# Environmental Testing and Emerging UK and EU Legislation

## Preface

The document forms part of a series of documents relating to the environmental aspects and the use of pulverised fuel ash (PFA) in construction applications. PFA has a long history of successful use in a wide range of applications from use as an engineering fill material, as a pozzolanic cement, brick and block manufacture, grouting of caverns and mines, etc. Full details of the possible applications are available on the UKQAA web site at www.ukqaa.org.uk as a series of datasheets and case studies. There is no known UK incident of PFA causing any environmental problems in any of these applications.

This series of documents explain the background to the uses of PFA, the relevant legislation, the environmental risks and what practices are recommended to ensure that no environmental damage occurs. For the full picture, one should read all these documents. These documents, by the very nature of the subject matter are frequently reviewed to ensure they reflect changes in environmental legislation and findings of testing and research projects. The user should ensure they have the latest version of the documents, which are freely available on the UKQAA web site www.ukqaa.org.uk. The documents are as follows:

- The production and applications for PFA.
- Environmental Testing and Emerging UK and European Legislation.
- Assessment of the Risk to the Environment from the use of Pulverised Fuel Ash.
- Environmental Code of Practice for the Sale and Use of Pulverised Fuel Ash (PFA).

# Introduction

Environmental legislation has increasing impact on the use of industrial by-products such as pulverised fuel ash (PFA), or fly ash as it is known in most European countries. UK legislation has developed over a period of years with PFA being classified as an engineering material for many applications including use as a fill material, in concrete, grouts, etc. Therefore, no specific environmental protection measures have been deemed necessary. Only when PFA is disposed in a landfill disposal scheme has it been treated as a waste material in the past. Fortunately, the Central Electricity Generating Board (CEGB) in the early 1980's carried out many research projects and studies on the environmental impacts of PFA. These researched the use of PFA when disposed of in lagoons and at sea, when used as a fill material, and the use in farming, effects on local rivers and wildlife, etc. This work is summarised in 'Ashes to Assets'[1] by Woolley et al. From this, it is clear that PFA, when used or disposed of in a sensible manner as described in the UKQAA 'Environmental Code of Practice for PFA as a Fill Material[2] has no significant impact on the environment. In fact, there is no known case of any significant environmental problems being caused by PFA within the UK.

With the large number of environmental 'directives' from both the UK government and the European Union (EU), significant changes in UK practice are inevitable. Environmental protection is controlled within the UK by both Borough and County Councils and, primarily, the Environment Agency (EA), an Executive Non-Departmental Public Body sponsored by the Department of Environment, Food and Rural Affairs (DEFRA) using the Environmental Protection Act[3].

The purpose of this report is to review UK and European Community legislation, the test regimes and any limiting leachate values. The legislation that may affect construction materials in general and, therefore, PFA is considered as appropriate.

# Types of Legislation that are applied to PFA

## Waste Regulations

At the time of writing PFA is not officially considered a waste if it is intended for use as a construction material. This is in accordance with the DOE circular 11/94, which was issued to aid the application of the Waste Management Licensing Regulations. The most significant reference is Paragraph 2.33 (b) "Substances or objects which can be put to immediate use otherwise than by a specialised waste recovery establishment or undertaking". This paragraph refers specifically to the use of power station ash. At the time of writing, it is not clear whether circular 11/94 has been withdrawn by the Department of Environment, Food and Regional Affairs (DEFRA).

This arrangement has resulted in a simple to understand system. When PFA is loaded on to a lorry for transport to a sale, it is not classified as waste because the intent is to use it as a product. When the material is sent to the PFA disposal site by slurry pipeline, lorry or conveyor then the PFA is waste because the intent is to discard the material.

These regulatory arrangements have been in operation since 1994 and the industry is not aware of any incident that would indicate that a different mode of regulation would be beneficial to prevent a significant environmental incident. Whether power station ash is treated as waste or not, its production, processing and shipment are regulated. The classification as waste is not necessary to achieve control. Further control would add duplication and complexity rather than regulatory value. The following existing regulatory controls apply: -

- All PFA production plants have Integrated Pollution Control (IPC) authorisations that cover on-site handling and storage of the product.
- Planning controls regulate the siting and designs of facilities. For many projects using ash as a material, the planning system and related regulations require an environmental impact assessment to be carried out.
- IPC and Integrated Pollution Prevention and Control (IPPC) 'permits' control ash processing plants such as Lytag or Aardelite that are considered as processing minerals.
- Discharge consents control any emissions to water.
- General environmental legislation controls nuisance and pollution not covered elsewhere.
- Health and safety legislation, road transport regulations, construction regulations etc apply to the loading, shipment and use of PFA.
- All landfill operations have waste management licences.

There are various interpretations of the Waste Framework Directive in existence around the EU. Several countries appear to take a similar position to the current practice in the UK where PFA is treated as a by-product; these include Italy, Portugal and some German districts.

### The Current Legal Situation

The PFA industry has carefully considered the UK and EU judgements that have occurred since the adoption of the current arrangements under circular 11/94. The industry is unable to find grounds in the case law that would lead to a necessity to change the current arrangements. It is not intended that this should become a legal treatise, but the following points are fundamental to the industry's view.

- Power station ash is demonstrably a useful product, which can be used without any treatment, either on its own or as raw material for other products. When it is produced, the intent is to use this product and it has not been discarded. Unless and until a material is discarded, it is not a waste.
- Many of the recent judgements relate to decisions on when wastes may be considered as recovered and therefore cease to be waste. Clearly, if a material is a product intended for the construction industry, the question of its reclamation does not arise and these judgements do not change the situation.
- There is a clear point at which power station ash that cannot be utilised within the near future is sent to a disposal site. At this point, the intent changes to an intent to discard and the material becomes waste. From this point onwards, the appropriate Regulations are already applied. This makes power station ash equivalent to all other materials, since all materials are designated as waste once there is intent to discard them.

