HEALTH TECHNICAL MEMORANDUM 2022 SUPPLEMENT 1

Medical gas pipeline systems Supplement 1: Dental compressed air and vacuum systems

2003

STATUS IN WALES

APPLIES

This document replaced
HTM 2022 Supplement 1
Medical gas pipeline systems
Dental compressed air and vacuum systems
1996

GIG CYMRU NHS WALES
Partneriaeth Cydwasanaethau
Gwasanaethau Cyfleusterau
Shared Services Partnership
Facilities Services

For queries on the status of this document contact
info@whe.wales.nhs.uk or telephone 029 2031 5512

Status Note amended March 2013

Dental compressed air and vacuum systems

AN UPDATE OF HTM 2022 – SUPPLEMENT 1

NHS Estates

Dental compressed air and vacuum systems

AN UPDATE OF HTM 2022 – SUPPLEMENT 1

London: The Stationery Office

NHS Estates

Published by TSO (The Stationery Office) and available from:

Online

www.tso.co.uk/bookshop

Mail, Telephone, Fax & E-mail

TSO
PO Box 29, Norwich NR3 1GN
Telephone orders/General enquiries 0870 600 5522
Fax orders 0870 600 5533
E-mail book.orders@tso.co.uk

TSO Shops

123 Kingsway, London WC2B 6PQ
020 7242 6393 Fax 020 7242 6394
68–69 Bull Street, Birmingham B4 6AD
0121 236 9696 Fax 0121 236 9699
9–21 Princess Street, Manchester M60 8AS
0161 834 7201 Fax 0161 833 0634
16 Arthur Street, Belfast BT1 4GD
028 9023 8451 Fax 028 9023 5401
18–19 High Street, Cardiff CF10 1PT
029 2039 5548 Fax 029 2038 4347
71 Lothian Road, Edinburgh EH3 9AZ
0870 606 5566 Fax 0870 606 5588

TSO Accredited Agents

(see Yellow Pages)

and through good booksellers

ISBN 0-11-322478-8

Second edition 2003
First edition published 1996

Printed in the United Kingdom for The Stationery Office

Executive summary

GENERAL

This Supplement provides advice and guidance on the specific requirements for compressed air and vacuum systems for use in dental hospitals, dental teaching schools, clinics and surgeries and primary care trusts (PCTs).

The Supplement should be followed for all new installations and refurbishment; existing installations should be assessed for compliance with this Supplement. Where necessary, a plan for upgrading the existing systems should be prepared, taking into account the priority for patient and staff safety and statutory requirements which may have become effective subsequent to any existing installations. Owners, occupiers, general managers and chief executives should ensure that the premises for which they have responsibility and any activities carried out therein comply with these statutory requirements. This compliance is obligatory.

Managers will need to liaise with dental and estates colleagues and take account of other guidance published by the Department of Health to assess the system for technical shortcomings.

The guidance given in HTM 2022 should generally be followed for these systems and plant accommodation, except where modified in this Supplement.

This Supplement supersedes 'HTM 2022 – Supplement 1: Dental compressed air and vacuum systems' first published in November 1996.

USE OF MEDICAL GAS SYSTEMS

Dental hospitals, clinics and surgeries require compressed air to power dental instruments and a vacuum system to remove detritus from the operation site.

The performance requirements of dental compressed air and vacuum systems differ from those for medical air and vacuum, and they should be provided in addition to the medical gas pipework systems (MGPS). To avoid confusion they will be referred to as dental compressed air and vacuum systems (DAVS). Medical gas systems should not be used for dental purposes. However, it may be possible to extend a surgical air system into a dental department for dental surgical purposes, provided that the existing system is capable of meeting the resulting increase in demand without detriment to the performance of either system.

QUALITY REQUIREMENTS

Dental air is usually supplied via a compressor, which should be fitted with an air-intake filter and a post-compression filtration and dryer system. This ensures that the air is clean and dry, minimising the risk of contamination of the system by micro-organisms and improving the efficiency of dental instruments.

- The **dryer system** should be capable of producing air with an atmospheric dew-point not less than –20ºC.
- The **filter system** should provide dust filtration down to 1 µm with a DOP (aerosol) efficiency of not less than 99.97% and bacteria filtration down to 0.01 µm with a DOP (aerosol) efficiency of not less than 99.9999%.

AIR COMPRESSORS

Wet and dirty air will eventually lead to damage and corrosion of instruments. Oil-free compressors offer a simple, cost-effective solution to the problem of oil contamination. However, for larger installations, there are implications of higher capital costs and noise levels.

Whatever compressor system is used, the importance of properly conducted regular maintenance cannot be overstressed. Filters should be changed at least annually and more frequently if recommended by the manufacturer.

PIPELINE MATERIALS

The pipework distribution system for dental air should be of a material technically suited to the application. Copper and nylon are commonly used in pipework.

Dental vacuum and exhaust line materials should also reflect current technology, with particular attention given to minimising the harmful effects of any effluent which pipework may carry. For example, copper pipe should not be used for wet vacuum systems, as it will be attacked by dental amalgam compounds.

VACUUM EXHAUST FILTRATION

The exhaust from the vacuum system should be sited outside, away from air intakes, opening windows etc (preferably above roof level) and be clearly labelled. A bacteria filter with particle removal to 0.01 µm with a DOP (aerosol) test efficiency of not less than 99.9999% should be inserted in the system, preferably between pipework and vacuum pumps. Small systems exhausting into the work area should have such a filter fitted to the pump exhaust.

WATER SUPPLIES

The design and installation of the surgery's water supply must take account of the Water Supply (Water Fittings) Regulations 1999, in particular the need to prevent contamination waste and undue consumption.

To prevent contamination of the sewerage drainage systems, amalgam separators should be fitted to all dental vacuum systems.

ACCOMMODATION

Accommodation for dental compressor and vacuum pumps should be carefully controlled to prevent overheating of plant and contamination of dental air supplies, or freezing of and subsequent damage to drying systems and vacuum plant

INSTALLATION, TESTING AND MAINTENANCE

Installation, testing and maintenance of these systems should be carried out by competent authorities, that is companies certificated under BS EN ISO 9000 with a defined scope of expertise. The Quality Assurance Scheme 3720 1/206.1A for MGPS is currently under review and will be revised to include dental installations and maintenance of both MGPS and DAVS.

COSHH

In areas where anaesthetic agents are in use, particular attention should be paid to the requirements of the COSHH Regulations 1999. However, it must be remembered that these Regulations also apply to many other compounds used in dentistry.

OPERATIONAL POLICY

An operational policy covering the day-to-day management and operation of the DAVS should be devised. Its preparation will usually be the responsibility of the senior partner/practice manager or the Authorised Person (MGPS), if the latter has responsibility for the DAVS.

PATHOLOGY DEPARTMENTS

Separate installations should be provided for pathology departments.

CE MARKING

All new plant should be marked with the appropriate CE mark; plant which is not so marked should not be installed. It should be remembered, however, that presence of a CE mark is no guarantee of conformity with relevant standards.

Acknowledgements

Geoffrey Dillow (Main author), Consultant, Geoffrey Dillow and Associates

Darryn Kerr (Chairman) and Committee Members **Mike Ralph**, **Steve Goddard**, **David Peel**, **Alex Black**, **Mike Arrowsmith**, **Ian Fraser**, **Paul Jones**, Medical Gas Association

Clive Shakesheff Site Investigations Technician, Bristol City Council

Clive Bray Director, Device Technology and Safety et al, Medical Devices Agency

Mike Ralph Plant Operations and Maintenance Manager, Great Ormond Street Children's Hospital

Ian Cooper Senior Dental Officer et al, Dental Division, Department of Health

Steve Goddard Training Consultant, Knowledge Pool

Mike Arrowsmith Arrowsmith & Associates

Steve Bailey Managing Director, Cattani ESAM UK Limited

Richard Orton, Technical Services Manager, KaVo Dental Ltd

David Robinson Sales Manager, DentalEZ Dental Products (GB) Ltd

Peter Stanford Sales Director, Bambi Air Compressors Ltd

Lyndon Saul Director Medical Architectural Systems, Dräger Medical

Henry Hicks Europe, Middle East and Africa Export Sales Manager, Penlon/East Healthcare

Steve Parkinson R&D Manager, Hill-Rom MEDÆS

Andy Booth International pipeline systems designer, Hill-Rom MEDÆS

Lynn Woods Health and Safety Advisor, **Lesley Derry**, Head of Professional Services, British Dental Association

Ian Pope Managing Director, Durr Dental (Products) UK Ltd

Siegfried Nafzger Product Management Equipment, Durr Dental Germany

Dr Frank Haines-Nutt (Chair), **Paul Jones**, **Ian Beaumont**, **Brian Midcalf**, **Ed Doyle** et al, Regional Pharmaceutical Officers Quality Control Group (Medical gases)

Steven Griffiths DEFRA

Richard Hurst Senior Account Executive, WRc-NSF Ltd.

Dr M Thorpe General Dental Surgeon, Gateshead

Dr H Thorpe Community Dental Officer, North Durham PCT

Staff Environment Agency, Exeter

Judith Reilly HM Inspector et al, Health & Safety Executive, Health Services Unit

Ian Beaumont, Director, **Kay Witham**, QA and Audit Officer, Quality Control North West

Paul Jones, **Ed Doyle**, **Richard Sutherland**, Directors, Medical Gas Testing Services

Mike George Managing Director, Dentalair UK

Garry Meager Building Services Engineer, Defence Estates

Russ Tebbs Director, Mossman–Tebbs Ltd

Lee Kingston, Special Waste Business Development Manager, Envirodent Ltd

Brian Elliott Higher Professional Technical Officer, Estates Policy, Health Estates Northern Ireland

Jonathan Oakley Sales Engineer, Dominick Hunter Filtration

M P Godden, Director, HVDS

Contents

1 Scope

1.1 This Supplement to HTM 2022 covers the design, installation, validation, verification, operational management and maintenance of compressed air and vacuum systems for use in dental hospitals (including dental teaching schools), surgeries and clinics. It supersedes 'HTM 2022 – Supplement 1: Dental compressed air and vacuum systems' first published in November 1996.

1.2 Other guidance on the provision of medical gas pipework systems (MGPS) is also given in the Health Building Notes. Guidance on COSHH requirements is given in the Health & Safety Commission's Health Services Advisory Committee publication 'Anaesthetic Agents: controlling exposure under COSHH'.

1.3 The guidance given in HTM 2022 should generally be followed for these systems, except where modified in this Supplement.

1.4 Dental compressed air and vacuum systems (DAVS) are installed to provide safe, convenient and cost-effective systems for dental staff at the point of use. Problems associated with portable cylinders and suction systems, particularly patient and staff safety, porterage and storage are reduced.

1.5 The guidance given in this Supplement should be followed for all new installations and refurbishment/extension.

1.6 The guidance given in this Supplement should be implemented for patient and staff safety and to comply with statutory requirements. Existing installations should be assessed for compliance with this Supplement. Where necessary, a plan for upgrading the existing systems should be prepared, taking account of the priority for patient and staff safety and compliance with statutory requirements which may have come into effect after any existing installations. Managers will need to liaise with dental and estates colleagues, equipment manufacturers and installers and heed other guidance published by theDepartment of Health (DoH) to assess the system for technical shortcomings.

1.7 The requirements in respect of compliance with statutory regulations apply to all premises where dental procedures are carried out, regardless of whether they are NHS or private premises.

1.8 Wherever possible, the appropriate British or equivalent European or international standards should be used.

2 Management responsibilities and guidance

COMPLIANCE WITH STATUTORY REQUIREMENTS

2.1 It is the responsibility of the owners and occupiers of premises, general managers and chief executives to ensure that their premises and the activities carried out within those premises comply with all appropriate statutory requirements, some of which are listed below:

- Management of Health and Safety at Work Regulations 1999.
- Workplace (Health, Safety and Welfare) Regulations 1992.
- Provision and Use of Work Equipment Regulations 1998.
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995.
- Manual Handling Operations Regulations 1992.
- Personal Protective Equipment at Work Regulations 1992.
- Electromagnetic Compatibility Regulations 1992.
- The IEE Wiring Regulations BS7671 2001.
- The Electricity at Work Regulations 1989.
- The Medicines Act 1968.

2.2 Particular attention is drawn to the following documentation:

- Pressure Systems Safety Regulations 2000 and Pressure Equipment Regulations 1999.
- The COSHH Regulations 1999 (see Appendix 3).
- The Water Resources Act 1991 (see Appendix 2).
- Advice Sheet A3: 'Health and safety law for dental practice' – BDA Advisory Service.
- Advice Sheet A12: 'Infection control in dentistry' – BDA Advisory Service (under revision).

FUNCTIONAL RESPONSIBILITIES

2.3 Where dental care is provided within a hospital or trust, the chief executive or general manager has the formal responsibility for the MGPS and the DAVS.

2.4 For a private practice, the formal responsibility for these systems rests with the senior partner, partners or principal(s) in the practice.

2.5 In all cases where an MGPS is installed, an Authorised Person (MGPS) [AP (MGPS)], as defined in HTM 2022 'Operational management', is responsible for the day-to-day management of the pipework system.

2.6 If an MGPS (or any part of it) extends to a dental surgery, the AP (MGPS) should assume responsibility for the DAVS.

2.7 In the following cases, responsibility for the management of the DAVS should be clearly defined in the MGPS operational policy:

a. In dental schools which may be supported by an associated hospital's MGPS.

b. In hospitals where the MGPS does not extend to an on-site dental surgery.

c. In community-based clinics which may or may not have an associated MGPS.

d. In a dental surgery, provided and maintained by a Trust, but rented to a private practice.

2.8 In an independent private practice, responsibility for the DAVS (and any associated MGPS) rests with the senior partner, partners or principal(s) in the practice.

USE OF THE MGPS PERMIT-TO-WORK SYSTEM

2.9 Where the AP (MGPS) has responsibility for both dental and medical gas systems, the HTM 2022 Permit-to-Work system should be used to control work on these systems. The standard MGPS permit form may have to be amended (along with an appropriate signature) to highlight procedural differences, for example in test routines. But this should not prevent its use, particularly in circumstances where a danger of cross-connection between systems exists. Sections of the permit which do not apply should be clearly annotated 'N/A' (not applicable).

2.10 Where no AP (MGPS) is involved in work on the system (for example in a private practice), it is especially important for a nominated senior partner/principal/practice manager to maintain concise records of maintenance and modifications to the system. This is to comply with the requirements of the Pressure Systems

Safety Regulations 2000. In these circumstances, use of the MGPS permit-to-work forms would encourage good practice but, ultimately, the form of documentation used is at the discretion of senior partner, partners or principal(s) in the practice. Typical documentation is shown in Appendix 5.

OPERATIONAL POLICY

2.11 In all areas where an MGPS is installed, an MGPS operational policy should be in place. Normally, this policy will be implemented and monitored by the AP (MGPS). It is, therefore, logical to extend the scope of this policy to encompass the DAVS, where the AP has a defined responsibility for these systems.

2.12 For DAVS that have no AP (MGPS) involvement, a simple operational policy should be prepared by the person(s) responsible for managing the system, detailing day-to-day operational requirements and arrangements for control and monitoring of modifications, maintenance and training. A typical operational policy data set is shown in Appendix 6.

TRAINING

2.13 Users of DAVS should have a sound general knowledge of the operating principles and safety procedures and should not attempt to operate equipment unless properly trained or supervised.

2.14 Installers and maintainers of DAVS should be able to verify competence in appropriate techniques and skills. (Proof of registration to BS EN ISO 9000, training records and current test equipment calibration certificates constitute evidence that should be requested by the AP (MGPS) or senior partner, partners or principal(s) in the practice, when approached by a potential installation and/or maintenance contractor.)

2.15 A training programme should be produced, and records be kept of all training carried out. This should be subject to annual review. The training programme should be referenced in the operational policy.

EXTENT OF SYSTEMS AND LIMITATION OF USE

2.16 In a dental surgery or clinic, compressed air is provided as the power source for the dental instruments; vacuum is required to remove detritus from the operation site.

2.17 The performance requirements of these systems differ from those for medical air and vacuum, and they should be provided in addition to the medical gas systems. However, the guidance given in relevant sections of HTM 2022 (in particular 'Design, installation, validation and verification') should generally be followed for these systems, except where modified in this Supplement.

2.18 Ideally, dental air and vacuum should be supplied from separate sources via dedicated pipework systems and the medical and surgical air and vacuum systems should not be used to provide dental air or dental vacuum. However, see the note below on extension of existing surgical air systems.

2.19 DAVS may be extended to the dental laboratory, provided the systems have been specifically designed to cope with this demand.

2.20 Very few dental chairs have their movement operated by compressed air. If the dental chair is to be operated by compressed air, a dedicated compressor for this purpose must be provided.

2.21 The dental air supply must not be used for this or for any purpose other than clinical and dental laboratory procedures.

2.22 Where medical gas pipelines are installed in a dental surgery or clinic, the guidance given in HTM 2022 should be followed for their installation.

2.23 Separate installations should be provided for pathology applications.

Note: Extension of surgical air systems into dental departments

There are many instances where an existing surgical air system has been extended into a dental department. From economic and air quality viewpoints, such an extension offers obvious advantages and will, therefore, continue to be considered as an alternative to separate provision.

