level. This latter height should not be regarded as necessary for all situations as the purpose of the sampling is to identify the need for improved process control and not necessarily to reflect exposure conditions in the test area.

APPENDIX 7 (i)

3. Principles of Collection and Evaluation:

3.1 Adsorption Tube Methods

Principles of Collection: A known volume of air at a predetermined flow rate is passed through a vapour adsorption tube containing an adsorbent bed, such as charcoal⁽³⁾ or polymer beads. For personal sampling it is common practice to employ a pocket-sized battery-powered, pump connected with flexible tubing to the vapour adsorption tube attached typically to the lapel. In areas where potentially explosive concentrations of vapour could conceivably be encountered, the pump should be of the intrinsically safe type.

The tubes are analysed by first desorbing the trapped benzene by either flash heating and flushing with an inert carrier gas (heat desorption) or with a solvent such as carbon disulphide. Analysis of the desorbed benzene is then usually carried out, using gas chromatography. In the case of heat desorption the sample is flushed directly into the G.C. in the carrier gas. With solvent desorption an aliquot of the extract is injected into the G.C. using a microsyringe. After separation in the G.C. column and detection using flame ionisation, the quantity of benzene in the original air sample is calculated and expressed in mg/m^3 or ppm (by volume). The time weighted average value may then be computed using the procedure described in Appendix 1. Using such techniques, detection limits well below 1 ppm can be achieved.

3.2 Alternative techniques to vapour adsorption are:

Long term sampling by slowly filling a container at a constant rate with air over the work period. Analysis of such samples is usually by gas chromatography.

Continuous short term sampling using an infra-red spectrophotometer as detector. Interference from CO_2 must be filtered out. With a multiple reflection gas cell and path lengths of several metres, a detection limit of < 1 ppm can be achieved. However, large volumes of air are required to purge the cell, and this system is therefore best suited to continuous sampling systems at fixed locations.

Chemical detector or indicator tubes can be used for approximate measurements of benzene over short periods, with a detection limit of about 0.5 - 5 ppm depending on the tube selected. Alkylbenzenes may interfere with the measurement unless a pre-cleanse layer is incorporated in the tube system.

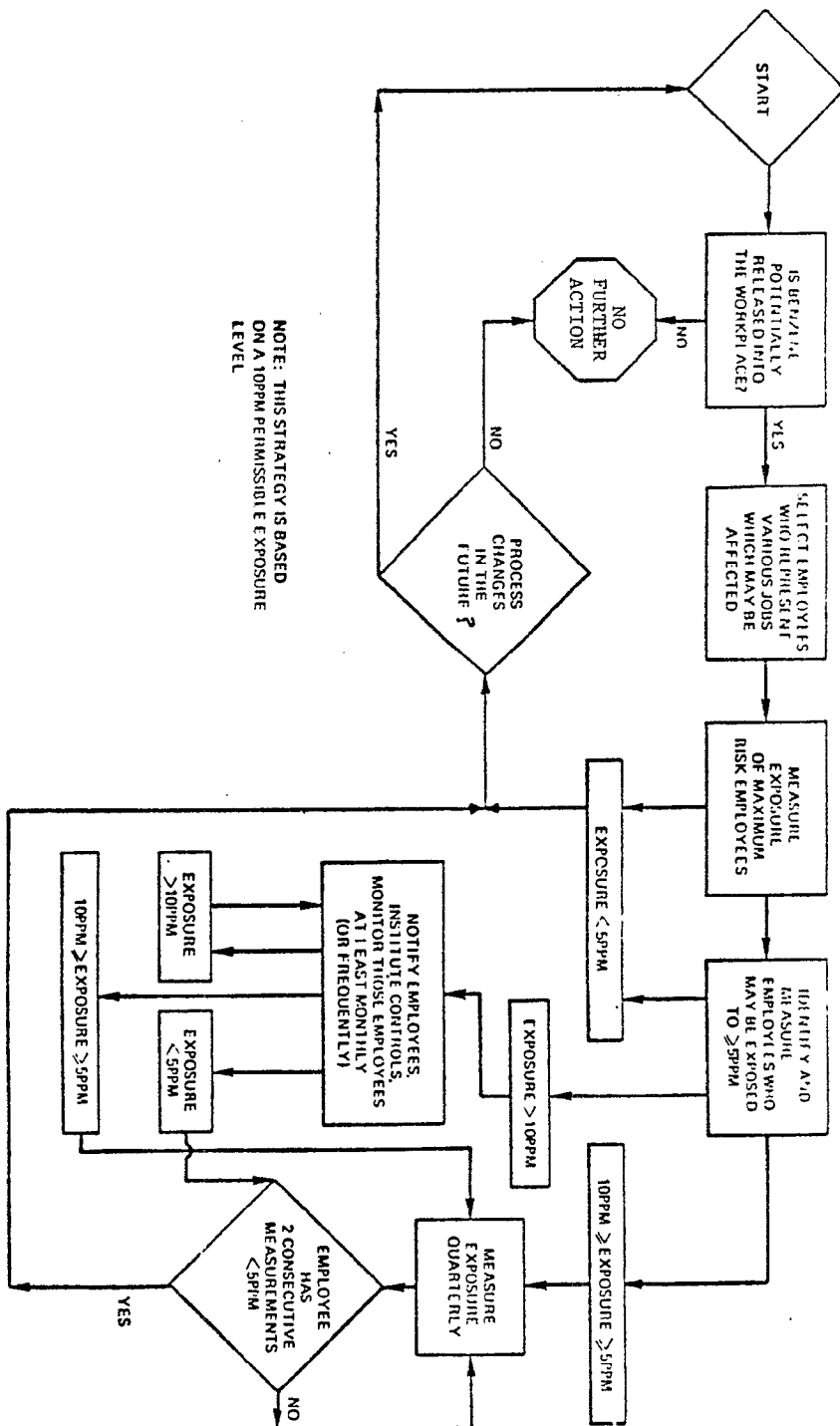
APPENDIX 7 (ii)