The conclusion is PFA being supplied to the construction site it should not be treated as a waste but as an engineering material. However, this situation is changing as more clarity is forthcoming on European Directives and regulations.

### Terminology

The problems with by-product materials, like PFA, have not been helped by the variable definitions of the words 'waste', 'recycling' and 'product' within legislation. The terminology varies depending on the waste legislation being considered. Therefore, great care must be taken when using the various words. The European Waste Framework Directive[4] addresses the concept of waste within the European Union. However, this legislation avoids a clear definition as to when a material is a 'waste' or a 'product'. As a result, a number of materials have become the subject of European and Crown court cases. In order to prevent unnecessary and expensive court cases, UNICE[5], a body representing business interests within Europe, have put forward a proposal for an amendment to the EU directives on waste to give clear definitions of 'waste' and 'product'. This would distinguish between activities carried out to recover waste and activities to dispose of waste.

The Waste Framework Directive was implemented in the UK by the Waste Management Licensing Regulations 1994[6] and subsequent amendments. An example of problems in the legislation is the definition of 'inactive', which applies to PFA under landfill taxation regulations but is different to the definition of 'inert hazardous waste' under the Landfill of Waste directive. However, just to add further confusion Customs and Excise, who collect the landfill tax, use the terminology 'active and inactive' for wastes and 'non-active' appears in some Government documents.

Landfill sites are classified in three categories under the UK's proposed Draft Landfill regulations 2001:

1 Hazardous waste – as defined in Article 1(4) of Directive 91/689/EEC[7]

2 Non-hazardous waste – is defined as waste that is not hazardous.

3 Inert waste – This is a sub-category of non-hazardous waste and is a material listed in the regulations or complying with a series of leachate limits. Unfortunately, these limits are prescribed within the Landfill Regulations; e.g. one requirement is that the total leachability should be insignificant. This has been subsequently addressed in Environment Agency Regulatory Guidance Note 2, which is described below.

Various materials are predefined as being 'inert' in the Landfill Directive including waste glass, concrete, bricks, soil and stones, tiles and ceramics. Unfortunately, PFA is not one of the materials mentioned.

### PFA and the current situation

As stated above, PFA has been considered for many years to be an engineering material that only becomes a waste when disposed of in landfill sites. PFA is classed as a 'Controlled Waste' in the UK for landfill purposes and to encourage recycling a landfill tax of £2.00 per tonne is applied to 'inactive' materials such as PFA.

PFA is included in the combined European Waste Catalogue and Hazardous Waste List[8] (EWC & HWL) as 'coal fly ash' (Code No. 10 01 02) as non-hazardous materials. Co-combustion fly ashes may be classified as hazardous wastes should they contain dangerous substances as follows; (10 01 16*) 'fly ash from co-incineration containing dangerous substances' and (10 01 17) 'fly ash from co-incineration other than those mentioned in 10 01 16'. The classification 'containing dangerous substances' for co-incineration ashes depends on the composition of the waste being co-incinerated and the resulting ash.

For PFA to be treated as an 'inert' non-hazardous waste under the EWC & HWL it would require the total leachability to be 'insignificant'. The EU Technical Adaptation Committee has yet to finalise proposals for leaching limits for waste acceptance criteria and procedures. The Landfill of Waste Directive became effective in July 2002 and Member States were obliged to have national lists and/or acceptance criteria. The UK Government in its consultation paper on the Landfill Directive has proposed limits[9] as defined in Schedule 2 of the Draft Landfill regulations 2001. However, this schedule is not helpful as it fails to give any specific values. Therefore, the Environment Agency was been forced to draw up limits in their Regulatory Guidance Note 2[10]. These values are under review at the time of writing (December 2002).

For any materials labelled with the title of 'waste' rather than a product would mean the supply and disposal of the material will be affected by a number of regulations as follows:

1 The Landfill Directive[11] - this would have an effect on the control of PFA disposal at a number of power stations that have been exempt, which would be subject to the IPPC regulations.

2 Groundwater regulations 1998 – these were introduced to protect groundwater from contamination.

3 Waste Management Licensing Regulations 1994 – for handling and disposing of the PFA.

4 Special Waste Regulations 1996 - the licensing system and procedures for disposing of special waste.

5 Carriage of Dangerous Goods Regulations – would have to be considered when taking the material to site.

6 Control of Pollution (Registration of Carriers and Seizure Vehicles) Regulations 1991 (as amended) (SI 1624).

7 Environmental Protection (Duty of Care) Regulation 1991 (as amended) (SI 2839).

8 Producer Responsibility Obligations Regulations.

Within Europe the potential risks of a waste material crossing national borders and whether it is, or is not a waste, was addressed through the OECD and Basel Convention lists. PFA appears in the Basel Convention catalogue twice, which makes the situation less than simple. This is best explained as in the following extract from a letter sent by Kramer[12], L of the European Commission to the Dutch Power industry:

> *Unfortunately, the classification of waste in EU legislation consists of three listing systems that apply in different situations. This fact contributes to a large extent to the complexity of certain issues related to the management of waste.*
>
> *1. LISTING SYSTEMS OF WASTE*
>
> *The first system is set up under Directive 75/442/EEC on waste and Directive 91/689/EEC on hazardous waste and consists of Decision 94/3/EC establishing a list of waste (further the European Waste Catalogue, EWC) and Decision 94/904/EC establishing a list of hazardous waste (further Hazardous Waste List, HWL). These lists consist of the harmonised European classification of waste and are used for the purposes of waste management in general in Europe, such as permitting, planning, control and statistics.*
>
> *The second system is the listing system of the OECD. This system consists of three lists called the green, amber and red list. These lists are used in the Regulation (EEC) N° 259/93 on shipments of waste as Annexes II, III and IV. The lists are used when waste is shipped for recovery across national borders. The lists determine which control procedure applies for these shipments. For red list waste the countries involved need to give explicit permission of the transport. For amber list waste the transport is allowed if no objections are raised within a fixed period. For green list waste there is no need for permission prior to the transport. Strictly speaking these lists do not distinguish between hazardous and non-hazardous wastes but only determine which control procedure applies during shipment. However, in most cases hazardous waste is subject to the amber or red list procedure and non-hazardous waste is subject to the green list procedure.*
>
> *The third system is the listing system of the Basel Convention. This Convention regulates the control of transboundary movements of hazardous wastes and their disposal. Two lists are developed. One list is a list of wastes that are hazardous (list A) and for which an export-ban applies for the export from OECD countries to non-OECD countries. The other list is a list of wastes that are not hazardous (list B) and for which the export-ban does not apply. These lists are included in Regulation (EEG) N° 259/93/EEC as Annex V and have as only purpose to determine which wastes are subject to the export ban to non-OECD countries.*
>
> *2. THE CLASSIFICATION OF FLY ASH FROM COAL FIRED POWER PLANTS IN THE THREE SYSTEMS*
>
> *In the EWC this waste type is in chapter 10, inorganic wastes from thermal processes, paragraph 10.01, wastes from power stations and other combustion plants (except 19 00 00, waste incineration) as item 10.01.02 coal fly ash. This waste is not included in the HWL and therefore coal fly ash is classified as a non-hazardous waste.*
>
> *In the OECD system it is classified on the green list as entry GG 040 coal-fired power plants fly ash. This implies that, within the OECD, it can be shipped for recovery (e.g. applications where the fly ash replaces other raw materials) without specific control procedures. The transporter of the waste only must have a tracking form with information on the type of waste, the origin and the destination.*
>
> *In the Basel system the waste is included in both lists. It is on list A as entry A2060, coal-fired power plant fly ash containing Annex I substances in concentrations sufficient to exhibit Annex III characteristics. On list B it is included as B2050, coal-fired power plant fly ash, not included on list A. The Annexes mentioned are those of the Basel Convention. The inclusion on list A was made by a non-OECD country that has experienced that the fly ash produced outside the OECD may be hazardous.*
>
> *The inclusion on list A implies that before shipment of the fly-ash to a non-OECD country can be considered, the fly ash has to be checked on contaminated with substances included in Annex I. Should this be the case in concentrations sufficient e.g. to render the waste toxic, carcinogenic or ecotoxic, the export is prohibited.*
>
> *3. CONCLUSION*
>
> *Within Europe coal fly ash is not classified as hazardous waste. There are no indications that that situation needs to be reviewed. For the export of the fly ash to non-OECD countries a check on the hazardous character of the waste needs to be done. The only remaining issue which is still unclear is the status of fly ash from power plants that co-incinerate waste. Fly ash from the incineration of waste is classified as hazardous waste in the HWL as entry 19.01.03. Fly ash from a coal-fired power plant that co-incinerates a certain amount of waste is therefore a mixture of the non-hazardous coal fly ash and hazardous incineration fly ash. The correct classification of this mixture needs further consideration. A first review of the HWL is foreseen in 1999. Since the review process is already very advanced it will not be possible to conclude on this issue in that review. A subsequent review is foreseen for 2000. In that review, the status of mixed fly ash should be considered.*

The above would appear to confirm that PFA is classed as a non-hazardous waste, however, it can be freely shipped across borders.

## Materials in contact with drinking water

PFA in its unbound form is rarely, if ever, exposed to water intended for drinking. However, pfa is often used in bound form in concrete, grouts, etc and may be used in such a manner that it is exposed to drinking water. Currently, various regulations have an impact in the UK:

1 Water Supply (Water fittings) regulations: 1999 and the Water Regulations Advisory Scheme (WRAS) – this is the scheme for approving the use of fittings and materials for use in the consumer's premises/private installations. However, it is voluntary.

2 Water Supply (Water Quality) regulations: 1989 amended in October 2000. This has requirements for materials, such as cementitious products, for use in contact with the public drinking water supply. The specification for testing of fittings/materials is covered by various parts of BS6920: 2000 – see appendix 2. BS6920 gives limiting values for certain metal leachates from such materials. These represent the minimum requirements for the public water supply. The October amendment cancelled 'traditional use exemption', that had been applicable to concrete for many years.

For the use in the public supply the Drinking Water Inspectorate (DWI), a Division of DEFRA's Land and Water Directorate, 'Committee on Products and Processes for use in the public water supply' (CPP) is all-powerful, having the backing of the Secretary of State. Therefore, the CCP requirements are mandatory with their aims being to minimise the risk to health of the consumers and safeguarding the quality of the public supply.

Within Europe the 'European Acceptance Scheme' (EAS) is being developed. This will form the basis of approving materials in contact with drinking water by ~2008. Inevitably, the requirements of BS6920 will be replaced by the harmonised standards resulting from the EAS.