While it is acceptable to extend a surgical air system into a dental department, a decision to do so should take into account the following:

a. The extra demand on the existing system should not compromise patient safety or operation of either the existing system or its extension. In particular, the ability of an existing emergency supply system to cope with potentially very high demands should be carefully assessed.

b. An AP (MGPS) who is responsible for the existing surgical air system will automatically assume responsibility for the whole of the DAVS.

c. Both AP (MGPS) and Quality Controller (MGPS) should be aware that extending a surgical air system into a dental unit for dental instrument use will introduce "non-standard" pipework terminations, for example crimped or compression fitted connectors in addition to non-degreased components. Failure of these non-standard components could lead to a serious depressurisation of the existing surgical air system and, if provided from the same source, the associated medical air system.

d. If the system is further extended into a dental laboratory, surgical air could be used to support the operation of such devices as natural gas/air burners. Cross-connection of these systems is unlikely but an assessment of the risk must be undertaken.

3 Dental compressed air systems

STATUTORY OBLIGATIONS

3.1 Reference to statutory guidance has been made in Section 2. In this section, particular attention is drawn to the Pressure Systems Safety Regulations (PSSR) and the Pressure Equipment Regulations (PER), as these apply to the provision of dental compressed air.

3.2 A term 'Competent Person' is defined in the PSSR (usually the insurance company or its agent and NOT the Competent Person (MGPS) referred to in the MGPS permit-to-work system). Guidance is also given in HTM 2022 'Operational management'.

3.3 The Regulations require that a 'written scheme of examination' be prepared by the Competent Person, as defined by the Regulations, for each pressure system.

3.4 This may include the compressed air system in dental surgeries, as the air receiver is a pressure vessel.

3.5 Periodic examination is a requirement of the PSSR and is independent of any insurance arrangement. The time between each examination should be agreed between the user and the Competent Person. If doubt exists about the need to insure a particular item of equipment, advice should be sought from the trust/hospital or practice insurer.

3.6 Depending on quality of the maintenance, 24-monthly inspections may be deemed appropriate but this could vary. Such an insurance inspection may mean shutting down the compressed air system, unless alternative provision is made.

3.7 For all pressure systems, the Regulations require that proper, documented maintenance is carried out in accordance with the manufacturers' recommendations.

THE NEED FOR HIGH QUALITY DENTAL AIR

3.8 A European Pharmacopoeia Standard is used to define the quality of medical air (Table 3.1). There is no doubt that dental air needs to be 'clean and dry' to:

- minimise the risk of contamination of the system by micro-organisms;
- improve the efficiency and working life of dental instruments; and
- maximise the efficacy of modern dental composites.

Even electric micromotor instruments will suffer damage from the use of cooling air contaminated with high levels of oil and water.

3.9 Historically, many smaller installations, for example up to three or four chairs, have used compressor systems which, in basic form, offer little by way of air treatment. Additionally, poor siting of compressed air plant has led to instances of overheating, resulting in

TABLE 3.1 MEDICAL AND DENTAL AIR QUALITY STANDARDS – COMPARISON

Content	Medical air	Dental air
Oxygen	20.9 ± 0.5%	20.9 ± 0.5%
Nitrogen	78.0% by inference	78.0% by inference
Carbon dioxide	<500 ppm v/v	<500 ppm v/v
Carbon monoxide	<5 ppm v/v	<5 ppm v/v
Oil	<0.1 mg/m^3	<0.1 mg/m^3
Water	<67 vpm (DPt –46ºC at atm p)	< 1032 vpm (DPt –20ºC at atm p)
Particulate	Free from visible particles in a 75-litre sample (taken at 150 litres/min)	
Sulphur dioxide	<1 ppm v/v	<1 ppm v/v
Nitric oxide + nitrogen dioxide	<2 ppm v/v	<2 ppm v/v

gross oil contamination, excessive levels of carbon dioxide and carbon monoxide and plant failure.

3.10 All plant suppliers offer advice on plant siting and associated filtration and drying equipment to enable production of air to the standard recommended in this Supplement. Users should discuss these requirements with supplier so that suitable plant performance is achieved.

3.11 The cost of instrument repair or replacement is high and these costs, along with an increased danger of infection and the inconvenience of system, equipment and dental composite failure, should be carefully weighed against the cost of installing the air treatment measures recommended below.

3.12 Regardless of system structure, poor or absent maintenance is still a significant factor in the degradation of air quality and consequent premature failure of air driven equipment. A properly planned and administered maintenance scheme, carried out by a competent organisation and meeting, in full, plant manufacturers' requirements will very quickly recoup its cost against the costs and inconvenience of equipment, plant and instrument repair or replacement.

DENTAL AIR QUALITY STANDARD

3.13 It can be seen from Table 3.1 that dental air is the same as medical air in all parameters except dew-point; that is, it is not necessary to achieve a dew-point of –46ºC at atmospheric pressure – a dew-point of –20ºC is adequate.

3.14 A medical gas particulate content test is normally conducted for 30 s at 150 l/min flow rate (see Table 3.1). This will not be practicable on all dental air systems, especially small, for example single-chair, installations. In these cases, purging of the system at full flow should be sufficient to remove particulates.

AIR TREATMENT REQUIRED TO MEET THE STANDARD

3.15 Contaminants can enter the compressed air systems from three sources: the atmosphere, the compressor and the pipework distribution system. Each potential source should be taken into account when specifying the type and location of air treatment equipment.

AIR INTAKE AND PRE-COMPRESSION FILTRATION

3.16 The air intake for the compressor plant should be suitably located to minimise contamination from internal combustion engine exhausts and discharges from vacuum systems, anaesthetic gas scavenging systems, ventilation systems or other potential sources of contamination.

3.17 For compressor protection, air-inlet filtration should be fitted immediately upstream of the compressor. In exceptional circumstances, additional screens, filters and silencers may be required.

3.18 A suitable intake filter would comply with BS ISO 5011: 2000 and be either medium filters or grade CA paper element filters, with a 5 µm particle size removal capacity. Intake structure will vary with the type of compressor.

COMPRESSOR SYSTEMS – SITING

3.19 The importance of correct siting for compressor plant cannot be overstressed. The following requirements (which also apply to the siting of dental vacuum plant) should be adhered to as closely as possible.

3.20 The plant should have all-round access and good lighting levels (200 Lux) for maintenance purposes. Allowance should be made for changing major components.

3.21 The compressor and dryer plant should ideally be installed in a well-labelled, locked, dust-free, dry, cool, well-ventilated room.

3.22 Most dental plant is rated for an operational ambient temperature range of 10–35ºC; the optimum range is 10–15ºC. The performance of the compressor and dryer may be seriously impaired if the ambient temperature rises above 35ºC, although some units are rated up to 40ºC (the HTM-specified maximum operational temperature in a hospital plant room).

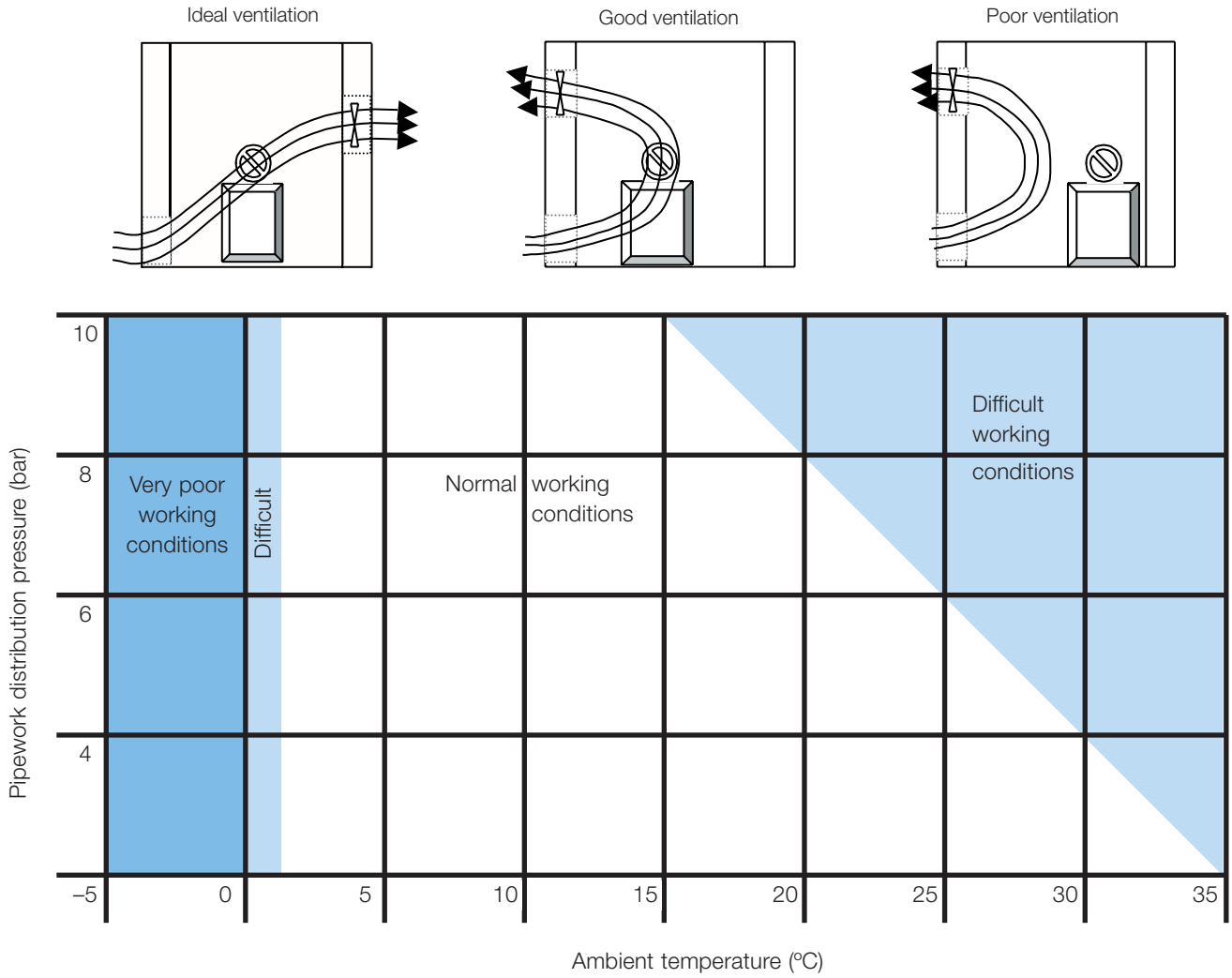
3.23 An air compressor gives off approximately 70% of its consumed power as heat energy; a compressor system designed to develop 500 l/min at 5 bar generates approximately 3 kW. This will need to be taken into account when considering the room ventilation.

3.24 Additional (forced) ventilation may be required if the ambient temperature exceeds 35°C.

3.25 Some units are not installed in controlled plant rooms and if the temperature is allowed to fall below +5°C condensation may form inside the compressor and dryer. In lubricated compressors, this could lead to oil emulsification, with a subsequent reduction in plant life arising from excessive wear of moving components.

3.26 Considerable damage can be caused if water-contaminated plant temperatures fall below freezing.

Figure 3.1 Plant accommodation ventilation and working conditions



3.27 Plant rooms constructed as part of a hospital should conform to the requirements of HTM 2022 'Design, installation, validation and verification'.

3.28 All plant accommodation should be clearly labelled as to its purpose. Details of emergency action procedures and location of keys should be posted, as should "no-smoking" and other warning signs.

COMPRESSOR SYSTEMS – TYPES AND NOISE LEVELS

3.29 Any type of compressor suitable for continuous running on load and stop-start duty may be used.

3.30 Oil-contaminated compressor condensate is classed as trade effluent and should only be discharged via an oil/water separator. Oil-free compressors have been used successfully in dental surgeries and obviate the need for oil separators and filters. Care should be taken to ensure that polytetrafluoroethylene (PTFE) components do not become excessively hot.

A temperature sensor should be fitted, with suitable controls, to cut off the power supply in the event of excessive temperatures.

3.31 Noise levels of plant obviously increase with the capacity. The maximum free field noise level at 1 m distance for unsilenced compressed air plant varies with the type and power of the plant (see Table 3.2). Many of the figures in Table 3.2 apply to larger plant units that are able to supply extensive compressed air systems and are normally housed in a specifically designed plant room. Many dental installations require much smaller units. However, even larger dental installations may be based upon split systems, using multiple plant, rather than one large, centralised unit.

3.32 In many installations, for example in small dental surgeries, pumps may be situated close to the operating area; thus noise control becomes more significant. In these circumstances, a maximum free field noise level of 65 dB(A) at 1 m from the plant is recommended. Note

TABLE 3.2 MAXIMUM FREE FIELD NOISE LEVELS AT 1 M FOR UNSILENCED COMPRESSED AIR PLANT

Noise level (dBA)	Power (kW)
Reciprocating	
85	<7.5
89	7.6–15
93	15.1–22
97	22.1–60
Screw	
76	<7.5
78	7.6–15
80	15.1–22
92	22.1–60
Vane	
76	<7.5
76	7.6–15
79	15.1–22
90	22.1–60

that some plant suppliers quote noise figures which are referenced to a 38 dB(A) background noise level.

3.33 There may be differences in noise levels between oil-free and oil-lubricated plant offering similar air-delivery capacities and this should be taken into account when considering installation in noise-sensitive areas.

3.34 The advice of manufacturers/suppliers should be sought when considering the merits of different plant types for a particular location and the availability of acoustic screening.

POST-COMPRESSION AIR TREATMENT

3.35 The amount of water liberated following air compression and subsequent cooling can be considerable. Much of this condensation, especially with smaller systems, will take place within the air receiver. Therefore, to maintain air quality and reduce internal corrosion and possible microbial contamination, particular attention should be given to regular draining of receivers not fitted with automatic drains.

3.36 Internally coated or stainless steel receivers offer obvious advantages in terms of air quality when a dryer system is not fitted before the receiver.

3.37 For large installations, where oil-lubricated compressors are installed, pre-filter, oil-coalescing and activated charcoal filters will be required as part of the air treatment process. A typical larger (duplex) installation is shown in Figure 3.2.

3.38 A duplex dryer system would not normally be required for dental surgeries, although it would be considered for a dental school or large department where (a) downtime for maintenance or insurance inspections or (b) examinations in accordance with the Written Scheme of Examination would cause unacceptable disruption.

3.39 Each dryer and filter assembly must be rated for continuous use at the system demand flow.

3.40 Some older units use refrigerant dryers to lower the dew-point of the delivered air. These are unlikely to meet the –20ºC dew-point requirement and, when upgrading, should be replaced with desiccant dryers.

3.41 The dryer can be located either upstream or downstream of the air receiver, depending upon the design of the system.

3.42 For small installations, especially those in which an oil-free compressor is used, there may be advantages in

Figure 3.2 A much larger (duplex) plant with duplex drying, filtration and pressure regulation equipment

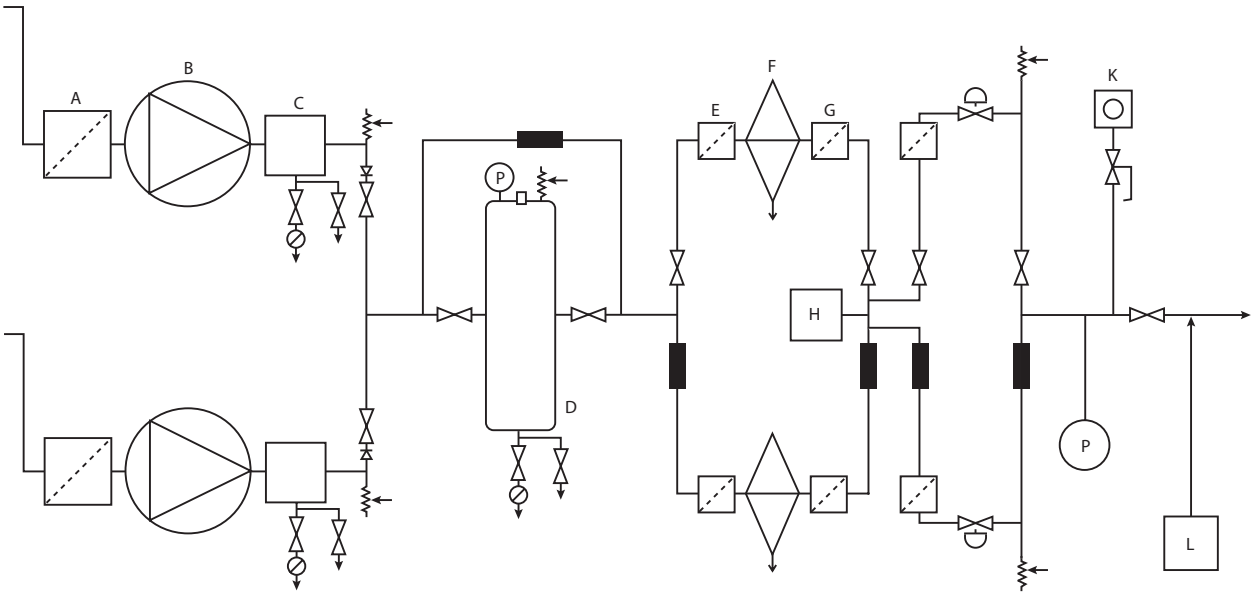
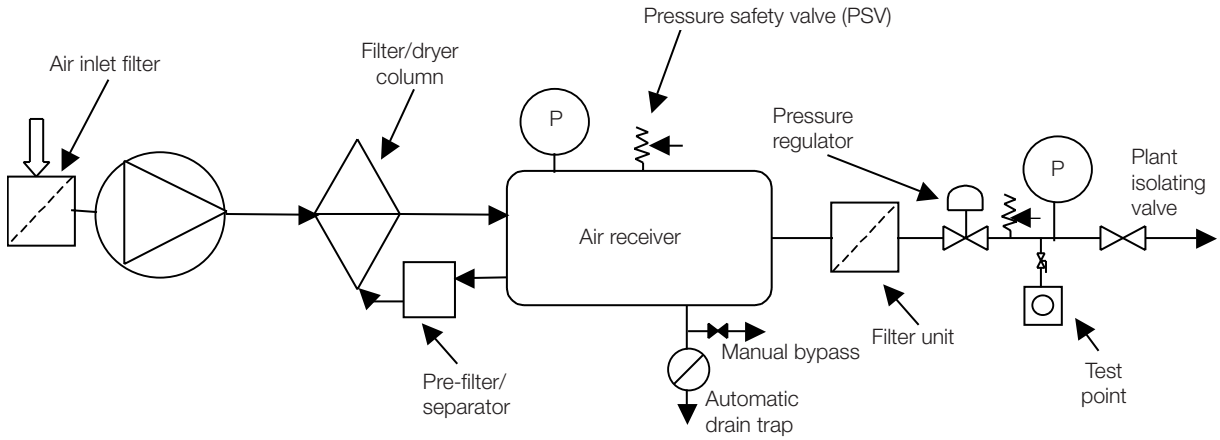


Figure 3.3 A small simplex air plant with single column regenerative dryer



Key:

A	Air inlet with filter
B	Compressor
C	Air cooler with automatic drain, manual drain by-pass and pressure safety valve
D	Air receiver with pressure gauge, fusible plug, pressure safety valve and drains, automatic drain, manual drain by-pass and pressure safety valve
E	Oil/water separator/pre-filter
F	Desiccant dryer unit
G	Dust filter
H	Humidity sensor
I	Bacteria filter (usually incorporating an activated charcoal element to remove odours)
J	Pressure regulator
K	Gas-specific test point
L	Emergency supply system (cylinder manifold)

locating the dryer upstream of the receiver to ensure that the air receiver is not contaminated with moist air and to enable dry air from the receiver to be used to regenerate the desiccant. A typical small installation is shown in Figure 3.3.