Passive samplers are now becoming commercially available for benzene. These comprise an adsorbent layer behind either a permeation membrane or a diffusion gap. Rate of uptake of benzene is linear with concentration and controlled by the permeation constant of the membrane or the rate of diffusion. Such samplers do not require the use of a pump, but must be carefully calibrated for uptake rate prior to field use. Analysis of the samples can be achieved by heat or solvent desorption, depending on the type of sampler employed, followed by gas chromatographic evaluation. Precision and accuracy of these newer sampling devices must be appropriately evaluated before they are introduced for general use.

References:

- (1) S.A. Roach "A Most Rational Basis for Air Sampling Programme".
Ann. Occup. Hyg., Vol.20, pp.65-84, 1977.
- (2) "Occupational Exposure Sampling Strategy Manual".
Leidel, Busch & Lynch. U.S. Dept. of Health,
Education & Welfare, NIOSH, Cincinnati, Ohio
45226. DHEW (NIOSH) Publication No. 77-173.
- (3) NIOSH Criteria Document "Occupational Exposure to Benzene". No. (NIOSH) 74-137, 1974.

BENZENE EXPOSURE MEASUREMENT STRATEGY



NOTE: THIS STRATEGY IS BASED ON A 10PPM PERMISSIBLE EXPOSURE LEVEL

APPENDIX 8

REGISTERS AND RECORDS

1. The following is the minimum information required for the purpose of Part 10 of these guidelines.
2. Personal Records
 - (i) Name and address, date of birth, NHS number and NI number of those involved with benzene.
 - (ii) Job classification(s), related to definite work areas where possible.
 - (iii) Date of starting work involving benzene, date of transfer from employment from such work and dates of any changes in job classification.
3. Results of Area Monitoring of Benzene

The results of each individual atmospheric sample together with relevant environmental and operational conditions should be recorded and all results analysed on a periodic basis showing number of tests at each location, average value, number in excess of the hygiene standard, highest results, etc. Where any unusual circumstances can be related to the results, this should be indicated and appropriate action initiated.
4. Results of Personal Monitoring

The results of personal monitoring should be analysed on a periodic basis by job category in each plant.
5. Results of Biological Monitoring

Where a biological monitoring programme is undertaken the results should be recorded in a manner suitable for epidemiological studies. The format of the record system should be determined in consultation with the medical supervisor of the programme. (See also Appendix 6).