## Materials in contact with groundwater

The Water Framework Directive[13] 2000 does not permit 'materials in suspension' to be put into the ground where they may affect groundwater/rivers. This blanket ban would have made the construction of many structures impossible, as piling, grouting, etc. could not be carried out. This issue was raised by the civil engineering and piling industries during 1999 and, because of this lobbying, the following alteration was made to the text within the directive:

> *For construction, civil engineering and building works and similar activities on, or in the ground which come into contact with groundwater: for these purposes, Member States may determine that such activities are to be treated as having been authorised provided that they are conducted in accordance with general binding rules developed by the Member State in respect of such activities.*

In this manner, National Governments are able to draw up rules that allow piling, the placing of grouts, etc. It is envisaged that 'codes of practice' will have to be developed in order to circumnavigate this directive.

# Thresholds for leachates from a material

Many power stations store PFA in lagoons where the ash is transported using a slurry of 60% - 85% water and PFA. Because of this, water containing the leachates from PFA will gradually drain from the lagoons. Therefore, the protection of groundwater substrata, rivers and the prevention of contamination are forefront in the minds of power station operators. In addition, PFA can be used for many engineering applications, as a fill material, in concrete and grouts, etc. Many differing environmental comparisons may be applied to any material.

There is no recognition within UK or EU legislation that any leachate emanating from a material will be diluted by groundwater. However, in the USA legislation, where solid wastes must be subjected to leaching tests to determine their suitability for disposal, the regulatory levels must comply with 100 times the Primary Drinking Water standards[14]. Therefore, this appears to be a recognised minimum attenuation factor of 100 for any species migrating from the deposit to the point of environmental exposure.

When carrying out an environmental risk assessment there are a range of target values that have been used, depending on the particular assessment. Some of the target values used are detailed in the following section.

### Comparison with requirements for materials in contact with drinking water

The leachate quality threshold from BS6920 as shown in Table 2 is applied to leachates from materials in contact with drinking water. The total concentrations data refer to the maximum permitted within a sample of the material. However, it would appear a dilution factor of 10:1 is normally allowed for leachates as barring the initial flush of water, as such elements would quickly reduce in concentration. The 10:1 reduction is permitted, for example, for concrete in contact with drinking water.

## Table 1 – Maximum allowable metals from BS6920: 2000

| Metal | Maximum allowable concentrations - µg/litre | Reporting limits - µg/litre [a] |
|---|---|---|
| Aluminium | 200 | 20 |
| Antimony | 10 | 0.5 |
| Arsenic | 50 | 1 |
| Barium | 1000 | 100 |
| Cadmium | 5 | 0.5 |
| Chromium | 50 | 5 |
| Iron | 200 | 20 |
| Lead | 50 | 1 |
| Manganese | 50 | 5 |
| Mercury | 1 | 0.1 |
| Nickel | 50 | 2 |
| Selenium | 10 | 1 |
| Silver | 10 | 1 |

[a]: The reporting limits required by the National Regulator for some metals are based upon the new lower requirements specified in EC Directive on the quality of water intended for human consumption (98/83/EC).

**Comparison with Landfill Directive criteria**

Whether a material in classified as an 'inert' waste depends on an assessment of the leaching of toxic materials. Regulatory Guidance Note 2 "Interim Waste Acceptance Criteria" (RGN 2) gives leachate limits for 'inert' wastes. However, at the time of writing RGN 2 is likely to be superseded by the National Interim Waste Acceptance Criteria Guidance that was issued for public consultation in September 2002.

The leachates are determined using CEN Technical Committee (TC) 292 'Characterisation of Waste' test methods as follows:

- BS EN 12457-1:2002 (One stage batch test performed at liquid/solid ratio of 2l/kg with high solid content and with particle size below 4mm (with and without size reduction).
- BS EN 12457-2:2002 (One stage batch test performed at liquid/solid ratio of 10l/kg for materials with a particle size below 10mm (with and with size reduction).
- BS EN 12457-3:2002 (Two-stage batch test performed at liquid/solid ratio of 2l/kg and 8l/kg for materials with a high solid content and with a particle size below 4mm (with and without size reduction).

**Comparison with contaminated soils criteria**

In the event that building are to be constructed on PFA, the material may be compared to a soil. In 1976 the UK Interdepartmental Committee for the Redevelopment of Contaminated land (ICRCL) was set up to consider the problems associated with the development of contaminated sites. A series of tentative trigger values were created for 19 contaminants plus pH. These consisted of 'threshold' and 'action' values. Three courses of action are possible; for contaminants below threshold values no action is required, between threshold and action values an 'informed judgement' should be taken and above action values some kind of remediation is required. These are shown in Tables 4 and 5, which relate to contaminated soils and coal mining sites, or coal carbonisation sites as they are called. The ICRCL limits have been replaced by Contaminated Land Environmental Assessment (CLEA)[15], a long awaited computerised system by which guideline/limiting values are computed. Table 3 summarises some the guideline values used with the CLEA model.

**Table 2– Soils Guideline values as a function of land use (CLEA March 2002)**

| Determinand[16] | Residential – with plant uptake | Allotment | Industrial |
|---|---|---|---|
| Arsenic | 20 mg/kg | 20 mg/kg | 500 mg/kg |
| Lead | 450 mg/kg | 450 mg/kg | 750 mg/kg |
| Cadmium (pH 6 data used) | 1 mg/kg | 1 mg/kg | 1400 mg/kg |
| Chromium | 130 mg/kg | 130 mg/kg | 5000 mg/kg |
| Mercury | 8 mg/kg | 8 mg/kg | 480 mg/kg |
| Nickel | 50 mg/kg | 50 mg/kg | 5000 mg/kg |
| Selenium | 35 mg/kg | 35 mg/kg | 8000 mg/kg |

The CLEA[17] software is freely available from the EA web site. This consists of the program, a series of explanatory documents and a comprehensive 'help' file/instructions[18]. The program calculates the cumulative intake of some toxic materials during a lifetime based on the initial value of contamination from the 'contaminated soil' being analysed. The uses of the land containing the contaminated soil are split into three categories, housing, allotments and industrial/offices. From the calculations it is clear whether the maximum recommended doses would be reached, and by how much. CLEA is also able to reverse calculate the maximum initial concentration of a contaminant to enable the user to estimate the degree of remediation that may be necessary. However, there is a significant flaw in the logic of the software. No guidance is given as to whether the initial value for the contaminant relates to the 'total concentration' or 'leachable' material. With PFA, most of the contaminants are held within the glassy matrix and unavailable for absorption by plants, etc. In reality, the CLEA software does not help the user in assessing PFA because of this dichotomy. We would suggest the values for the total amount of water-soluble elements are more appropriate for materials like PFA.