3.43 If the dryer is located downstream of the receiver, the receiver acts as a secondary after-cooler and also smooths out the pulsing effect of a reciprocating pump. This may be appropriate to larger installations.

3.44 There should be a dust filter downstream of the dryer to remove particles down to 1 µm with a DOP (aerosol) efficiency of not less than 99.97%.

3.45 A bacteria filter should be fitted downstream of the dust filter. The filter should provide particle removal to 0.01 µm and a DOP (aerosol) efficiency of not less than 99.9999%. Modern monobloc air treatment filters offer the required degree of bacterial protection and combine odour, dust and bacteria removal elements.

3.46 Micro-organisms can penetrate a bacteria filter if the material becomes wet. It is essential that the dryness of the dental air supplied to a bacteria filter is checked at least annually to ensure that the filter does not become wet.

3.47 A filter incorporating an activated charcoal element will remove odours from the delivered air.

3.48 Filtration to the above specifications may be achieved via discrete or combined filter elements.

PIPEWORK SYSTEM DESIGN

3.49 Installation of a duplex compressor set, as seen in many medical air installations, is not common practice in dental air systems. Additionally, many small dental air systems are localised, for example to a single chair, with a compressor matched to the needs of the air instruments. The pipework in such cases is a means of interconnection than rather a 'system'. For small surgeries, a single compressor system would supply a maximum of about five chairs via a pipework system comprising synthetic flexibles, for example nylon. A ten-chair unit is often supported by two compressor systems, each feeding five chairs via a dedicated pipework system, rather than a larger single plant. This configuration has the added advantage of a degree of service protection, should one plant fail. (Emergency supply manifolds are not often used to support dental air systems.)

3.50 The design of larger systems may also involve split installations; for example, in a dental hospital with an integral dental school, a large number of teaching chairs will be in use simultaneously. It is possible that the total flow requirement of the teaching school and hospital would be supplied from separate compressor plant.

A combination of central and local provision, depending on the type of equipment in use, may be the preferred option.

3.51 Planning and design of DAVS, therefore, needs full co-operation between user, supplier and installer to achieve the most effective design. The parameters below will serve as guidelines when designing dental air systems.

Flow and pressure requirements at the dental chair

3.52 A system should be able to provide a minimum flow of 50 l/min at the instrument connection end of the operating hose, with the system operating at design flow. A typical pressure of 550 kPa at the floor-box outlet connection will be required to achieve this.

Diversity factors and plant sizing

3.53 To ensure that a minimum of 50 l/min is available at each operating point, the dental air system should be designed to offer a minimum plant outlet pressure of 600 kPa at design flow.

3.54 For surgeries with up to ten dental chairs, it can be assumed that all chairs may be in use simultaneously, each requiring a flow of 50 l/min. For surgeries with more than ten dental chairs, it can be assumed that 60% of the remainder of the chairs will be using compressed air simultaneously.

3.55 A maximum pressure drop of 50 kPa from plant to dental chair floor-box outlet connection can be tolerated under design flow conditions, although it should be borne in mind that commissioning routines do not include a full design flow test, unless specifically requested by the user.

3.56 Compressed air receiver volume can be increased at the discretion of the plant supplier to meet higher short-term flow demands.

3.57 For the purposes of plant sizing, the total system demand (Q) will be as follows:

$Q = 500 + [(n - 10)30_{l/min}]$;
i.e. $(10 \times 50) + [(n - 10)(0.6 \times 50)]$,
where n = number of dental chairs.

Example 1. For a dental department with 30 dental chairs, the system demand would be:

$Q = 500 + [(30 - 10)30] = 1100$ l/min.

Example 2. For a dental teaching section of 70 chairs integral to a hospital dental department fitted with a further 200 outlets:

70 chairs simultaneously will use 3500 l/min of air, assuming 50 l/min delivered flow at each air instrument connection point and no diversity.

In the dental hospital (200 outlets), a further (diversified) flow of 6200 l/min will be required.

Special cases

Dental schools

3.58 For dental teaching schools it can be assumed that all chairs in the teaching department will be in use simultaneously at a delivered flow of 50 l/min each. This flow should be added to the diversified flow of any associated system.

Dental laboratories

3.59 When the dental air supply is to be extended into a dental laboratory, additional flow capacity will have to be designed into the system. Equipment manufacturers' data will give the flow and pressure requirements for individual items of equipment. No diversity allowance should be made, unless agreed or specified by the user.

New technology

3.60 Occasions may arise when advances in technology result in equipment requiring pressures or flows considerably more than the current norms. Each such case should be treated individually and the advice of the specialist manufacturer or supplier sought to achieve the full potential of the equipment. Under no circumstances should the use of such equipment compromise the integrity of the existing system. If necessary, a separate pressure source will have to be installed to cope with the demands of the new equipment.

Pipework sizing

3.61 The pipework should be designed to produce a minimum of 550 kPa at each dental chair floor connection outlet, with plant operating at a nominal delivery pressure of 600 kPa at total system design flow, taking into account any allowance for diversity.

3.62 For the purpose of calculating pipework sizes/ pressure drops, the following formula can be used:

$$\Delta p = P_1 - 100\sqrt{\left[\left(\frac{P_1}{100}\right)^2 - \frac{(0.1152Q^2L)}{d^5}\right]}.$$

where:

Δp = pressure drop (kPa)
P_1 = inlet pressure (kPa absolute)
Q = flow (l/min measured at 15ºC and 1013 mbar)
L = pipe length (m)
d = internal diameter of pipe (mm)

TABLE 3.3 PIPEWORK SIZING: ALLOWANCES FOR EQUIVALENT LENGTH OF FITTINGS

	6mm	8mm	10mm	12mm	15mm	22mm	28mm	35mm	42mm	54mm	76mm
Ball valve	0.1	0.1	0.2	0.3	0.3	0.6	0.9	0.9	1.1	1.2	1.2
Tee (Thru')	0.12	0.15	0.18	0.21	0.32	0.42	0.54	0.70	0.82	1.05	1.56
Tee (Branch)	0.46	0.52	0.70	0.80	0.95	1.26	1.6	2.10	2.45	3.14	4.67
90º Elbow	0.17	0.20	0.25	0.33	0.47	0.63	0.80	1.05	1.23	1.58	2.36

Allowances for equivalent lengths of fittings (see Table 3.3) should be included where appropriate.

Test point

3.63 To facilitate pharmaceutical testing of the dental air system, test points (e.g. 3/8" BSP male tapping with integral isolating valve) should be provided at the plant and in each of the dental unit floor connection boxes.

Pipework materials and jointing techniques

3.64 All pipework should be of materials appropriate to the demands of the system. Traditionally, synthetics such as nylon have been used for smaller installations while copper has been used in larger installations. This is no longer the case, with synthetic pipeline systems being installed in units having considerably more than two or three chairs. If synthetics are used, care should be taken to ensure that microbiological and fire safety are not compromised.

3.65 Copper systems should be installed using a fluxless jointing technique in accordance with HTM 2022 'Design, installation, validation and verification'.

3.66 Any appropriate method of jointing compatible with the system operating pressure (for example compression fittings) may be used with synthetic materials.

Pressure safety valves

3.67 Pressure safety valves should be provided on pressurised vessels and pipework in accordance with the system requirements.

3.68 All pressure safety valves should conform to BS6759 Part 2: 1984 or equivalent. A receiver pressure safety valve will typically have a nominal lifting pressure 10% above receiver working pressure. It should never be set to lift at a pressure higher than the maximum allowable pressure of the vessel which it protects. Furthermore, the normal working pressure in the vessel should be below the pressure-safety-valve set pressure by a suitable margin to protect against nuisance opening and to permit the pressure safety valve to reseat.

3.69 Pressure safety valves protecting distribution pipework should have a lifting pressure 25% above nominal line pressure.

3.70 A certificate of conformity should be supplied with each pressure safety valve.

3.71 All pressure safety valves should be replaced as identified in the 'Written Scheme of Examination' (usually every five years).

PLANT MONITORING AND ALARM SYSTEMS

3.72 Small installations are not generally provided with plant or pipework monitoring and alarm systems, failure of the service being considered sufficient indication of plant or pipework failure. Indeed, attaching an alarm system to monitor, for example, line pressure would prove difficult, as it is good practice to turn off small compressors when the surgery is not in use.

3.73 In systems where no alarms are fitted, particular attention should be paid to regular maintenance to ensure a continual high level of air quality and to avoid the inconvenience of plant or equipment failure.

3.74 Where provided, in small installations a simplified operating and indicating system should signal any plant fault conditions in the dental surgery.

3.75 In large (hospital) installations, where plant failure would cause a major disruption in clinical services, the following indications are recommended as a minimum:

- A simple alarm status indicator unit, forming an integral part of the plant control unit, or a discrete unit linked to plant via an interface unit, should be mounted in the plant room.
- Further repeater panels should be installed within the dental department, telephone operators' room etc as required.

A schedule of indications is listed in Table 3.4.

TABLE 3.4 SCHEDULE OF ALARM SYSTEM INDICATIONS

	Normal condition	Plant fault	Pressure fault
At the plant	Plant and system operating within specified parameters – signalled as a GREEN light	i) compressor unit: failed to start, overheated, overload-tripped or any other plant alarm as determined by the plant manufacturer – signalled as a YELLOW light (ii) dryer unit: dryer failure, dew-point above –20°C at atmospheric pressure – signalled as a YELLOW light	Line pressure ±20% of nominal – signalled as a RED light
In the dental department or other specified location	GREEN	YELLOW	RED

Notes:

Yellow and red alarms should be accompanied by an audible warning (with 15-minute, user-operated MUTE facility).
Regardless of whether an alarm system is fitted, the departmental operational policy should detail staff actions in the event of service failure.

EMERGENCY SUPPLIES

3.76 If the user considers that sudden loss of, or interruption to, the dental compressed air system would compromise patient safety, some form of emergency supply should be available. For example, this could be a cylinder of medical compressed air complete with regulator and appropriate hose and instrument fittings. However, this may not be viable, as difficulties with cylinder handling and connection may preclude its use.

3.77 In small surgeries this provision may not be justifiable, if it is thought that the possible consequences of such an interruption would be insignificant. The chief executive, senior partner or principal should carry out a risk assessment to ensure that appropriate emergency provision is available.

3.78 For larger systems, consideration should be given to providing an emergency inlet for connection to an emergency supply or installing a permanently piped manifold system (manual or automatic) that is able to come on line automatically (via a non-return valve) in the event of primary system failure.

Warning: emergency supply capacity

Very high flow rates are possible on dental systems, particularly if multiple chairs are in use. The capacity of a cylinder supply may be severely limited in such circumstances. Care should be taken when extending MGPS surgical air systems into dental departments to ensure that these potentially high demands do not pose unnecessary risks to the MGPS surgical air supply or any associated medical air or emergency reserve supplies.

4 Dental vacuum systems

SYSTEM TYPES

4.1 Dental vacuum systems are classified as:

a. **dry** systems in which, with an air separator, dental detritus, sputa and cooling water from high-speed drills and instruments have been removed from the air flow and passed to a drain before the air enters the vacuum pump, and in which the separator and vacuum pump are two different devices (see Figure 4.1).

b. **semi-dry** systems in which a similar separation takes place but the vacuum pump and separator are combined into one device (see Figure 4.2).

c. **wet** systems in which larger solids have been removed from the air/water/debris mixture by a filter before air and liquid enter the vacuum pump, where they are in turn separated (see Figure 4.3).

The merits of each system are not described here, as installations will need to be assessed on an individual basis to find the most effective solution.

4.2 A further classification, according to the air volume flow rate provided, is given in BS EN ISO 10637 as follows:

a. **High volume** systems: vacuum system with an air intake of more than 250 l/min at each cannula connector of the largest bore operating hose when operated at full power and in accordance with the manufacturer's instructions.

b. **Medium volume** systems: vacuum system with an air intake between 90 and 250 l/min at the cannula connector.

4.3 Medium volume systems are not generally specified in the UK and will not be considered further here.

Figure 4.1 Dry system

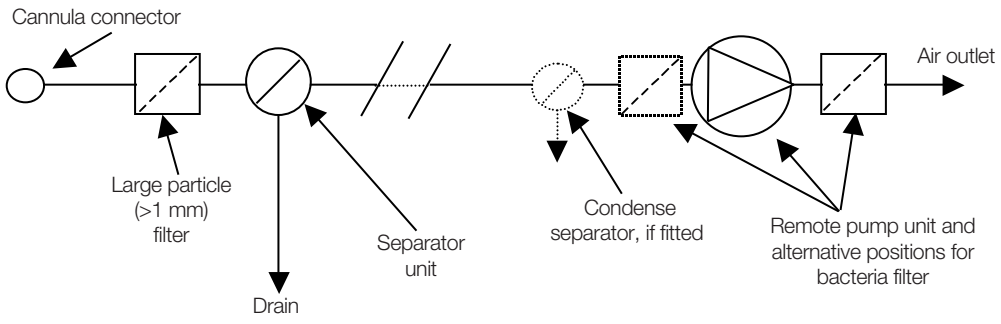


Figure 4.2 Semi-dry system

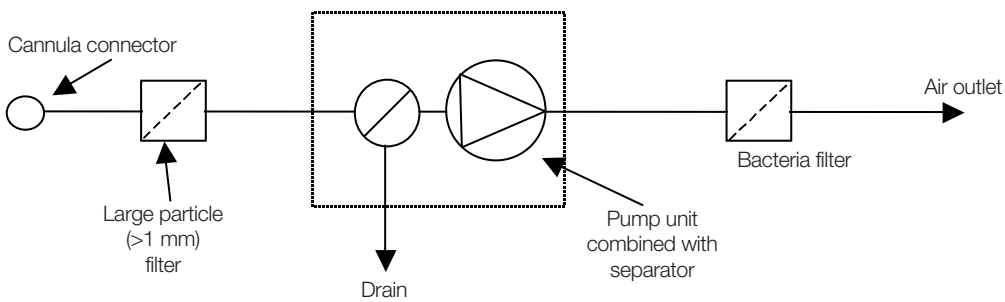
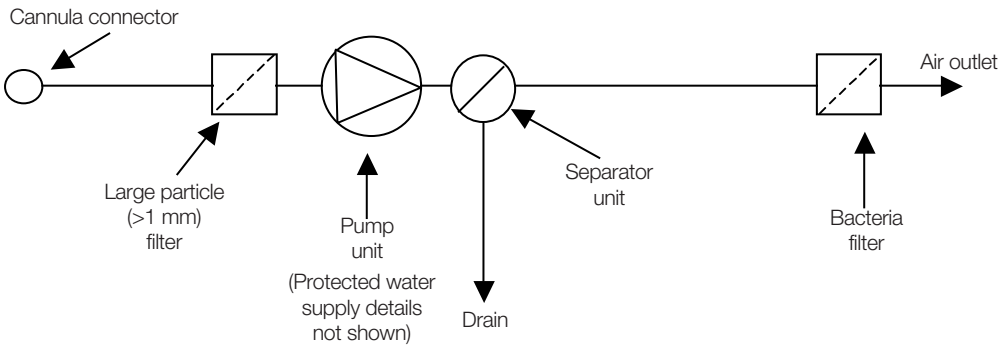


Figure 4.3 Wet system



4.4 Low volume systems, that is those less than 90 l/min, are not used in dentistry. Medical vacuum is typically 40 l/min.

4.5 In dry systems, the vacuum line is relatively dry and clean compared with a wet system, which helps minimise bacterial contamination of the vacuum line, However, some 'dry' systems are installed with the separator unit relatively close to the pump(s), leaving a considerable amount of the pipework to carry detritus. This should be taken into account when carrying out maintenance on such systems.

4.6 An amalgam separator should be included in all systems, either as an integral part of the vacuum plant or as a discrete recovery unit. Appendix 1 gives guidance on amalgam separation.

4.7 Special attention should be given to protecting water supplies to dental units from cross-infection and contamination arising from the use of dental vacuum plant. Advice is given in Appendix 2.

4.8 The operational policy should detail hygiene procedures covering all work on vacuum systems to ensure staff and patient safety when, for example, breaking into an existing system. The advice of the local Control of Infection Officer should be sought. See also BDA Advice Sheet No 12 – 'Infection control in dentistry'.

4.9 In all systems, drainage of water from the pumps/separators will pass into the normal foul drainage system. Efficient separation of detritus/amalgam will, therefore, help prevent pollution of sewerage systems. Pipeline falls are not generally required but may be incorporated, depending on the system type and building structure.

PLANT SITING

4.10 The details given in paragraphs 3.19–3.28 on dental compressed air apply to the siting of vacuum plant.

4.11 Maintaining a minimum temperature of 10ºC is particularly important in the case of wet vacuum systems which, if exposed to freezing temperatures, could suffer considerable damage.

4.12 Dry vacuum systems can suffer from excessive condensation if pipework is exposed to low temperatures and, if necessary, should be fitted with a condensation separator, mounted as close as practicable to the pump units. This separator should be fitted with an automatic drain. A second separator with automatic drain will be needed at the bottom of a main riser in situations where the pumps are mounted at a high level.

PLANT TYPES AND NOISE

4.13 Electrically driven, side-channel pumps are frequently used in dental vacuum systems and may be combined with a separator unit. An amalgam separator may also form an integral part of the unit or be fitted as a discrete self-powered unit elsewhere in the system.

4.14 Wet-ring pump systems usually employ water-saving measures, for example a recirculation system, and may be fed from a reservoir or from the water mains via an air break system (see Appendix 2).

4.15 For plant situated in a typical plant room, the noise levels below are considered as maxima:

Free field noise at 1 m	Power
75 dBA	<5 kW
82 dBA	5.1–15 kW
89 dBA	15 kW+

4.16 Smaller plant will produce much lower noise levels; for example, a single chair unit combining pump, separator and amalgam separator may produce a typical noise level of 64 dB(A).

4.17 Acoustic screening, giving (typically) 10 dB(A) reduction in noise level, may be added if desired.

4.18 Vacuum plant should be fitted with a vacuum gauge capable of displaying maximum system vacuum.

FILTRATION

4.19 In dry vacuum systems, it may be feasible and is certainly desirable to fit a bacteria filter between (condensate) separator and pump inlets. In wet systems this is not practicable. If upstream filtration is not possible, a bacteria filter should be fitted in the pump exhaust line. All filters and their housings should be capable of withstanding the maximum system negative pressure when installed upstream of the pump unit.

4.20 The exhaust pipe from the vacuum system should be sited outside, preferably at roof level and away from air intakes, opening windows etc. It should be clearly labelled 'Dental vacuum discharge point – do not obstruct'.

4.21 The exhaust pipe should turn down to prevent influx of rainwater and have a mesh to protect against ingress of insects, vermin, birds etc.

4.22 The exhaust pipe should be provided with a drain valve at its lowest point.

4.23 A silencer should be fitted to the exhaust if required.

4.24 The exhaust from a duplex (or triplex) pump system may be manifolded together via non-return valves to one external exhaust.

4.25 The vacuum pumps should be sized to take into account the back-pressure of the exhaust system and the resistance of any bacteria filter which may be fitted.

4.26 In the very few cases where it would be impracticable to extend an exhaust line to the outside of a building, a bacteria filter must be fitted in the exhaust line. This should be integrated with an activated charcoal filter to remove unpleasant odours arising from the system.

4.27 The filter should provide particle removal to 0.01 µm with a DOP (aerosol) efficiency of not less than 99.9999%.

4.28 The bacteria filter unit should be marked with the legend 'bio-hazard' together with a description of a safe procedure for changing and disposing of the filters and emptying the drainage trap.

4.29 These filters should be changed in accordance with manufacturers' instructions. A procedure applicable to the changing and disposal of filters is described in Section 10 of HTM 2022 'Operational management'. Vacuum filters are classified as clinical waste and they should be treated accordingly. Filters containing waste amalgam should be disposed of via a specialist waste contractor.

PIPEWORK SYSTEM DESIGN

4.30 Vacuum system design can be complicated by various factors, for example:

a. **Flow resistance of a condensate separator** on a dry vacuum system. Condensate separators should offer no more than 0.2 kPa resistance under design flow conditions.

b. **The siting of the pump unit(s)**. Many dental suites use pumps mounted next to the chair as an extension of the floor-box system. In other suites, a similar duty pump could be sited on a different floor of the surgery and use extended pipework.

c. **The pipework arrangement**. A 'series' (see Figure 4.4) connection is often used for dry vacuum

Figure 4.4 Series connection of chairs to pump unit

Figure 4.5 'Star' connection for improved liquid flow

systems, as only air is aspirated through the pumps. Wet or semi-dry vacuum systems additionally aspirate liquid through the pipework system which, if installed in a series arrangement, could cause a loss in performance at some of the chairs. A 'star' arrangement, in which all chairs drain back via individual pipework to the pump/separator unit, is therefore quite common in these systems (Figure 4.5).

d. **The type of pump/separation method employed**. Vacuum generation and separation functions are often driven by the same power source. The number of chairs such a unit is able to support will be determined not only by the vacuum capability of the unit but also by the maximum flow rate of liquid the separator is able to process. Additionally, the specifications of a discrete amalgam separator should be taken into account when defining the number of chairs to be attached to a system.

4.31 For these reasons, it is especially important that full consultation between designer, installer and user takes place to choose the most appropriate system.

4.32 The diversity factors here are presented for guidance only. Each installation should be considered on an individual basis, as it is not unknown for users to request a 60% diversity factor on a low number of chairs.

Performance requirements

4.33 The system is designed to aspirate air, saliva, blood, amalgam, dust from tooth tissue and other materials using a high flow rate together with a specially designed cannula.

4.34 The detritus is aspirated through the suction hose at a typical air speed of 15–20 m/s. A filter for larger particles, that is >1 mm, fitted upstream of the air separator/pump unit may be specified by plant manufacturers. The air separator separates the residual particles and water.

4.35 For high volume systems (dry or wet), the system performance should be based on a flow rate of 300 l/min at each dental chair cannula connector.

4.36 For surgeries with **up to ten dental chairs**, it can be assumed that **all chairs** may be in use simultaneously, each requiring a flow rate of 300 l/min and, therefore, no diversity should be allowed.

4.37 For systems with **more than ten dental chairs**, it may be assumed that **60% of the remainder** of the chairs will be in use simultaneously.

4.38 The total system demand therefore will be:

$$Q_{vac} = (10 \times 300) + [(n - 10)(0.6 \times 300)];$$
$$\text{i.e. } 3000 + (n - 10)180_{l/min}$$

n = number of chairs

For example, for a 20-chair system, total flow will be 4800 l/min.

4.39 The system should be designed to allow a maximum pressure loss of 6 kPa for large systems (>7000 l/min) and 3 kPa for smaller systems between the plant and the cannula connector (including any loss across a condensate separator in a dry system). The pumps should be capable of generating a maximum negative pressure of 25 kPa (65 kPa absolute) but systems are normally set to provide a maximum

operating negative pressure of 18 kPa (82 kPa absolute).

Special circumstances

Dental schools

4.40 For dental teaching schools it can be assumed that all chairs in the teaching department may be in use simultaneously at a delivered flow of 300 l/min each. This flow will need to be added to the diversified flow of any associated dental system.

Dental laboratories

4.41 An apparatus such as a dust extraction unit uses very high flow rates (typically >1000 l/min) and connection of such equipment to the dental vacuum system could impose unacceptable loads. Equipment manufacturers' data will give the flow and pressure requirements for individual items of equipment. No diversity allowance should be made, unless agreed or specified by the user.

Safety – anaesthetic gas scavenging

4.42 Dental vacuum systems operate at very high flow rates and, as a result, there will inevitably be some scavenging of gases (via the cannula) exhaled by patients during surgery. Under no circumstances, however, should the dental vacuum system be considered an anaesthetic gas scavenging system. Scavenging systems are not generally applied to patients undergoing relative analgesia and an accurate risk assessment of residual levels of anaesthetic agents must be made to establish appropriate measures for controlling staff exposure (see Appendix 3).

Vacuum system pipework sizing

4.43 The formula for flow and pressure drop given in paragraph 3.62 can be used to calculate pipework pressure drops. Equivalent lengths for typical vacuum fittings are shown below.

	40mm	50mm	70mm	100mm	125mm
Tee (Thru')	0.95	1.23	1.65	2.2	2.56
Tee (Branch)	2.76	3.38	4.57	6.12	7.68
90º elbow	1.25	1.71	2.44	3.08	3.84

4.44 Exhausts are chosen to match pump outlet port size. However, if the length of the exhaust is greater than 20 m, the next larger pipe diameter should be used.

Vacuum pipework materials and jointing techniques

4.45 The vacuum and exhaust lines should comprise materials resistant to attack from substances carried and be so constructed as to withstand a negative pressure of 25 kPa. Pipework made from ABS/ASA material are generally found to be unsuitable as they will suffer chemical attack. Copper pipes will be attacked by dental amalgam if used in wet systems.

4.46 Polyethylene, polypropylene and heat-welded uPVC have all been found suitable.

4.47 Where non-metallic pipework pass through fire compartment walls/barriers they should be suitably sleeved.

4.48 Solvent, ultrasonic and heat welding are all suitable as jointing techniques but any method which ensures system integrity under vacuum may be used.

PLANT MONITORING AND ALARM SYSTEMS

4.49 The guidelines given in paragraphs 3.72–3.75 for dental compressed air plant monitoring and alarm systems should be followed. The 'pressure fault' alarm, if fitted, should be activated when the system vacuum is 20% less than its value under commissioning conditions.

4.50 When an amalgam separator is fitted, indication of (a) unit failure and (b) its reaching of separation capacity should be provided and, if the amalgam separator is remotely sited, relayed to the dental suite.

5 Validation and verification

GENERAL PRINCIPLES

5.1 Installation and commissioning of DAVS differs from that of medical gas systems in that fewer tests are performed, some to different parameters. Connection of dental equipment (functional tests) is an essential part of the validation and verification process.

5.2 Each system will need to be examined in the light of these recommendations. Sometimes, it will be unpractical to apply a test in full. For example, leaks on a single-chair dental-air installation could easily be discovered by application of leak detector fluid; it would waste unnecessary time to conduct a two-hour leak test in these circumstances.

TEST GAS FOR DENTAL AIR SYSTEMS ENGINEERING TESTS

5.3 The dental compressor may be used as the source of test gas, particularly for smaller systems. For large systems, a cylinder of medical air can be used as an alternative.

TEST EQUIPMENT FOR ENGINEERING TESTS

5.4 For **dental air**:

a. A pressure gauge to BS EN 837-1: 1998, capable of reading up to 10 bars full scale with a minimum diameter of 100 mm. Alternatively, digital gauges of comparable accuracy can be used.

b. A flowmeter capable of reading up to 100 l/min full scale and rated for pressures up to 10 bars.

5.5 For **dental vacuum**:

a. A vacuum gauge, analogue or digital, capable of reading 30 kPa negative pressure (70 kPa absolute).

b. A flowmeter with a full scale reading up to 400 l/min at the above vacuum.

5.6 Fittings for all the above equipment will be needed to enable connection to instrument hoses, vacuum cannula connectors and pipework test points.

5.7 All test equipment should be supplied by the contractor and be calibrated to NAMAS (National Accreditation of Measurement and Sampling) standards.

COMMISSIONING TESTS

General principles

5.8 It is not necessary to purge out vacuum pipework but dental air lines should be purged using clean air (from a cylinder or a fully tested dental compressor). A particulate test, using an in-line (0.8 µm) filter at the floor-box connection point, will establish the air cleanliness.

5.9 For DAVS installed alongside medical gas systems, the advice given in HTM 2022 'Design, installation, validation and verification' should be followed as far as is practicable.

5.10 For labelling and marking, gas flow direction and identity labels should be in place. These should be applied near valves, junctions, walls etc. Self-adhesive or clip-on labels can be used. All colour-coded tapes applied by the pipework manufacturer should be removed.

5.11 For sleeving and supports, sleeving/protection of pipework should be provided according to contract specification. Pipework support separations for copper pipework are given below.

	Maximum separation	
Pipework OD (mm)	**Vertical runs (m)**	**Horizontal runs (m)**
12	1.2	1.0
15	1.8	1.2
22	2.4	1.8
28	2.4	1.8
35	3.0	2.4
42	3.0	2.4
54	3.0	2.7
76	3.6	3.0

5.12 Pipework supports for synthetic materials should be fitted such that undue mechanical stress is not placed upon any part of the system. Manufacturers' guidelines should be followed.

5.13 At this stage of the examination, methods of protection of the pipework from external damage should be checked, along with any fire protection measures.

Cross-connection test

5.14 If the system is in copper and installed simultaneously and adjacent to an MGPS, all attempts should be made to prevent cross-connection of the systems. In this respect, the cross-connection test applied to the medical gas pipework should be extended to the dental air and medical vacuum pipework, especially if the dental air pipework is copper, or if the medical vacuum system comprises synthetic material.

5.15 Where systems are installed independently of (but possibly adjacent to) the medical gas systems, which remain pressurised during the installation, there is no need to depressurise the medical gas systems to effect a full cross-connection test. However, care must be taken to minimise risks of cross-connection by appropriate labelling of the new pipework and ensuring that no gas other than dental air is delivered from the dental air system.

5.16 In circumstances where dental air and vacuum only are being installed, any cross-connection either will be unlikely, due to differences in pipework materials and structure, or will become immediately apparent on pressure testing.

Dental air system tests

Pipework pressure test

5.17 The test is performed on a complete system. It is not usual to perform an initial carcass test, as the dental-chair floor connections form an integral part of the system. Measurements should be taken at the floor-box-to-chair connection point.

5.18 With the pipework pressurised to working pressure and the source of compression isolated, the system should show no pressure loss over a two-hour period.

Flow test at working pressure

5.19 With all dental chairs connected to the floor-box connections, each instrument hose should be tested in turn with a flowmeter connected between the instrument and the hose. It should be possible to deliver the specified flow rate (usually a minimum of 50 l/min) to the instrument. Adjustment of the chair airline regulator (if fitted) may be necessary.

Design flow and pressure drop test

5.20 This test, performed for medical gas systems, is not normally applied to dental air systems. By agreement between user and installer, the flow test may be extended such that the performance of the system can be verified with a previously specified number of air instruments operating.

Safety valve test

5.21 A visual inspection of the safety valve compliance certificate and the safety valve markings is carried out and documented in the Written Scheme of Examination. It is advisable for the system user to keep a copy of the certificate for examination purposes.

Vacuum system tests

Leak test

5.22 The structure of most dental vacuum systems precludes the performance of the pressure test defined in HTM 2022 'Design, installation, validation and verification'. The pipework of a dry system installed in copper can be tested as described in HTM 2022 but leak testing of synthetic systems is limited by equipment connections and characteristics. However, all practicable means should be taken to ensure that the system is leak-tight. In its simplest form this test may be limited to a water-leak test; that is, the system is examined for leaks during the flow of clean water.

Cannula flow test

5.23 With the vacuum pump(s) operational and all dental chairs connected to the system, each cannula connector should be tested in turn with the flowmeter. It should be possible to generate the specified flow rate (a minimum of 300 l/min) at the flowmeter. This test should be performed using the largest diameter delivery hose but the user may specify other hoses at his/her discretion. Again, a full diversity flow test will not be performed unless specifically requested by the user.

Vacuum-limiting device test

5.24 With all other cannula connections closed and all pumps operating, a vacuum gauge is attached to a selected cannula connection and the vacuum observed. The gauge should not read more than 18 kPa negative pressure (82 kPa absolute).

TESTS FOLLOWING REPAIRS/MODIFICATIONS

5.25 All attempts should be made to ensure that system integrity and performance is maintained following repair, modification or replacement of system elements. Some or all of the above tests may need to be performed, depending on the degree of the work. Tests performed

should be at the discretion of the maintenance organisation.

5.26 Confirmation of system performance should be given to the user in the form of a service report

5.27 It may be necessary under the Pressure Systems Safety Regulations to notify the Competent Person if repairs and modifications are made to the pressure system. In addition, the Written Scheme of Examination may need changing.

PHARMACEUTICAL TESTING

5.28 Pharmaceutical testing, by either the QC (MGPS) or an independent Air Purity Testing Company (APTC), of the dental air to ascertain whether it complies with the required standard (see Table 3.1) should be performed on system commissioning.

5.29 Further testing should preferably be performed quarterly but at least annually and after major plant/pipework repairs or modifications. Users and the QC (MGPS)/APTC should agree the test requirements and frequency, and a reference made in the operational policy.

5.30 The user should keep records of pharmaceutical tests for at least two years.

5.31 Details of pharmaceutical test procedures are given in HTM 2022 'Design, installation, validation and verification' and in the NHS Pharmaceutical Quality Control Committee publication 'Testing of piped medical gases'.