Within the UK, permission is given by the EA on a contract-by-contract basis by carrying out a 'risk analysis'. This implies that for each job a complete re-analysis of the leachates would be required. In practice acceptance of concrete comprising cement, fly ash/PFA, ggbs, natural aggregates and some admixtures have been accepted as being usable when in contact with drinking water.

## Table 3 - ICRCL tentative "Trigger concentrations" for selected inorganic contaminants

| Contaminants | Planned Uses | Trigger Concentrations (mg/kg air-dried soil) | |
|---|---|---|---|
| **Group A: Contaminants which may pose hazards to health** | | **Threshold** | **Action** |
| Arsenic | Domestic gardens, allotments. | 10 | - |
| | Parks, playing fields, open space. | 40 | - |
| Cadmium | Domestic gardens, allotments. | 3 | - |
| | Parks, playing fields, open space. | 15 | - |
| Chromium (hexavalent)(1) | Domestic gardens, allotments. | 25 | |
| | Parks, playing fields, open space. | No limit | No limit |
| Chromium (total) | Domestic gardens, allotments. | 600 | - |
| | Parks, playing fields, open space. | 1000 | - |
| Lead | Domestic gardens, allotments. | 500 | - |
| | Parks, playing fields, open space. | 2000 | - |
| Mercury | Domestic gardens, allotments. | 1 | - |
| | Parks, playing fields, open space. | 20 | - |
| Selenium | Domestic gardens, allotments. | 3 | - |
| | Parks, playing fields, open space. | 6 | - |
| **Group B: Contaminants which are phytotoxic but not normally hazards to health** | | **Threshold** | **Action** |
| Boron (water-soluble) (3) | Any uses where plants are to be grown (2, 6) | 3 | - |
| Copper (4, 5) | Any uses where plants are to be grown (2, 6) | 130 | - |
| Nickel (4, 5) | Any uses where plants are to be grown (2, 6) | 70 | - |
| Zinc (4, 5) | Any uses where plants are to be grown (2, 6) | 300 | - |

NOTES:
* Action concentration will be specified in the next edition of ICRCL 59/83 - [suggested levels below]
1. Soluble hexavalent Cr extracted by 0.1M HCl at 37°C; solution adjusted to pH 1.0 if alkaline substances present.
2. The soil pH value is assumed to be about 6.5 and should be maintained at this value. If the pH falls, the toxic effects and the uptake of these elements will be increased.
3. Determined by standard ADAS method (soluble in hot water).
4. Total concentration (extractable by $HNO_3/HClO_4$).
5. The phytotoxic effects of copper, nickel and zinc may be additive. The trigger values given here are those applicable to the 'worst-case': phytotoxic effects may occur at these concentrations in acid, sandy soils. In neutral or alkaline soils, phytotoxic effects are unlikely at these concentrations.
6. Grass is more resistant to phytotoxic effects than are most other plants and its growth may not be adversely affected at these concentrations.

CONDITIONS
1. This Table is invalid if reproduced without the conditions and footnotes.
2. All values are for concentrations determined on "spot" samples based on an adequate site investigation carried out prior to development. They do not apply to analysis of averaged, bulked or composite samples, nor to sites which have already been developed. All proposed values are tentative.
3. The lower values in Group A are similar to the limits for metal content of sewage sludge applied to agricultural land. The values in Group B are those above which phytotoxicity is possible.
4. If all sample values are below the threshold concentrations then the site may be regarded as uncontaminated as far as the hazards from these contaminants are concerned and development may proceed. Above these concentrations, remedial action may be needed, especially if the contamination is still continuing. Above the action concentration, remedial action will be required or the form of development changed.

**Table 4 – ICRCL tentative "Trigger concentrations" for selected contaminants associated with former coal carbonisation sites**

| Contaminants | Proposed Uses | Trigger Concentration | (mg/kg air-dried soil) |
|---|---|---|---|
| | | Threshold | Action |
| Polyaromatic hydrocarbons (1,2) | Domestic gardens, allotments, play areas. | 50 | 500 |
| | Landscaped areas, buildings, hard cover. | 1000 | 1000 |
| Phenols | Domestic gardens, allotments, play areas. | 5 | 200 |
| | Landscaped areas, buildings, hard cover. | 5 | 1000 |
| Cyanide (Free) | Domestic gardens, allotments, play areas. | 25 | 500 |
| | Landscaped areas, buildings, hard cover. | 100 | 500 |
| Cyanide (Complex) | Domestic gardens, allotments, play areas. | 250 | 1000 |
| | Landscaped areas, buildings, hard cover. | 250 | 5000 |
| | Buildings, hard cover. | 250 | No limit |
| Thiocyanate | All proposed uses | 50 | No limit |
| Sulfate | Domestic gardens, allotments, landscaped. | 2000 | 10000 |
| | Buildings, (9). | 2000 | 50000 |
| | Hard cover | 2000 | No limit |
| Sulfide | All proposed uses | 250 | 1000 |
| Sulfur | All proposed uses | 5000 | 20000 |
| Acidity | Domestic gardens, allotments, landscaped. | pH<5 | pH<3 |
| | Buildings, hard cover | No limits | No limit |

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2. All values are for concentrations determined on "spot" samples based on an adequate site investigation carried out prior to development. They do not apply to analysis of averaged, bulked or composite samples, nor to sites which have already been developed.
3. Many of these values are preliminary and will require regular updating. They should not be applied without reference to the current edition of the report "Problems Arising from the Redevelopment of Gas Works and Similar Sites". (1)
4. If all sample values are below the threshold concentrations then the site may be regarded as uncontaminated as far as the hazards from these contaminants are concerned and development may proceed. Above these concentrations, remedial action may be needed, especially if the contamination is still continuing. Above the action concentration, remedial action will be required or the form of development changed.

In October 1979 Mr R T Kelly, the then scientific advisor to the Greater London Council, delivered a paper entitled “Site investigation and material problems” in which he considered the risks with contaminated land. He produced a series of lists, one of which is reproduced in Table 6. This list was adopted by many waste regulation authorities as well as the Healt h and Safety Executive.

The Netherlands is well known throughout Europe for their approach to the environment. In many ways, they are in advance of most countries as they have comprehensive, clear legislation as to contaminated land and the environment. Table 7 lists the range of 67 contaminants with target and intervention values. The target values represent the value below which any contaminant is felt to pose no risk to the environment, whereas the intervention values are those where some form of remediation is required. If the average of these two values is exceeded then further investigation and some remediation is required.

## Table 5 – Kelly guidelines for classification of contaminated soils

| Guidelines for classification of contaminated soils - suggested range of values (mg/kg) on air-dried soils, except for pH. | | | | | |
|---|---|---|---|---|---|
| Parameter | Typical values for uncontaminated soils | Slight contamination | Contamination | Heavy contamination | Unusually heavy contamination |
| | A | B | C | D | E |
| pH (acid) | 6-7 | 5-6 | 4-5 | 2-4 | <2 |
| pH (alkaline) | 7-8 | 8-9 | 9-10 | 10-12 | >12 |
| Antimony | 0-30 | 30-50 | 50-100 | 100-500 | >500 |
| Arsenic | 0-30 | 30-50 | 50-100 | 100-500 | >500 |
| Cadmium | 0-1 | 1-3 | 3-10 | 10-50 | >50 |
| Chromium | 0-100 | 100-200 | 200-500 | 500-2500 | >2500 |
| Copper (available) | 0-100 | 100-200 | 200-500 | 500-2500 | >2500 |
| Lead | 0-500 | 500-1000 | 1000-2000 | 2000-1.0% | >1.0% |
| Lead (available) | 0-200 | 200-500 | 500-1000 | 1000-5000 | >5000 |
| Mercury | 0-1 | 1-3 | 3-10 | 10-50 | >50 |
| Nickel (available) | 0-20 | 20-50 | 50-200 | 200-1000 | >1000 |
| Zinc (available) | 0-250 | 250-500 | 500-1000 | 1000-5000 | >5000 |
| Zinc (equivalent) | 0-250 | 250-500 | 500-2000 | 2000-1.0% | >1.0% |
| Boron (available) | 0-2 | 2-5 | 5-50 | 50-250 | >250 |
| Selenium | 0-1 | 1-3 | 3-10 | 10-50 | >50 |
| Barium | 0-500 | 500-1000 | 1000-2000 | 2000-1.0% | >1.0% |
| Beryllium | 0-5 | 5-10 | 10-20 | 20-50 | >50 |
| Manganese | 0-500 | 500-1000 | 1000-2000 | 2000-1.0% | >1.0% |
| Vanadium | 0-100 | 100-200 | 200-500 | 500-2500 | >2500 |
| Magnesium | 0-500 | 500-1000 | 1000-2000 | 2000-1.0% | >1.0% |
| Sulphate | 0-2000 | 2000-5000 | 5000-1.0% | 1.0-5.0% | >5.05 |
| Sulphur (free) | 0-100 | 100-500 | 500-1000 | 1000-5000 | >5000 |
| Sulphide | 0-10 | 10-20 | 20-100 | 100-500 | >500 |
| Cyanide (free) | 0-1 | 1-5 | 5-50 | 50-100 | >100 |
| Cyanide | 0-5 | 5-25 | 25-250 | 250-500 | >500 |
| Ferricyanide | 0-100 | 100-500 | 500-1000 | 1000-5000 | >5000 |
| Thiocyanate | 0-10 | 10-50 | 50-100 | 100-500 | >2500 |
| Coal tar | 0-500 | 500-1000 | 1000-2000 | 2000-1.0% | >1.0% |
| Phenol | 0-2 | 2-5 | 5-50 | 50-250 | >250 |
| Toluene extract | 0-5000 | 5000-1.0% | 1.0-5.0% | 5.0-25.0% | >25.0% |
| Cyclohexane extract | 0-2000 | 2000-5000 | 5000-2.0% | 2.0-10% | >10.0% |