6 Maintenance of dental air and vacuum systems (DAVS)

STANDARDS

6.1 Installation, testing and maintenance of DAVS should be carried out by competent authorities, that is companies certificated under BS EN ISO 9000 with a defined scope of expertise. The Quality Assurance Scheme 3720 1/206.1A for MGPS is currently under review and will be revised to include dental installations and maintenance of both MGPS and dental systems. The manufacturer(s) of the plant and user equipment, the equipment installer, the pipework installer and the maintenance company are frequently unrelated organisations. Therefore, care should be taken to ensure that all systems are maintained regularly (see 'Maintenance schedules' section below).

6.2 All servicing/repairs should be documented in the form of a service report, a copy of which should be left with the user or AP (MGPS) as appropriate.

MODIFICATIONS – SAFETY

6.3 Special precautions are required when existing installations are to be modified or extended to ensure that the sections of the pipework systems remaining in use are not contaminated or the supply compromised by (for example) cross-connection. This is particularly important when MGPS are installed in the same room(s) as the dental systems. In this instance, work should be controlled by application of the MGPS permit-to-work system.

INSURANCE INSPECTIONS

6.4 In addition to routine maintenance, examinations of some pressure vessels are required under the Pressure Systems Safety Regulations 2000. Arrangements for alternative provision of service may have to be made during this inspection.

MAINTENANCE SCHEDULES

6.5 All plant and equipment should be serviced regularly and in accordance with manufacturers' procedures. However, users can take some preventive measures regularly that will help maintain systems at peak efficiency:

a. **After procedures involving blood**: a glass of cold water to be aspirated through the hose or hoses used.

b. **Daily**: a suitable cleaning and disinfecting agent to be aspirated through the system.

These measures are particularly pertinent to systems which do not include an automatic irrigation system. For further advice on infection control, see BDA Advice sheet No 12: 'Infection control in dentistry'.

c. **Daily**: clean out large-particle filters. Do not dispose of waste down drains.

d. **Daily**: switch off small compressor units at the close of surgery.

e. **Weekly**: empty the receivers of all air compressors that are not fitted with automatic drains.

f. **Weekly**: check oil levels of lubricated plant.

g. **At the specified frequency**: change filter elements, in traps, separators etc. Clean these units as specified. Filters should be treated as clinical waste and disposed of accordingly. Maintenance personnel should wear protective gloves and a face-mask when changing filters/cleaning filter housings. Local infection control procedures should be followed, or, in their absence, the advice on bacteria filter changing given in HTM 2022 'Operational management'.

6.6 Amalgam separators – at the specified frequency, or on a 'full' alarm indication: removal of the separated amalgam and replacement of the amalgam container. The waste should be packaged and sent to a specialist reclamation unit.

6.7 Other servicing, carried out by specialist organisations, will include:

a. **Amalgam separators:**

   i) **Annually**: a function test of the unit.

   ii) **five yearly**: a function and separation test. Note that a full separation test as defined in BS EN ISO11143 may be impossible to perform on site. In such cases, an alternative method of validating separation performance is acceptable.

b. **Compressor and vacuum plant (general):** function and performance tests and essential repair/replacement of specified components.

c. **Oil-free compressors:** A regular check (to manufacturers' recommendations) of the condition of the PTFE piston rings etc.

d. **Safety valves**: in accordance with written scheme of examination; replacement with a certificated unit.

6.7 Pharmaceutical testing of air quality: to be performed at least annually at all test points. Documentation to be retained by the user for at least two years.

Appendix 1 – Dental vacuum systems and amalgam separation

INTRODUCTION

Dental amalgam is about 50% mercury by weight (other components include silver, zinc, copper, tin). Mercury is on the UK 'red list' of dangerous substances that represent the greatest threat to the aquatic environment. This is because of their toxicity, persistence and capacity for bioaccumulation. It is a list 1 substance in EC Directive 76/464/EEC (the Dangerous Substances Directive) which obliges member states to take appropriate steps to eliminate pollution by list 1 substances from the aquatic environment.

WASTE AMALGAM

This arises:

a. when new amalgam becomes surplus during treatment and cannot be reused. A 1997 survey suggests that, on average, perhaps 17% of amalgam once mixed is surplus;

b. when old amalgam fillings, or teeth with fillings, are removed from patients' mouths during treatment, or during drilling, carving and burnishing;

c. when dental equipment is cleaned;

d. as residues in packaging, including used capsules; and

e. as residues removed during cleaning or maintenance of separators, sieves and traps.

AMALGAM IN WASTE-WATER

Particles of waste amalgam become mixed with water during treatment, rinsing and cleaning. If particles are not separated out of waste-water, they will be carried into drains and sewers, eventually ending up in sludge at sewage treatment works and in effluent from those works. Most will lodge in pipes and drains along the way and may be released much later.

The mercury in dental amalgam is in a bound form and is not biologically available (not readily absorbed). The Department of Health advises that the use of dental amalgam does not risk systemic toxicity (general rather than localised toxic effect) and only a few cases of hypersensitivity (excessive reaction) occur in individuals.

However, once waste amalgam enters the wider environment, it may present different and more significant risks.

LEGAL ISSUES

Both waste-water and waste are covered by laws intended to protect human health and the environment.

- **The Water Industry Act 1991 (section 118)** requires that anyone discharging trade effluents into the sewers gets permission first from the sewerage undertaker. Breach of section 118 is a criminal offence. The Environment Agency would expect to use their powers (under section 132) to impose conditions on such permissions, limiting how much mercury goes into the sewers.

- **Section 111** of the above Act makes it an offence to discharge matter into a public sewer likely to 'affect prejudicially the treatment and disposal of its contents'. Waste amalgam released into drains might in some circumstances be considered as having that effect. For example, it might mean that sewage sludge is less readily incinerated or spread on farmland because of difficulty in meeting pollution limits at the sites in question.

- **Section 33(c) of the Environmental Protection Act 1990** makes it an offence to 'deposit, recover or dispose of controlled waste in a manner likely to cause pollution of the environment or harm to human health'.

- **Section 34 of the Environmental Protection Act 1990** imposes a statutory duty of care on those concerned with controlled waste, including everyone who produces it (except for householders' own refuse) and thus includes dentists producing waste amalgam. Among other things, wasteholders must make sure that it is transferred only to an authorised person, and parties to any transfer must complete, sign and keep a transfer note. Breach of the duty is a criminal offence. Practical guidance for meeting the duty is in 'Waste management: the duty of care – a code of practice'.

- **The Special Waste Regulations 1996** impose additional safeguards where waste meets the

definition of special waste. At present, waste amalgam and associated packaging, which typically arise from dental practices, are not generally considered to be special waste by the enforcing authorities. However, the European Commission has proposed that amalgam should be added to the EC Hazardous Waste List. If the EU agrees to this, waste amalgam would become special waste.

The UK, along with other countries, is committed to reducing the amount of mercury in the environment. 'Dental amalgam: an environmental code of practice' (to be published by DEFRA in 2002) aims to help dentists, practice managers and their staff minimise the uncontrolled release of mercury from dental surgeries, including discharges to sewers. The code is non-statutory and relates to England. (Similar codes are envisaged in Scotland, Wales and Northern Ireland.) The code lists six 'good practices' and shows how to achieve them. Most dentists already follow some or all of these practices or are adopting them. Research published in 1997 by the Department of the Environment, Transport and the Regions (DETR) entitled 'Amalgam purchase, use, recovery and release' shows that up to a quarter of dentists surveyed had already fitted separator systems.

In summary, the six 'good practices' are:

1. Use amalgams effectively; this will reduce waste and cost.
2. Install amalgam separators as soon as possible; fit them either to existing equipment or when replacing equipment. Other traps and sieves may still be useful as supplements.
3. Make sure that amalgam separators protect all the normal routes such as spittoons, sinks or basins by which amalgam might enter the drains. When working with amalgam, do not use any unprotected routes into the drains. This includes the cleaning of instruments and utensils. Waste amalgam must not be put directly down the drains and never flushed down the toilet. During refurbishment or cleaning, care should be taken to ensure that sediments in pipes are not flushed into drains.
4. Keep waste amalgam separate from other waste. This will help with the recycling of its silver and mercury content; but if the recycling is not feasible, it will make disposal safer. Use only authorised waste management firms – and remember the duty of care. Specialised firms offer sealed container systems and separate collection. Dispose of packaging with amalgam residues either in clinical waste containers or as normal refuse, or through other general arrangements for packaging waste.
5. Follow any regulatory advice from local sewerage operators or other bodies, for example the WRAS Guide highlighted elsewhere in this Supplement
6. Take stock of equipment in use now; operational procedures and additional measures needed to follow the code.

NB: The effectiveness of this Code will be reviewed in January 2006. Amalgam separators should be fitted before then.

Design and performance criteria for amalgam separators are given in BS EN ISO 11143.

Appendix 2 – Water supply systems to dental departments and practices

INTRODUCTION AND LEGAL RESPONSIBILITIES

All owners or occupiers of premises are responsible for the water systems within their premises. The extent of these responsibilities is described in detail in Section 73 of the Water Industry Act 1991 and comparable Northern Ireland and Scottish Acts. The Act defines responsibilities and penalties placed on water suppliers and customers.

It is the duty of the water supplier to supply 'wholesome' water to the premises – that is, suitable for normal domestic purposes and complying with the quality requirements of the Water Supply (Water Quality) Regulations. In addition, The Environment Act 1995 requires water suppliers to promote efficient use of water by their customers.

The customer (owner or occupier) should ensure that there is no risk of deterioration in the quality of the water from any cause whatsoever and must comply with the Water Supply (Water Fittings) Regulations 1999 (and the equivalent Byelaws 2000 in Scotland), including taking responsibility for installing and maintaining fittings to ensure that they satisfy the Regulations. The Regulations apply from the point where the pipework from the water main becomes the responsibility of the owner of the premises. This is usually, but not always, at the boundary of the property or the boundary of the road in which the water main is laid. The Regulations apply from this point throughout the premises, for the purposes of preventing contamination, waste, misuse or undue consumption of water. It is a criminal offence to commence most types of installation work without the local water supplier's consent, which must be obtained by notifying the details of the work to the water supplier.

The information given below is based upon the content of 'Water supply systems – prevention of contamination and waste of drinking water supplies' a guide (due for release in 2002) prepared by the Water Regulations Advisory Scheme Technical Support Group in co-operation with the dental profession.

The Guide is an aid to installing and maintaining water systems in accordance with The Water Supply (Water Fittings) Regulations 1999 which are based on the requirements of the 1991 Act and is aimed to prevent pollution by back-flow, back-siphonage, cross-connection and also waste of water. It is also intended to help those working for, and in, dental practices when considering the design of new installations, modifying and maintaining existing systems, and implementing back-flow prevention and frost-protection measures to prevent burst pipes and fittings. It encourages good practice and water conservation and supports efforts to establish common procedures and installation criteria for water supplies in the dental profession.

CAUSES OF CONTAMINATION AND WASTE

If back-flow occurs, water is drawn back from an appliance or fitting into the pipework supplying it. Any contamination present in the appliance could find its way into water used for drinking or food production, with serious consequences for health. There are two causes of back-flow – back pressure (where the water is forced in the reverse direction by an excess pressure) and back-siphonage (where water passes back into the pipework by siphoning under gravity). Within dental practices, there are many areas where a back-flow incident could present a major hazard to the quality of the water supply, thus placing both staff and patients at risk. With existing systems, it is therefore necessary to identify and modify any part of a water supply system which could give rise to such contamination. With new systems, consideration should be given to this at the design stage.

WHERE THE RISKS ARE

Many of the situations regarded as 'high risk' (that is having the potential to cause hazardous back-flow) that are found in dental premises are identified in the following schedule. This list is representative only and should not be regarded as exhaustive.

Each listed appliance or fitting is allocated a fluid category according to the risk of water contamination likely to exist. The category takes into account the concentration and toxicity of the contaminant likely to be present.

Installation protection options to ensure safe systems are shown below.

The Water Regulations classify contamination risks into five fluid categories, including wholesome water. These

fluid categories range from fluid category 1, wholesome water, to fluid category 5, the highest risk to health.

Fluid category 1

Wholesome water supplied by a water undertaker and meeting the requirements of the Water Supply (Water Quality) Regulations 2000 for drinking water.

Fluid category 2

Water which would be in fluid category 1 but whose aesthetic quality is impaired owing to:

a. a change in its temperature; or

b. the presence of substances or organisms causing a change in its taste, odour or appearance, including water in a hot water distribution system.

Fluid category 3

Fluid which represents a slight health hazard because of the concentration of substances of low toxicity, including any fluid which contains:

a. ethylene glycol, copper sulphate solution or similar chemical additives; or

b. sodium hypochlorite (chloros and common disinfectants).

Fluid category 4

Fluid which represents a significant health hazard because of the concentration of toxic substances, including any fluid which contains:

a. chemical, carcinogenic substances or pesticides (including insecticides and herbicides); or

b. environmental organisms of potential health significance.

Fluid category 5

Fluid representing a serious health hazard because of the concentration of pathogenic organisms, radioactive or very toxic substances, including any fluid which contains:

a. faecal material or other human waste;

b. butchery or other animal waste; or

c. pathogens from any other source.

SCHEDULE OF RISKS IN DENTAL INSTALLATIONS

Facility	Risk/fluid category
Dental equipment	
1. Drill turbine	5
2. Syringe (air/water)	5
3. Descaler	5
4. Spittoon	5
5. Cup filler	5
Waste systems	
6. Aspirator (wet)	5
7. Automatic separator (wet)	5
8. Water powered aspirator	5
9. Automatic separator (dry)	5
10. Saliva ejectors	5
Self-contained systems	
11. Bottled water	Not applicable
Hygiene security	
12. Injection dosing (auto/manual)	5
13. Autoclave	5
14. Backwash systems	5
15. Compressed air injection	5
X-ray equipment	
16. Developers	4
Washing machines	
17. Clothes washing[a]	5
Sanitary wares	
18. Macerators	5
Miscellaneous	
19. Drinks dispenser	3/2
20. Hot-water heater	2
21. Water softener[a]	5/4/3/2
Hose union taps	
22. Domestic areas	3
23. Other risk areas[a]	5/4

Notes:

[a]Risk category to be determined by the water supplier.

The risk/fluid category should be viewed as the potential contaminant. For example, if a supply is sited within reach of a drugs or cleaning fluid storage area they should be regarded as the risk/fluid category from which the water system needs protection.

Before commencing the water-supply design of any surgery, details should be obtained of all the equipment that is to be installed within the practice, whether it is to be supplied with mains or stored water and if a back-flow prevention arrangement or device is an integral part ('point-of-use protection') of a unit or whether back-flow protection has to be provided.

In new multi-occupancy premises, it is a water-supply industry requirement that, in addition to 'point of use protection', individual surgeries be:

- supplied by means of a separate, dedicated branch supply or distribution pipe; and
- provided with a fluid/risk category 3 protection device at the point of entry to the surgery.

A surgery should have its own stop-valve for isolating the water supply.

Before carrying out any remedial or new works in an existing surgery, it is important that an installer makes a comprehensive survey of the water-supply system in the premises, as water-supply systems will vary considerably from one dental practice to another.

It is recommended that all water that comes into contact with patients during treatment should be of the quality provided by the water supplier. Where there is a fluid category 5 risk of potential back-flow, it may be necessary to design or to modify an existing installation to include suitable protection, for example a type AB air gap and cistern suitably protected to maintain water quality.

Note: No water used for domestic purposes shall be distributed from a cistern and any associated pump delivery pipe used to protect dental equipment.

Cistern temperatures should be kept below 20ºC to minimise the growth of microbial organisms. Keep cisterns and cold water pipes away from all sources of heat, including sunlight. Where this is not possible, they should be insulated to protect against heat.

High risk back-flow protection (fluid category 5) should be provided for water-supply connections to separators (dental air/liquid waste) and pumps which aid the induction of a vacuum or provide coolant to the motor bearings of aspirator/vacuum systems. However, although this arrangement meets the water-supply industry's requirements, the risk of cross-contamination to the 'hygienic water' is reduced if a dedicated stored water system is provided for these types of apparatus.

In certain types of equipment or installations, 'cross-connections' may exist between, or within, types of water-using apparatus. In many cases, these are not easily identified owing to the complexity of the equipment. The units should therefore be regarded as being in fluid category 5. Examples of units within which such connections may exist are:

- injection disinfection dosing units (automatic or manual);
- back-wash systems;
- compressed-air injection units, water-powered aspirators.

MAINTENANCE OF AND REPAIRS/ALTERATIONS TO WATER SYSTEMS

Except for repairs and like-for-like replacements, it is a criminal offence to undertake installation, alteration or modification of plumbing systems in dental premises without the water supplier's consent.

Remedial plumbing work in any surgery should be completed in accordance with the information set out in the WRAS 'Water Regulations Guide' and in the forthcoming WRAS 'Dental Premises Guide'. Always use a reputable plumber. Many water suppliers now maintain registers of Regulations-accredited plumbers.

Suppliers are not required by law to sell plumbing fittings that comply with the Water Regulations, but both the installer and user will be responsible if fittings do not comply. Approved fittings may carry the WRAS mark and/or the BSI 'kite-mark' and the supplier should confirm that fittings are of an appropriate quality and standard.

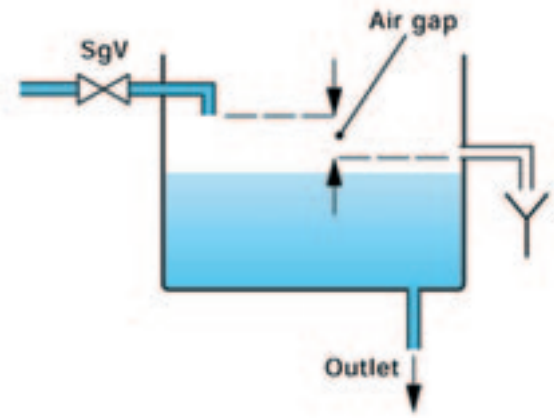
Note: All mechanical back-flow prevention devices can fail and therefore need planned inspection and maintenance or replacement. Back-flow of contaminated water from the surgery to the mains or to the domestic section of any surgery may be harmful to health.