**LIST OF TYPICAL DETERMINATIONS**

1. (a) pH – values outside the range 5-9, dependent options i) acidity ii) alkalinity
   (b) Acid soluble sulphate (5% HCL extract)
   (c) Magnesium (dependent option when sulphate exceeds%)
2. (a) Elemental sulphur
   (b) Sulphide
   (c) Total cyanide (dependent options ferro ferricyanide, thiocyanate and free cyanide, when total cyanide exceeds 20 ppm)
3. (a) Phenols
   (b) Toluene extract
   (c) Cyclohexane extract
   (d) Coal tar (dependent option when toluene or cyclohexan extract exceeds 5000 ppm)
   (e) Organic chlorine
   (f) Mineral oil (dependent option as for coal tar)
4. Total metals
   (a) Lead
   (b) Cadmium
   (c) Mercury
   (d) Antimony
   (e) Arsenic
5. Available metals
   (a) Zinc
   (b) Nickel
   (c) Lead
   (d) Copper
   (e) Boron
6. Miscellaneous
   (a) Manganese (total)
   (b) Chromium (total)
   (c) Selenium (total)
   (d) Barium (total)
   (e) Vanadium (total)
   (f) Beryllium (total)

## Table 6 – Dutch intervention rules

| IN STANDARD SOIL & GROUNDWATER<br>mg/kg dry matter & micrograms / litre (unless stated)<br>NB: In the following d = detection limit | | | | |
|---|---|---|---|---|
| | Soil mg/kg dry matter | | Water µg/l | |
| **Compound** | **Target Value** | **Intervention Value** | **Target Value** | **Intervention Value** |
| I Metals<br>(* note soil type correction formula) | | | | |
| arsenic | 29 | 55 | 10 | 60 |
| barium | 200 | 625 | 50 | 625 |
| cadmium | 0.8 | 12 | 0.4 | 6 |
| chromium | 100 | 380 | 1 | 30 |
| cobalt | 20 | 240 | 20 | 100 |
| copper | 36 | 190 | 15 | 75 |
| mercury | 0.3 | 10 | 0.05 | 0.3 |
| lead | 85 | 530 | 15 | 75 |
| molybdenum | 10 | 200 | 5 | 300 |
| nickel | 35 | 210 | 15 | 75 |
| zinc | 140 | 720 | 65 | 800 |
| II Inorganic Compounds | | | | |
| cyanides - free | 1 | 20 | 5 | 1500 |
| cyanides - complex (pH<5) | 5 | 650 | 10 | 1500 |
| cyanides - complex (pH≥5) | 5 | 50 | 10 | 1500 |
| thiocyanates | | 20 | | 1500 |
| III Aromatic Compounds<br>(** note soil type correction formula) | | | | |
| benzene | 0.05 d | 1 | 0.2 | 30 |
| catechol | | 20 | d | 1250 |
| cresols | | 5 | d | 200 |
| ethyl benzene | 0.05 d | 50 | 0.2 | 150 |
| hydroquinone | | 10 | | 800 |
| phenol | 0.05 d | 40 | 0.2 | 2000 |
| resorcinol | | 10 | | 600 |
| toluene | 0.05 d | 130 | 0.2 | 1000 |
| xylenes | 0.05 d | 25 | 0.2 | 70 |
| IV Polycyclic Aromatic Hydrocarbons<br>(** note soil type correction formula) | | | | |
| PAH (sum of 10) (see notes 2 and 11) | 1 | 40 | - | - |
| anthracene | | | 0.02 | 5 |
| benzo(a)anthracene | | | 0.002 | 0.5 |
| benzo(a)pyrene | | | 0.001 | 0.05 |
| benzo(ghi)perylene | | | 0.0002 | 0.05 |
| benzo(k)flouranthene | | | 0.001 | 0.05 |
| chrysene | | | 0.002 | 0.05 |
| fluoranthene | | | 0.005 | 1 |
| indeno(1,2,3 -cd)pyrene | | | 0.0004 | 0.05 |
| naphthalene | | | 0.1 | 70 |
| phenanthrene | | | 0.02 | 5 |
| V Chlorinated Hydrocarbons<br>(** note soil type correction formula) | | | | |
| chlorobenzenes (sum) (notes 3, 11) | - | 30 | - | - |
| monochlorobenzene | d | - | 0.01 d | 180 |
| dichlorobenzene | 0.01 | - | 0.01 d | 50 |
| trichlorobenzene | 0.01 | - | 0.01 d | 10 |
| tetrachlorobenzene | 0.01 | - | 0.01 d | 2.5 |
| pentachlorobenzene | 0.0025 | - | 0.01 d | 1 |

| | | | | |
|---|---|---|---|---|
| hexachlorobenzene | 0.0025 | - | 0.01 d | 0.5 |
| chloronapthalene | - | 10 | - | 6 |
| chlorophenols (sum) (notes 4,11) | - | 10 | - | - |
| monochlorophenols (sum) | 0.0025 | - | 0.25 | 100 |
| dichlorophenols (sum) | 0.003 | - | 0.08 | 30 |
| trichlorophenols (sum | 0.001 | - | 0.025 | 10 |
| tetrachlorophenols (sum) | 0.001 | - | 0.01 | 10 |
| pentachlorophenols (sum) | 0.002 | 5 | 0.02 | 3 |
| 1,2-dichloroethane | - | 4 | 0.01 d | 400 |
| dichloromethane | d | 20 | 0.01 d | 1000 |
| polychlorinated biphenyls (sum) (note 5) | 0.02 | 1 | 0.01 d | 0.01 |
| tetrachloroethene | 0.01 | 4 | 0.01 d | 40 |
| tetrachloromethane | 0.001 | 1 | 0.01 d | 10 |
| trichloroethene | 0.001 | 60 | 0.01 d | 500 |
| trichloromethane | 0.001 | 10 | 0.01 d | 400 |
| vinyl chloride | - | 0.1 | - | 0.7 |
| VI Pesticides | | | | |
| (** note soil type correction formula) | | | | |
| aldrin | 0.0025 | - | d | - |
| atrazine | 0.05Fg/kg | 6 | 0.0075 | 150 |
| carbaryl | - | 5 | 0.01 d | 0.1 |
| carbofuran | - | 2 | 0.01 d | 0.1 |
| DDT/DDE/DDT | 0.0025 | 4 | d | 0.01 |
| dieldrin | 0.0005 | - | 0.02 ng/l | - |
| drins (see note 7) | - | 4 | - | 0.1 |
| endrin | 0.001 | - | d | - |
| HCH-compounds (see note 8) | - | 2 | - | 1 |
| - alpha | 0.0025 | - | d | - |
| - beta | 0.001 | - | d | - |
| - gamma (lindane) | 0.005Fg/kg | - | 0.2 ng/l | - |
| maneb | - | 35 | d | 0.1 |
| VII Miscellaneous | | | | |
| (** note soil type correction formula) | | | | |
| cyclohexanone | 0.1 | 270 | 0.5 | 15000 |
| mineral oil (see note 10) | 50 | 5000 | 50 | 600 |
| phthalates (sum) (see note 9) | 0.1 | 60 | 0.5 | 5 |
| pyridine | 0.1 | 1 | 0.5 | 3 |
| styrene | 0.1 | 100 | 0.5 | 300 |
| sulpholane | 0.1 | 90 | 0.5 | 30 |
| tetrahydrofuran | 0.1 | 0.4 | 0.5 | 1 |