No pipe or fitting, particularly a plastic pipe or fitting, may be installed in contact with contaminated material, regardless of any protection given, to prevent permeation and thereby contamination of the water supply.

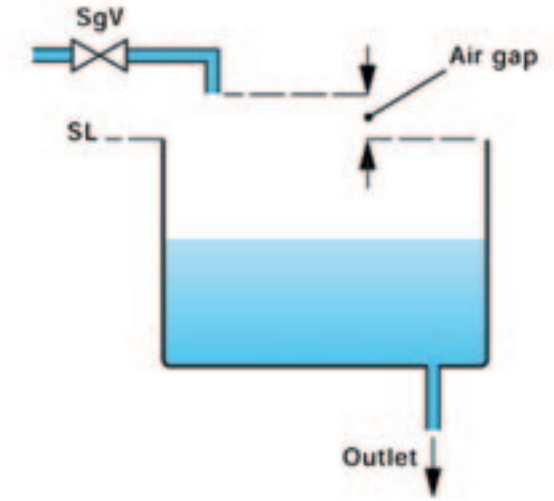
Water meter readings should be checked regularly (high readings can indicate a burst pipe or wastage).

The use of new lead pipe or fittings in contact with drinking water is now prohibited. Care should be taken to ensure that only approved solders, marked 'lead free' are used for drinking water installations.

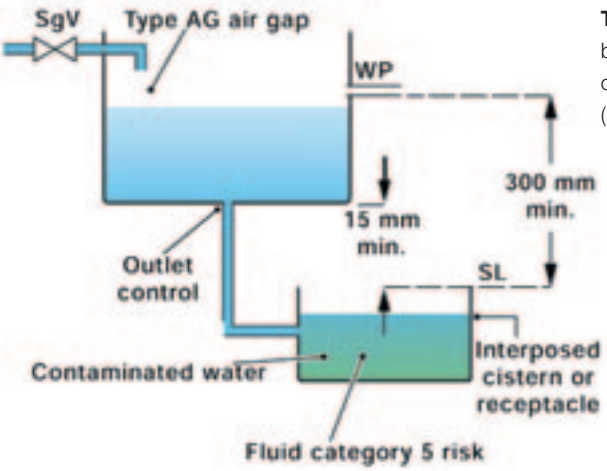
Pipes located in roof spaces and any other unheated space need to be insulated for frost protection.



Type AF air gap with circular overflow. This provides back-flow protection to fluid category 4. The dimension of the air gap between the discharge point and the 'critical water level' (water level two seconds after closing the inlet) must meet the minimum requirements for the standard.



Type AA air gap, with unrestricted discharge. This provides back-flow protection to fluid category five. The discharge point is located above the spillover level (SL) of the receptacle. The minimum distance between the discharge and the spillover level must meet the requirement for a type AA air gap.



Type AUK1 air gap with interposed cistern. This provides back-flow protection to fluid category five. The air gap in the cistern must meet the requirements for a type AG air gap (British Standard BS6281: Part 2).

Key:
SgV = servicing valve
WP = warning pipe
SL = Spillover level

Some equipment may require an operating water pressure that is higher than the incoming mains pressure and a booster pump may be required. In such cases the water supplier should be consulted and its consent gained for the installation of pumps which deliver more than 12 l/min.

It is potentially hazardous and unacceptable to connect electrical appliances or electrical installations to water pipes for earthing purposes. Installations must be properly earthed in accordance with the latest edition of the IEE Wiring Regulations.

Manufacturers of some type of equipment for dental use specify limits of water hardness and acidity. Water treatment plant may be needed to achieve the required limits. Any water treatment plant must be installed with due regard to the above Regulations.

Appendix 3 – COSHH: anaesthetic agents and other substances

THE USE OF ANAESTHETIC AGENTS

Before any Control of Substances Hazardous to Health (COSHH) assessment is carried out, all AGS/ventilation systems must meet performance standards established at commissioning.

The COSHH Regulations 1999 set out the legal requirements for protecting the health of staff in the workplace; anaesthetic agents are covered by these regulations.

COSHH requires employers to ensure that exposure of their employees to substances hazardous to health is either prevented or, where this is not reasonably practicable, adequately controlled. There is a legal requirement for the exposure of staff to anaesthetic agents to be controlled by any assigned Occupational Exposure Standard (OES) in accordance with the requirements of COSHH. The Health and Safety Executive are empowered to enforce these standards.

In 1976, in response to concerns about exposure to anaesthetic agents, the Department of Health issued HC(76)38 advising health authorities on the need to install control measures in operating theatres. At that time, no OESs had been set for anaesthetic agents.

In 1992 the Health and Safety Commission's Advisory Committee on toxic substances suggested that OESs should be set for four anaesthetic agents, that is:

Anaesthetic agent	OES (ppm)[a]
Nitrous oxide	100
Enflurane	50
Isoflurane	50
Halothane	10

[a]Over an 8-hour time-weighted average reference period

These OESs (published in 1995) apply to wherever these substances are used. This means that the OES for nitrous oxide will apply not only in hospital operating theatres but also in small practices where the gas is used in relative analgesia, rather than general anaesthesia.

ACTIONS TO BE TAKEN TO COMPLY WITH THE REQUIREMENTS OF COSHH

A 'suitable and sufficient' risk assessment to identify the hazards (anaesthetic agents used), when and where they are used and the staff most exposed is a legal requirement. This will involve monitoring residual gas levels to assess staff exposure and establish what, if any, additional control measures are required. If the risk assessment shows that existing controls and procedures are satisfactory, periodic review will offer compliance with COSHH. The length of period chosen will depend on the nature of the risk, the work and a judgement on the likelihood of changes occurring, but in any case, the risk assessment should be reviewed at least every five years.

When the risk assessment identifies inadequate control measures or work practices, improvement must be made to comply with COSHH.

Control measures may mean using active anaesthetic gas scavenging systems or increased local ventilation. The user should discuss such requirements with estates colleagues, where appropriate.

An operational policy for the management of the DAVS and covering COSHH (specifically exposure to anaesthetic agents) should be in place. This policy should identify those individuals responsible for the implementation and monitoring of the policy. Annual review of the policy is recommended, but if work practices change significantly, interim reviews will be needed.

All staff should be reminded to reduce leaks from equipment and medical gas systems to a minimum; for example, flowmeters should be turned off when not in use.

GENERAL ANAESTHESIA

Wherever this technique is used, a risk assessment should be carried out as for a general operating theatre. Duration of exposure is particularly important in areas where the ventilation system does not comply with HTM 2025.

RELATIVE ANALGESIA (RA)

The risk assessment will need to take into account the number of patients to whom RA is administered, as although short-term concentrations of nitrous oxide may be high, exposure averaged over eight hours [time-weighted average (TWA)] can be considerably less.

In clinics where there is inadequate or no ventilation, control measures will depend on the patient throughput. Usually, some form of artificial ventilation will be needed.

COSHH AND OTHER SUBSTANCES USED IN DENTISTRY

Changes in technology mean that it is not possible to provide a list of all substances likely to be covered by

COSHH Regulations. BDA Advice Sheet A3 gives safety advice on the use of methyl methacrylate, mercury and glutaraldehyde. But where any element of uncertainty in the use of a compound exists, the appropriate safety data sheets, which detail OESs for that compound, should be consulted.

Appendix 4 – Electricity supplies and fire detection systems

GENERAL

The installation should comply in all respects with BS 7671 – 'Requirements for electrical installations', IEE Wiring Regulations, 16th edition' (and subsequent amendments) and HTM 2007 – 'Electrical services: supply and distribution'.

Care is required when selecting pipework routes to prevent pipes coming into contact with electric cables and wiring and to minimise the risk of electric shock in the event of a fault on cables near to metallic pipework.

The final connection to any equipment, for example alarm panels or control panels, should be made via an unswitched fused connection unit. However, switching facilities to enable isolation of all poles of the mains supply to equipment should be provided to enable safe working on that system.

EARTHING

Metal pipework should be bonded to the consumer's earth terminal as required by BS 7671. This bonding should be made as near as possible to the point at which the pipework enters the building from the plant. The size of the bonding conductor should be in accordance with BS 7671. The pipework itself should not be used for earthing the electrical equipment.

Flexible pipework connections between the compressors or vacuum pumping plant and the fixed pipework should be metallically bonded across to comply with this requirement. Flexible connections in the fixed pipework should not normally be used, but if they are specially approved they should be similarly bonded across.

INSTALLATION OF ELECTRICAL CABLES

Distribution pipework should preferably be physically separated from the metal sheath and armour of electrical cables as well as from metal conduits, ducts and trunking and bare earth-continuity conductors associated with any electric cables which operate at low voltage (i.e. below 1000 V a.c. or 1500 V d.c.) or above.

When physical separation is impracticable, or where there might be contact with extraneous metalwork, for example where the pipes are carried in metal partitions, the pipework should be effectively bonded to the metalwork in accordance with Regulation 525-10 of the IEE Regulations.

Where piped gases and electrical wiring are enclosed in a boom, gas control panel, dental pedestal or other similar enclosure, the wiring should be carried in separate conduit or trunking so that it cannot come into direct contact with the piped gas installation. Where this is not possible, the wiring should be secured in the most effective possible manner clear of the medical/dental gas pipes, and the cables should comply with Regulation 523-17 of the IEE Regulations.

ELECTRICAL WIRING IN PLANTROOMS

All electrical wiring in these rooms should be carried out using MICS cable or cable of the type indicated in IEE Regulation 523-17 with adequate protection against mechanical damage.

Fire-resistant cable to BS 6889, PVC armoured cables and single insulated cables in conduit may also be used.

Each compressor, vacuum pump and manifold should be supplied from a separate sub-circuit where appropriate.

Metal-clad sockets, connection units and switches should be used in plantrooms; plastic fittings are not appropriate.

FIRE DETECTION SYSTEMS

Smoke alarms or rate of change of heat detectors should be installed in the plantrooms in any health building or practice having a fire detection system in accordance with HTM 82 'Firecode: alarm and detection systems'.

Appendix 5 – Sample document for control of work on plant and pipework systems in dental practices

Dental air and vacuum systems

Control of work form

Practice name _____

Location _____

Permission is given by:

Name (print) _____ Title _____

Signature _____ Date _____

for the following work to take place on the dental air/dental vacuum system(s)

_____

_____

_____

on Date _____ between the hours of _____ and _____

I accept responsibility for the work described above. No other work will be carried out under this authorisation.

Name (Print) _____ Company _____

Signature _____ Date _____ Time _____

The work described has been completed and tested in accordance with HTM 2022 Supplement No 1 (Dental Compressed Air and Vacuum Systems). A copy of the test results/service report has been left with the Practice Manager.

Name (Print) _____ Company _____

Signature _____ Date _____ Time _____

Following successful test results, I accept the above system(s) back into clinical use.

Name (Print) _____ Title _____

Signature _____ Date _____

Appendix 6 – Operational policy guidelines

The purpose of this appendix is to offer guidelines to users/managers of DAVS which are not under the authority of an AP (MGPS). Where the AP (MGPS) has responsibility for the DAVS, the MGPS operational policy can be extended to include the DAVS.

- It is wise to produce a policy that is looseleaf in format. This gives the greatest flexibility when updates to personnel details, procedures etc are required.
- It is not wise to produce an unnecessarily bulky document. The policy should be relevant, clear and concise.
- Details of personnel telephone numbers and emergency procedures can be inserted as appendices. In this way, updating is made simpler.
- The content of the basic (four-section) structure below is not exhaustive but can be used as a starting point for policy preparation.

1. Signatories and defined responsibilities

This section will contain the signature(s) of the senior partner/partners or principal and will define the aims/objectives and scope of the policy. It will also define day-to-day responsibility for the DAVS (including the control and recording of work on the systems) and contain the signature of the person thus defined.

A small (schematic) plan of the installation can be added to this section.

A reference to responsibility for user training should also be included.

2. System components

In this section, the DAVS should be defined in terms of location, arrangements for system security, safety procedures and routine operation. Nominated personnel should be referenced to an appendix giving contact details. Typical inclusions:

- security key control,
- actions in the event of system failure,
- use of protective equipment,
- safety hazard of equipment,
- start up/shut down procedures,
- user maintenance routines.

3. Operational management

This section should contain details of paperwork controlling:

- maintenance;
- installation;
- validation and verification;
- cylinder management procedures (where appropriate);
- COSHH-related statements, for example procedure for monitoring of waste anaesthetic gases;
- bacteria-filter changing procedure;
- a reference to fire-safety procedures;
- statements appropriate to the use of maintenance contractors, for example permission to access departments/equipment.

4. Appendices

a. A list of personnel, contractors etc with contact numbers and details of arrangements for cover in the event of absence.

b. A list of actions to be taken in the event of an emergency, for example loss of supply, fire.

Appendix 7 – Glossary of terms

Activated carbon/charcoal filter: Activated charcoal is often used to remove odours from compressed air systems. An activated charcoal element is often incorporated with the bacteria filter in a medical air system.

Adjustable pressure limiting (APL) valve: A user-adjustable valve that releases gases to the atmosphere or a scavenging system and that is intended to provide control of the pressure in the breathing system. The volume of gas above that which is needed to achieve the required patient pressure is vented.

After-cooler: A heat-exchanging device used to cool and hence release water by condensation from compressed air. It is usually mounted in the output pipework from a compressor.

Alarm signal status unit: A small indicator panel affixed to all major plant items and displaying normal and fault operating conditions.

Alarm system: A series of interconnected electronically operated units that continually monitor pipework pressure and plant operating conditions and relay these to appropriate personnel via coloured indicator display panels.

Allowable pressure drop: The maximum permissible pressure drop when a medical gas system is delivering its full design flow.

Amalgam: a mixture of mercury with another metal, dental amalgam consisting of about 50% mercury by weight (other components include silver, zinc, copper, tin).

Anaesthetic agent: A drug used to reduce or abolish feeling.

Anaesthetic gas scavenging system (AGSS): A complete system which conveys expired and/or excess anaesthetic gases from the breathing system to the exterior of the building(s) or to a place where they can be discharged safely, for example to a non-recirculating exhaust ventilation system.

Anaesthetic vaporiser: A device used to facilitate the change of an anaesthetic from a liquid to a vapour.

Analgesic drug: A drug used to reduce or abolish pain.

Area valve service unit (AVSU): A valve assembly within an enclosure provided for maintenance or for connecting a temporary supply or, in emergency, for shutting off the gas flow to a specific area or for the purging and testing of gas supplies after engineering work.

As-fitted drawings: Scale drawings of a pipework system which shows the exact positions of pipework, valves etc with respect to the layout of the building in which the system is fitted.

Authorised Person (MGPS) – AP (MGPS): A person who has sufficient technical knowledge, training and experience in order to understand fully the dangers involved and who is appointed in writing by the executive manager on the recommendation of a chartered engineer with specialist knowledge of MGPS. The certificate of appointment should state the class of work that the person is authorised to initiate and the extent of his/her authority to issue and cancel permits-to-work. The Authorised Person (MGPS) should have read, have understood and be able to apply the guidance in HTM 2022, especially in relation to validation and verification, and should also be completely familiar with the medical gases pipe routes, their means of isolation and the central plant. He/she should ensure that the work described in any permit-to-work is carried out to the necessary standards.

Bacteria filter: The final stage of filtration in a medical air system, usually placed before the pipework pressure regulator and often constructed with an integral activated charcoal filter which is used to aid odour removal. For a medical air system, such a filter will be specified to an efficiency of 99.9999% according to the DOP (aerosol) test.

Back-flow: Flow in a direction contrary to the intended normal direction of flow.

Batch number: A distinctive combination of numbers and/or letters that specifically identify a batch or lot and permit its history to be traced, for example the batch number on a medical gas cylinder.

Bodok seal: A type of (high-pressure) gas seal featuring a (neoprene) rubber flat disc washer bonded to an outer alloy ring. Such seals are commonly used in connections of medical gas cylinders to manifold systems.

Breathing system: A gas pathway in direct connection with the patient, through which gas flow occurs at respiratory pressure, and into which a gas mixture of controlled composition may be dispensed. The function of the breathing system is to convey oxygen and anaesthetic gases to the patient and remove waste gases from the patient. Scavenging equipment is not considered part of the breathing system. Also referred to as breathing or patient circuit, respiratory circuit or system.

Breathing system (semi-closed): This is a system that allows some of the expired gases to leave the circuit; the remainder mixes with fresh gases and is rebreathed. A carbon dioxide absorber is used in this system.

Breathing tubes: Large bore, flexible tubes of rubber or plastic used in most breathing systems to convey gases to and from the patient. They are usually corrugated to prevent obstruction and increase flexibility.

Buffer vessel: A reservoir used to smooth out variations in pressure caused by varying demands in a PSA system.

Bull nose valve: A type of cylinder valve in which connection of equipment is effected via a threaded valve outlet.

Cannula: A (usually) Hand-held hollow tube designed for insertion into a body cavity. It may be attached to a vacuum system for purposes of fluid/detritus removal.

Cannula connector: Cartridge at the end of the hose part of a suction system, intended for fitting of cannulae and for placement in a mobile support. Also called a suction handpiece.

Carbon dioxide absorber (Circle absorber): A device used to remove carbon dioxide chemically from exhaled patient gas. Primarily used in closed or semi-closed circle breathing systems, which require carbon dioxide removal to make rebreathing possible.

Check valves: Also known as unidirectional valves or one-way valves, these units allow passage of a gas or liquid in only one direction.

Client's representative: The person, or that person's representative, as defined under the designated Standard Form of Building Contract issued by the Joint Contracts Tribunal 1980 (JCT 98).

CCU: Coronary care unit.

Common (fresh) gas outlet: The port through which the mixture of gases and vapours dispensed by an anaesthetic machine is delivered to the breathing system. Also referred to as the machine outlet.

Competent Person (MGPS) – CP (MGPS): A person having sufficient technical knowledge, training and experience to carry out his/her duties in a competent manner and understand fully the dangers involved, and whose name is on the register of Competent Persons (MGPS). The register should be maintained by either a specialist contractor or by the Authorized Person (MGPS) as appropriate.

- He/she should be familiar with and be able to read the record drawings and should have received specific training on MGPS.
- He/she should be able to identify all types of medical gases terminal units and should be familiar with all testing and commissioning procedures referred to in HTM 2022. The person maintaining the register should assess a person's competence, taking account of his/her training and experience.

Competent Person (Pressure Systems): As defined by the Pressure Systems and Transportable Gas Containers Regulations 1989 and subsequently the Pressure System Safety Regulations 2000. A full list of the attributes required is given in the Regulations, but in summary, minor systems require a Competent Person (Pressure Systems) of at least Incorporated Engineer status while intermediate and major systems require Chartered Engineer status.

Compound: A term used to describe a usually locked, fenced area housing a VIE installation. In chemistry a compound is a substance formed by the combination of atoms.

Contamination:

a. Of a water supply: Changes to the nature of the water and, or, deterioration of the quality of the water supplied by the water supplier, whether it be harmful to health or not.

b. Of a medical/dental gas supply: Changes in the physical or chemical composition of a medical gas or gas mixture such that it no longer meets Pharmacopoeia specifications.

Contract: The agreement concluded between the trust and the contractor, including all specifications, contractor's samples, plans, drawings and other documentation which are incorporated or referred to therein.

Contract supervising officer (CSO): The person authorised by the hospital authority to witness tests and checks under the terms of contract. He/she should have specialist knowledge, training and experience of MGPS and HTM 2022.

Contractor: The contractor commissioned typically as a subcontractor for the installation of the MGPS under the Standard Form of Building Contract issued by the Joint Contracts Tribunal 1980 (JCT 98). All contractors working on MGPS and DAVS should be registered to BS EN ISO 9000 with scope of registration defined as appropriate.

Contractor's Representative (CR): The person nominated by a contractor to oversee the installation of an MGPS. This may be a contractor's project manager. The CR should have received training appropriate to the work under his/her control.

Control panel: A term usually applied to the pressure-reducing and monitoring unit used with a VIE. The term is also attributed to the gas supply-switching unit of an automatic manifold system and to the electrical control units of compressor and vacuum plants.

Control valve: An isolating valve mounted in a medical gas pipework and which is usually used for engineering purposes. These valves are usually mounted in ceiling voids, ductwork and plantrooms. They may be locked in their normal working position.

Cross-connection:

a. Medical gas: any connections between two or more medical gas services or between a medical gas service and any other piped service.

b Water system: any connection between water supplied by the water supplier and a source other than from the water supplier's mains.

Cryogenics: The science of low temperatures; specifically, those below –40ºC.

Cryogenic liquid system (CLS): A source of supply containing liquefied gas stored under cryogenic conditions. See also VIE (vacuum insulated evaporator).

Decanting: The act of transferring a gas (usually oxygen) under pressure, normally from a large cylinder to a smaller, usually transportable, one. This procedure should only be carried out under controlled and documented conditions with the sanction of the quality controller (QC).

Design flow: A calculated value of gas flow which allows for flow diversity factors and which is used in estimation of primary gas source capacity.

Designated medical and nursing officer – DMO/DNO: The medical or nursing officer designated by the chief executive to act as a focal point for communications related to MGPS in a specified department or departments. There would ideally be a designated medical officer and a designated nursing officer in each department. The designated officer gives permission for any interruption to the MGPS.

Designated Person: A suitably trained person who has been given responsibility for a particular operation involving medical gas cylinders, for example responsibility for changing cylinders on the MGPS manifold. A role fulfilled by a medical gas porter.

Diameter Indexed Safety System (DISS): A method of ensuring gas specificity by dimensional coding of connectors etc.

DOP: Dioctylphthalate. A compound of accurately controllable particle size used in the efficiency testing of filter media. This test has generally been replaced by a Dispersed Oil Particulate test (also using the DOP acronym!) which is an aerosol test.

Diversity: When calculating medical gas flows from, say, a ward area an allowance is made for the fact that it would be exceedingly unusual for all terminal units to be in use simultaneously. This allowance is called a diversity factor and, for flow calculation purposes, will give a flow value for a particular area that is less than the mathematical (algebraic) sum of the flows from all the terminal units.

Dry vacuum system: A pump-driven dental vacuum system in which mouth washings are separated from the pipework airflow (usually) at the dental chair. Only air will flow through the vacuum plant.

Duplex plant: Two identical plant items, for example vacuum pumps. One is the 'Duty' or working plant, the other is the 'Standby' plant, which will come on line automatically in the event of failure of the duty plant.

Dynamic pressure: The nominal pressure in a pipework when gas is flowing through it.

Earth bonding (on an MGPS): A low resistance electrical connection between the copper pipework and an electrical earth conductor. Also used to describe electrical continuity connection across flexible (non-conductive) couplings on plant, for example between pump output port and copper exhaust lines on a medical vacuum plant or any electrical connection to earth of parts of plant, alarm systems etc.

Emergency inlet port: A gas specific connector allowing connection of emergency gas supplies to medical air or oxygen systems in the event of a major gas failure (e.g. primary and secondary supplies).

Entonox: BOC trade name for a 50/50 mixture of nitrous oxide and oxygen. Used for pain relief.

Equanox: Linde trade name for a 50/50 mixture of nitrous oxide and oxygen. Used for pain relief.

Equipment: A device, such as a pressure regulator and flowmeter, which is connected to a single cylinder for the administration of medical gas to an individual patient or gas apparatus.

Equivalent length: The resistance to flow, in terms of a length of pipe of the same diameter, caused by insertion of a fitting; for example, inserting a ball-valve into a 22 mm diameter pipe gives rise to a flow resistance equivalent to 0.6 m of straight pipe: 0.6 m is the equivalent length of the valve.

Emergency supply/reserve manifold – ESM/ERM: A manual or automatic manifold used to supply gas in the event of failure of the primary supply. A manual ESM is usually specified as support for an automatic manifold and a fully automatic ESM for a medical air compressor, oxygen concentrator or cryogenic liquid system, where the latter is a single vessel primary supply.

Essential supply: An electricity supply intended to be maintained in the event of failure of the main supply. It is usually provided from an on site emergency generator. Medical gas systems and alarms should be connected to the essential supply.

Evaporator: A heat-exchanging device in the cryogenic liquid output line from a VIE, in which the liquid boils under constant pressure at atmospheric temperatures to produce gas.

First fix: The gas-specific back part of a terminal unit. It contains an automatic isolating valve.

Flammable: Capable of burning with a flame. (Analogous to inflammable.)

Floor box: A term frequently applied to the floor mounted distribution unit for compressed air vacuum and electrical services in a dental surgery. It is usually adjacent to the dental chair.

Flow algorithm: A mathematical equation incorporating diversity factors, allowing the calculation of flow rates of gases within a pipework system.

HTM 22: Hospital Technical Memorandum 22 - 'Piped medical gases, medical compressed air and medical vacuum installations' (first published by HMSO for the Department of Health and Social Security as Hospital Technical Memorandum 22 in May 1972, and as amended by HN(76)175), and last reprinted in 1978 with minor corrections.

HTM 2022: HTM 2022: 1997, began life as Health Technical Memorandum 22, published in 1974. Currently, the document comprises two main volumes:

Volume 1 'Design, installation, validation and verification' ISBN 0-11-322067-7

Volume 2 'Operational management' ISBN 0-11-322068-5.

There are two Supplements to this publication; 'Dental compressed air and vacuum systems' ISBN 0-11-322040-5 and 'Medical gas systems for ambulances' ISBN 0-11-322052-9.

HTM 2022 (1997) is supported by Model Engineering Specification C11 and a Permit to Work System, published by the Department of Health and HMSO, respectively.

The objective of the guidance printed in HTM 2022 is to ensure the provision of medical gas pipework systems that guarantee the safety of patients served by them.

Hyperbaric chamber: A medical treatment device in which a patient is subjected to (usually) elevated concentrations of oxygen at a pressure above atmospheric. Blood oxygen levels and oxygen exchange rates are increased.

ICU: Intensive care unit (analogous to ITU).

ITU: Intensive therapy unit.

Inflammable: Capable of burning with a flame. The same as flammable.

Local area alarm: An alarm indicator unit sited in areas of (usually) high dependency and used to signal high or low medical gas pipeline pressures to local staff.

Main cylinder storage area: The main area where all cylinders on a site are stored, excluding only those cylinders in use in manifold rooms or in ready-to-use stores.

Manifold (automatic): A device that allows connection of high-pressure gas cylinders to a medical gas system. It comprises a control panel which reduces the pressure to its working value, an automatic changeover facility (empty to full cylinders) and alarm indicators. Automatic manifolds are designed such that they will continue to supply gas in the event of an electrical supply failure.

Manifold (manual): A manifold that requires manual intervention to initiate a changeover from empty to full cylinders.

Manifold room: A purpose-built room designed to accommodate a cylinder manifold installation and reserve cylinders as appropriate.

Maximum pressure drop: The maximum allowable pressure difference in a medical gas pipework between plant room outlet and point of use. For example, the maximum pressure drop allowed in a medical vacuum system at a nominal plant room outlet pressure of 450 mmHg is 50 mmHg between the plant room and the back of the most remote terminal unit, under dynamic conditions.
Individual terminal units and flexible hoses will also have maximum allowable pressure drops at flow rates determined by design parameters and defined in the appropriate design standard(s).

Medical gas: Any gas used in a regime of patient therapy and defined as a medicine under The Medicines Act 1968.

Medical gas pipework systems (MGPS): The fixed medical gases pipework and the associated supply plant or pumping equipment and warning and alarm systems. This definition includes medical compressed air and medical vacuum installations and anaesthetic gas scavenging systems.

Minimum leak device/low loss tee: A small orifice permanently fitted in a pipework and used as a connection point for control devices, for example pressure switches. The device allows removal and repair/refitting of the switch without supply interruption.

Molecular sieve: Any compound capable of selective adsorption of gas molecules, for example the Zeolites used in PSA plant.

Muting: Silencing, on a temporary or permanent basis of the audible alarm on a medical gas alarm system.

NC: Normally closed. Usually used with reference to valves.

NO: Normally open. Usually used with reference to valves.

Nominal distribution pressure: The pressure in a pipework under design flow conditions. For medical gases in the UK the nominal distribution pressure is 400 kPa, except for surgical air, which may have distribution pressures between 700 kPa and 1100 kPa. Medical vacuum has a nominal pressure of 450 mmHg (60 kPa) below atmospheric.

Non-flammable: Not capable of burning in air.

Octopus: A device comprising an assembly of suction cups and control mechanisms for restraining the heart during surgery. It is operated from the medical vacuum system.

Oxygen-free nitrogen: A gas recommended for use as an inert shield purge during the hot jointing of copper medical gas pipework. It obviates the need to use flux.

Passive system: A reference to a type of AGSS in which there is no active element, that is a pump. Waste gases are propelled through the system by patient exhalation or the exhaust function of a patient ventilator.

Peak flow: The likely flow through a medical gas system under conditions of maximum demand.

Pendant: A mechanical device, usually ceiling mounted in an operating theatre and designed to facilitate easy access to medical gas and electrical supplies. It may be a fixed unit (a 'rigid pendant'), a telescopic pendant (a variation on the rigid unit) in which some vertical movement (usually motor driven) of the pendant is possible or a complex unit in which movement in all planes is possible. A single, ceiling-mounted hose is also often called a pendant.

Permit-to-work: A form of declaration, or certificate, in eight parts, for signature as appropriate. It states the degree of hazard involved, defines all services to be worked on and the points where isolation of the affected sections are carried out, describes the work to be done and requires a signature of a designated medical or nursing officer before work on a MGPS is allowed to commence. It is not a permit for the use of the installation for clinical purposes until all parts have been completed. A pro forma is given in the permit-to-work section of HTM 2022 'Operational management'.

Pin-Index(ed) Safety System (PISS): A method of ensuring gas-specific connections by the provision of interlocking pin/socket combinations. The pin position is defined for each gas service. Pin-indexing is used on many medical gas cylinder valves.

Pin-index valve: A medical gas (cylinder) valve constructed with an integral pin-index system: one or two sockets drilled into the valve body in positions defined by the gas contained in the cylinder and into which a corresponding item of pin-indexed equipment, for example cylinder yoke, will fit. Such an assembly offers a gas specific connection.

Pipework carcass: The pipework installation with terminal unit base blocks and area valve service units (excluding pressure switches, flexible assemblies, etc).

Pipework manifold: A pipe to which cylinder tail-pipes are connected, which in turn is connected to the control equipment by means of which medical gas is delivered to the MGPS.

Pipework odour: Any odour resulting from internal contamination of the MGPS copper pipework, for example by residual cleaning agent or arising from the supply system. Odours may be detected when testing flexible hoses. These arise from plasticisers in the hose material.

PPM: Planned preventive maintenance. A scheme of work contrived to attain maximum plant efficiency.

Premises: The premises should be the hospital site, healthcare building or other establishment where the MGPS is installed and the services are to be provided, as defined in the contract.

Pressure gas: A term applied to gases that are delivered at pressures above atmospheric. In the case of medical gases, pressure gases are oxygen, nitrous oxide, Entonox/Equanox, medical air, surgical air, nitric oxide and oxygen carbon dioxide mixtures. With the exception of surgical air, which is distributed at pressures up to 1100 kPa, medical gases are distributed at a nominal pressure of 400 kPa.

Pressure-reducing valve: A device used to control the operating pressure in a gas system

Pressure-regulating valve/pressure regulator: Same as pressure-reducing valve.

Pressure safety valve (pressure relief valve): A valve to limit pressure within a pipework or other pressurised system. Medical gas pipework safety valves are usually set at 530 kPa on a 400 kPa system.

Pressure Systems Regulations (1989): (Now replaced by Pressure Systems Safety Regulations (2000) and the Pressure Equipment Regulations (1999)). In the regulations three categories of pressure system are defined.

a. Minor systems: pressure less than 20 bar (2.0 MPa) and the pressure volume product for the largest vessel should be less than 2×10^5 bar-litres (20 MPa · m^3);

b. Intermediate systems: these include systems that do not fall into either of the other two categories;

c. Major systems: steam-generating systems exceeding 10 MW, pressure storage systems in excess of 10^6 bar-litres (100 MPa · m^3);

Most MGPS and dental air systems fall into the minor systems category. Systems with a largest pressure vessel × working pressure product of less than 250 bar-litres are exempt from some of the Regulations.

Pressure swing adsorber (PSA): Medical oxygen concentrator. System comprising compressor(s), nitrogen adsorber unit(s) and reservoir by means of which oxygen-enriched, clean, dry, oil-free air is generated from atmospheric air.

Pressure switch: An adjustable electromechanical device in which varying pressures in a (medical) gas system activate electrical contacts and hence an alarm system.

Probe: A gas specific connector used to connect equipment to a terminal unit. It is either attached to a hose (remote probe) or to a piece of equipment, for example flowmeter (direct probe).

Procedure: A written method, which has been drawn up by a person familiar with the system and the requirements of this HTM, and checked by the QC or Authorized Person (MGPS), as appropriate. It should be signed by both persons and be dated, and include a review date.

Protective cover: A tamper-evident means of protection of the cylinder valve or valve gas-outlet which may be achieved by a viscose seal, plastic cap or metal cover.

Quality controller (QC): A person appointed in writing by the executive manager on the recommendation of the chief pharmacist. The QC should normally be a pharmacist or other suitably qualified person and should have specialist knowledge, training and experience of MGPS and HTM 2022. The QC is responsible for the quality of the medical gases; his/her duties include carrying out the quality tests in accordance with the procedures specified in 'Validation and verification'.

QC (MGPS): Current terminology used to identify a quality controller with MGPS testing duties.

Ready-to-use store: A local subsidiary to the main store for a limited number of medical gas cylinders, usually cylinders for immediate use and one day's supply for reserve purposes.

Receiver: A specially strengthened vessel used to store compressed air and smooth out variations in pressure caused by compressor pumps and varying system demand.

Regulator: Same as pressure-reducing valve.

SCBU: Special care baby unit.

Scavenging: The collection of excess gases from a patient breathing circuit and removal of these gases to an appropriate place of discharge outside the working environment.

Scavenging system: An assembly of specific components that collects and removes excess anaesthetic gases released from a breathing circuit. There are three types; Active, in which a pump is used to create a flow which carries the waste gases; Passive, in which the patient or patient ventilator provides the driving force for the gas expulsion; Semi-active, in which a small amount of flow in the scavenging system is generated, for example, by the room ventilation system.

Schematic drawing: A drawing of a pipework showing the general layout of the system. Exact positions of the pipework and components with respect to building layout are not shown. Schematic drawings are not usually scaled.

Second fix: The gas specific front part of a medical gas terminal unit. It contains a self-sealing valve.

Semi-dry vacuum system: A dental vacuum system in which a separation similar to that of a dry vacuum system takes place but the vacuum pump and separator are combined into one device.

Semi-passive system: A type of AGSS in which there is no integral active pump, but negative pressure is generated, for example, utilising the venturi effect of the ambient-air conditioning system.

Services: The services and goods which the contractor is required to supply in accordance with the contract.

Shield gas: The gas used to provide an inert shield during the brazing of medical gas pipework (usually oxygen-free nitrogen).

Simplex: A single plant item, for example one compressor, used as a primary supply.

Sodium flame test: A method of testing filter element efficiency using a cloud of known size-range sodium chloride particles as the challenge medium.

Specialist fire safety advisers: This post is fully described in 'Firecode: policy and principles'.

Static pressure: The pressure inside a pipework under zero flow conditions.

Suction device: A passive entity which can only induce an air flow when connected to a suction machine.

Suction system: Active entity of dental equipment, including a suction machine (vacuum pump) which enables a flow to be induced which is designed to remove spray, liquids and solids from the mouth of a dental patient during treatment.

Suitably Qualified Person (SQP): The HTM 22 nomenclature for the Quality Controller (MGPS) – (QC(MGPS)).

Synthetic air: Medical 'air' comprising a mixture of approximately 20% oxygen with 80% nitrogen. The air is synthesised (mechanically mixed) from the gases vaporised from cryogenic supplies of liquid oxygen and liquid nitrogen. A synthetic air system is able to provide a hospital site with synthetic air, oxygen and (surgical) nitrogen.

Tail-pipe: A flexible connecting pipe that connects a medical gas cylinder to a medical gas pipework manifold via a gas-specific connector.

Telemetry: An electronic processing unit that relays to the gas supplier, via a telephone modem, information on the contents and internal pressure of a VIE.

Terminal unit: A gas-specific socket, usually wall- or pendant-mounted, which is used as a connection point between medical equipment and the medical gas pipework system.

Test point: A terminal unit and lockable control valve connected to all main plant items and used to facilitate engineering and pharmaceutical testing of the plant.

Third means of supply: A term used to describe additional support for a medical gas (oxygen) system in the event of failure of the primary system and its ESM. A typical example would be provision of a fully automatic manifold system, permanently connected into the hospital end of a main pipework from a cryogenic liquid system installation. Hence, failure of the primary plant or the pipework would not immediately deprive the hospital of oxygen, as the manifold (the third means of supply) would take over in these circumstances.

Tracheal tube: Also called an endotracheal tube, intratrachael tube and catheter, it is inserted into the trachea and used to convey gases and vapours to the lungs.

Training (gas cylinders): Formal instruction in the safe handling and storage of gas cylinders and associated equipment to ensure that staff are aware of the dangers involved and will act accordingly.

Trap: A mechanical device that allows automatic drainage of (condensed) water from a pipework or compressed air plant.

Trunking (also called bedhead/walling systems): Wall mounted plastic or metal ductwork, usually with some aesthetic appeal, which carries services, such as MGPS, around a patient area.

Trust: Trust means an NHS Trust, Special Health Authority or other health authority as appropriate.

TWA: Time-weighted average (concentration). A way of expressing exposure such that the amount of time spent exposed to each different concentration level is weighted by the amount of time a worker is exposed to that level.

Vacuum insulated evaporator (VIE): A source of supply containing liquefied gas stored under cryogenic conditions.

WAGS: Waste anaesthetic gas system/scavenger/scavenging – same as AGSS.

Wet vacuum system: A pump-driven dental vacuum system in which mouth washings are transferred via a pipework system (and the pump) to a central reservoir for disposal.

White spot nitrogen: Another term for oxygen-free nitrogen. Used as shield gas when brazing medical gas pipework. So called because of the white spot (or spots) painted on the black cylinder shoulder. Note that this cylinder colour code is changing to meet the new European Standard (EN 1089-3) in which oxygen-free nitrogen is represented by a grey-bodied cylinder with a black shoulder, that is no white spots.

Written Scheme of Examination: A document detailing frequency and degree of examination of a pressure system by a Competent Person as defined by the Pressure Systems Regulations.

Yoke: A mechanical assembly usually having integral gas-specific components, for example the pins of a pin-index system, for attaching a compressed (medical) gas cylinder to a piece of equipment, for example an anaesthetic machine or a system supply manifold.

References

NHS ESTATES PUBLICATIONS

Health Technical Memoranda

HTM 2007 Electrical services: supply and distribution. HMSO, 1993 (issued in 4 parts).

HTM 2022 Medical gas pipeline systems

Vol 1: Design, installation, validation and verification. HMSO, 1997.

Vol 2: Operational management. HMSO, 1997**.**

Supplements:

Piped medical gases in ambulance vehicles. HMSO, 1997.

Permit-to-work forms. HMSO, 1999.

HTM 2025 Ventilation in healthcare premises. HMSO, 1994 (issued in 4 parts).

Health guidance notes

The Pressure Systems and Transportable Gas Containers Regulations 1989. HMSO, 1993.

Model Engineering Specifications

C11 Medical gases. HMSO, 1996.

Firecode

82. Alarm and detection systems. HMSO, 1996 (new edition in preparation).

Policy and principles. HMSO, 1994.

ACTS AND REGULATIONS

SI 3246: 1994 SI 437: 1999 The Control of Substances Hazardous to Health (COSHH) Regulations. HMSO, 1999.

EC Directive 76/464/EEC: Water pollution by discharges of certain dangerous substances. European Commission.

SI 635: 1989 The Electricity at Work Regulations. HMSO, 1989.

SI 2372: 1992 The Electromagnetic Compatibility Regulations. HMSO, 1992.

The Environment Act 1995. HMSO, 1995.

The Environmental Protection Act 1990. HMSO, 1990.

SI 3242: 1999 The Management of Health and Safety at Work Regulations. HMSO, 1999.

SI 2793: 1992 The Manual Handling Operations Regulations. HMSO, 1992.

The Medicines Act 1968. HMSO, 1968.

SI 2966: 1992 The Personal Protective Equipment at Work Regulations. HMSO, 1992.

SI 2001: 1999 The Pressure Equipment Regulations. HMSO, 1999.

SI 2169: 1989 The Pressure Systems and Transportable Gas Containers Regulations. HMSO, 1989. Now replaced by **SI 825: 1996 Pipeline Safety Regulations (1996)** and the **SI 128: 2000 Pressure Systems Safety Regulations 2000)**.

SI 2306: 1998 The Provision and Use of Work Equipment Regulations. HMSO, 1998.

SI 3163: 1995 The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR). HMSO, 1995.

SI 972: 1996 The Special Waste Regulations. HMSO, 1996.

The Water Byelaws 2000 Scotland.

The Water Industry Act 1991. HMSO, 1991.

SI 3184: 2000 The Water Supply (Water Quality) Regulations. Amended by **The Water Supply (Water Quality) (Amendment) Regulations SI 2885: 2001**.

The Water Resources Act 1991. HMSO, 1991.

The Water Supply (Water Fittings) Regulations 1999. HMSO, 1999.

SI 1148: 1999 The Water Supply (Water fittings) Regulations. HMSO 1999. Amended by **The Water Supply (Water Fittings) (Amendment) Regulations SI 1506: 1999**.

SI 3004: 1992 The Workplace (Health, Safety and Welfare) Regulations. HMSO, 1992.

BRITISH AND INTERNATIONAL STANDARDS

BS 1780:1985(1992) Specification for bourdon tube pressure and vacuum gauges. Superseded by BS EN 837-1:1998, British Standards Institution, 1992.

BS 6281:Part 2:1982 Devices without moving parts for the prevention of contamination of water by backflow. Specification for type B air gaps. British Standards Institution, 1982.

BS 6387:1994 Specification for performance requirements for cables required to maintain circuit integrity under fire conditions. British Standards Institution, 1994.

BS 6759:Part 2:1984 Safety valves. Specification for safety valves for compressed air or inert gases. British Standards Institution, 1984.

BS 6889:1987 Specification for generating racks for synchronous belt drive pulleys. British Standards Institution, 1987.

BS 7226:1989 Methods of test for performance of inlet air cleaning equipment for internal combustion engines and compressors. Withdrawn and replaced by BS ISO 5011: 2000, British Standards Institution, 1989.

BS 7671:1992 Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition. Withdrawn and replaced by BS 7671:2001, British Standards Institution, 1992.

BS EN ISO 9000:2000 Quality management systems. Fundamentals and vocabulary. British Standards Institution, 2000.

BS EN 837-1:1998 Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing. British Standards Institution, 1998.

BS EN 1089-3:1997 Transportable gas cylinders. Gas cylinder identification (excluding LPG). Colour coding. British Standards Institution, 1997.

BS EN 60529:1992 Specifications for degrees of protection provided by enclosures (IP code). British Standards Institution, 1992.

BS EN ISO 10637:2000 Dental equipment. High and medium volume suction systems. British Standards Institution, 2000.

BS EN ISO 11143:2000 Dental equipment. Amalgam separators. British Standards Institution, 2000.

BS EN 21942-4:1994 Dental vocabulary – Part 4: Dental equipment. British Standards Institution, 1994.

BS EN ISO 7494:1998 Dental units. British Standards Institution, 1998.

BS EN ISO 9687:1996 Dental equipment – Graphical symbols. British Standards Institution, 1996.

BS ISO 5011:2000 Inlet air cleaning equipment for internal combustion engines and compressors. Performance testing. British Standards Institution, 2000.

MISCELLANEOUS PUBLICATIONS

Advice Sheet A3: Health and safety law for dental practice. British Dental Association (BDA), 1993.

Advice Sheet A12: Infection control in dentistry. British Dental Association (BDA) (under revision for publication late 2002), 1996.

Amalgam purchase, use, recovery and release. DETR, 1997.

Anaesthetic agents: controlling exposure under COSHH. Health & Safety Commission's Health Services Advisory Committee, 1995.

Dental Premises Guide. Water Regulations Advisory Scheme (forthcoming 2002).

Dental amalgam: an environmental code of practice. To be published by DEFRA in 2002.

Occupational exposure limits – EH40/96. Health and Safety Executive, Sudbury, HSE Books, 1996.

Occupational exposure standards for anaesthetic agents – EL(96)33. A 'Dear Colleague' letter issued from the NHS Executive Headquarters to NHS Trust Chief Executives and FHSA General Managers on behalf of General Dental Practitioners, March, 1996.

Standard Form of Building Contract. Joint Contracts Tribunal (JCT 98).

Testing of piped medical gases. NHS Pharmaceutical Quality Control Committee, 2nd edition, 1991.

Waste management: the duty of care – a code of practice. The Stationery Office.

The Water Regulations Guide. Water Regulations Advisory Scheme, 2001.

Water supply systems – prevention of contamination and waste of drinking water supplies. Water Regulations Advisory Scheme Technical Support Group (due for release in 2002).

Water Fittings and Materials Directory. Water Regulations Advisory Scheme, 2002.

USEFUL ADDRESSES

The Water Regulations Advisory Scheme (WRAS), Fern Close, Pen-y-Fan Industrial Estate, Oakdale, Gwent, NP1 4EH. Tel: 01495 248454; Fax: 01495 249234.

About NHS Estates guidance and publications

The Agency has a dynamic fund of knowledge which it has acquired over 40 years of working in the field. Our unique access to estates and facilities data, policy and information is shared in guidance delivered in four principal areas:

Design & Briefing

These documents look at the issues involved in planning, briefing and designing facilities that reflect the latest developments and policy around service delivery. They provide current thinking on the best use of space, design and functionality for specific clinical services or non-clinical activity areas. They may contain schedules of accommodation. Guidance published under the headings Health Building Notes (HBNs) and Design Guides are found in this category.

Examples include:

HBN 54, Facilities for cancer care centres
HBN 28, Facilities for cardiac services
Diagnostic and Treatment Centres: ACAD, Central Middlesex Hospital – an evaluation
Infection control in the built environment: design and planning

Operational (Engineering, Facilities Management, Fire, Health & Safety and Environment)

These documents provide guidance on the design, installation and running of specialised building service systems and also policy guidance and instruction on Fire, Health & Safety and Environment issues. Health Technical Memoranda (HTMs) and Health Guidance Notes (HGNs) are included in this category.

Examples include:

HTM 2007, Electrical services supply and distribution
HTM 2010, Sterilization: operational management with testing and validation protocols
HTM 2040, The control of legionellae in healthcare premises – a code of practice
HTM 82, Fire safety – alarm and detection systems

Strategic

These are documents which deal with areas of broad strategic concern and planning issues, including capital and procurement.

Examples of titles published under this heading are:

Estatecode
How to Cost a Hospital
Developing an Estate Strategy
Sustainable Development in the NHS

NHS Estates Policy Initiatives

In response to some of the key tasks of the NHS Plan and the Modernisation Agenda, NHS Estates has implemented, project-managed and monitored several programmes for reform to improve the overall patient experience. These publications document the project outcomes and share best practice and data with the field.

Examples include:

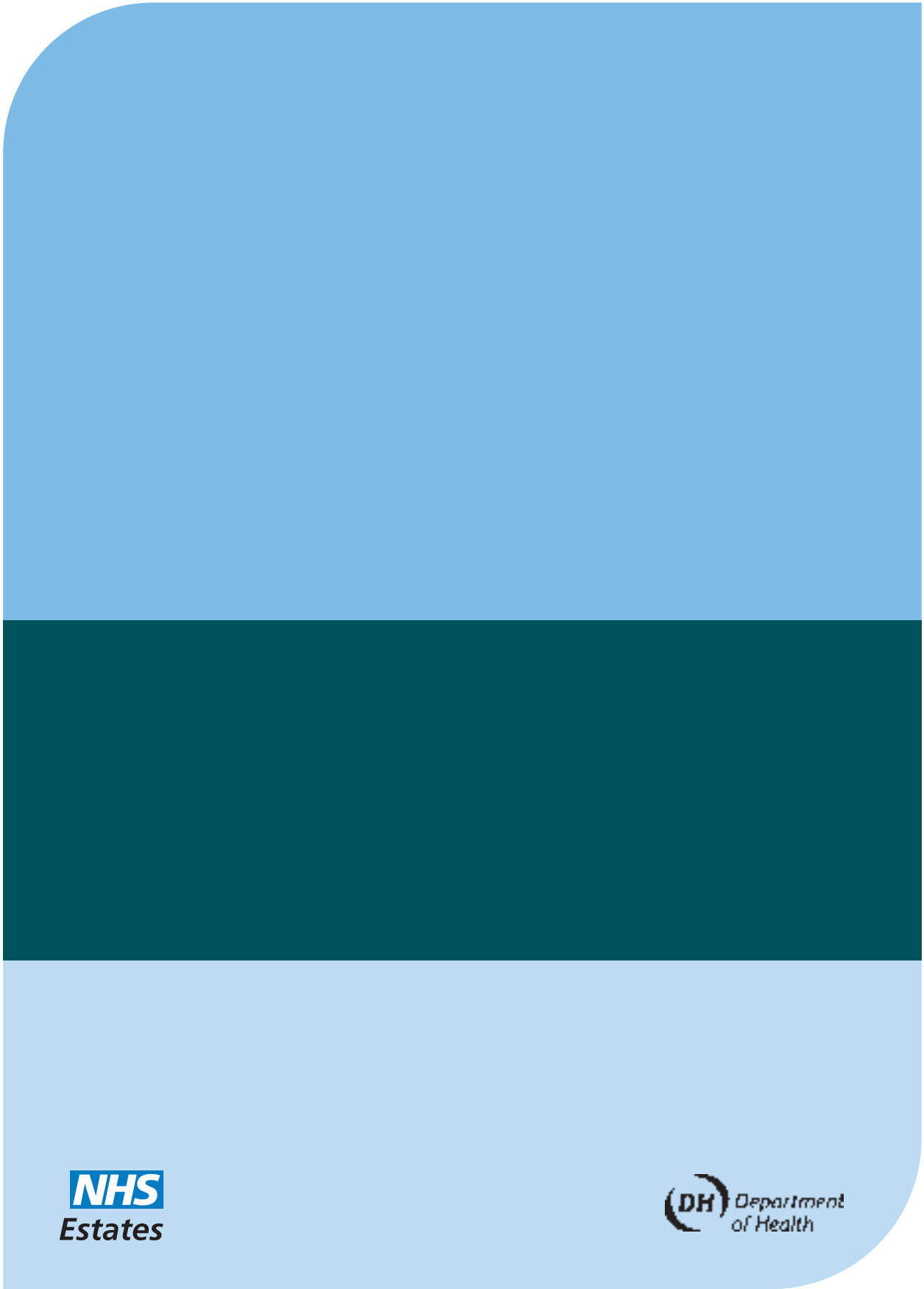
National standards of cleanliness for the NHS
NHS Menu and Recipe Books
Sold on Health

The majority of publications are available in hard copy from The Stationery Office Ltd (TSO):

The Stationery Office
PO Box 29
Norwich NR3 1GN
Telephone: 0870 600 5522
Fax: 0870 600 5533
http://www.tso-nhse.co.uk
e-mail book.orders@tso.co.uk
Textphone: 0870 240 3701

Publication lists and selected downloadable publications can be found on our website:
http://www.nhsestates.gov.uk

For further information please contact our Information Centre:
e-mail: nhs.estates@doh.gsi.gov.uk
tel: 0113 254 7070


NHS
Estates
DH Department of Health