**Notes:**

1. Acidity: pH (0.01 M $CaCl_2$). For the determination of pH higher or equal to 5 and pH lower than 5 the 90th percentile of the measured values is taken.
2. For PAH (sum of 10 compounds), read: the sum of anthracene, benzo(a)anthracene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, phenanthrene, fluoranthene, indeno(1,2,3 -cd)pyrene, naphthalene, benzo(ghi)perylene.
3. For chlorobenzenes (sum) read the total content of chlorobenzenes (mono-, di-, tri-, tetra-, penta- and hexachlorobenzene).
4. For chlorophenols (sum) read the total content of chlorophenols (mono-, di-, tri-, tetra- and pentachlorophenol).
5. The intervention value for polychlorinated biphenyls (sum) is the total of PCB 28, 52, 101, 118, 138, 153, 180. For the target value PCB 118 is excluded.
6. For DDT/DDE/DDD, read: the sum of DDT, DDE and DDD.
7. For drins, read: the sum of aldrin, dieldrin and endrin.
8. For HCH-compounds, read: the sum of alpha-HCH, beta-HCH, gama-HCH and delta-HCH.
9. For phthalates (sum), read: the sum of all phthalates.
10. Mineral oil includes the sum of all alkanes. Where mixtures (eg petrol, diesel or lubricating oil) exist, the content of aromatic compounds and polycyclic hydrocarbons will also have to be determined. For practical reasons

this cumulative parameter is considered to give sufficient information. Further toxicological and chemical differentiation is being studied.

11. The cumulative value for polycyclic aromatic hydrocarbons, chlorophenols and chlorobebzenes, in soil, is valid only for the total concentration of compounds within each group. If contamination is caused by only one of the compounds, the cumulative value becomes the intervention value for this one compound. Where two or more compounds are present, the sum of their concentrations is compared to the cumulative value of PAH (sum).

12. For soil / sediment the effects can be added up (ie the effect of 1 mg of compound A is equal that of 1 mg of compound B) and can be compared to the cumulative value by adding up the concentrations of the relative compounds. For groundwater the effects can be added indirectly, as a fraction of the individual intervention value (ie 0.5 of the intervention value compound A has the same effect as 0.5 of the intervention value compound B). As a consequence, an accumulative formula is needed to judge whether or not the intervention value is exceeded. The latter is the case for a group of compounds in groundwater if:

$$\sum \frac{conc}{I_i} \geq 1$$

Where: conc = measured concentration of compound from the relevant group
$I_i$ = intervention value of the compound concerned

ADJUSTMENTS TO VALUES FOR DIFFERENT SOIL TYPES

Target and intervention values vary according to the clay and organic matter content of the soil. The following formula is used to calculate these values for heavy metals (including arsenic):

*

$$I_b = I_{st} \times \frac{A + (B \times \%\ clay) + (C \times \%\ organic\ matter)}{A + (B \times 25) + (C \times 10)}$$

Where:
$I_b$ = intervention value for the relevant soil in mg/kg
$I_{st}$ = intervention value for the standard soil in mg/kg
% clay = measured % clay in the relevant soil, minimum 2%
% organic = measured % of organic matter in the relevant soil,
with a minimum 2% and maximum 30%
ABC = compound dependant constants (see table below)

**

The following formula is used to calculate these values for organic compounds:

$$I_b = I_{st} \times \frac{\%\ organic\ matter}{10}$$

Where:
$I_b$ = intervention value for the relevant soil in mg/kg
$I_{st}$ = intervention value for the standard soil in mg/kg
% organic = measured % of organic matter in the relevant soil,
with a minimum 2% and maximum 30%

| **Compound** | **A** | **B** | **C** |
|---|---|---|---|
| Arsenic | 15 | 0.4 | 0.4 |
| Barium | 30 | 5 | 0 |
| Cadmium | 0.4 | 0.007 | 0.021 |
| Chromium | 50 | 2 | 0 |
| Cobalt | 2 | 0.28 | 0 |
| Copper | 15 | 0.6 | 0.6 |
| Mercury | 0.2 | 0.0034 | 0.0017 |
| Lead | 50 | 1 | 1 |
| Molybdenum | 1 | 0 | 0 |
| Nickel | 10 | 1 | 0 |
| Zinc | 50 | 3 | 1.5 |

## Test methods for leachate assessment

A considerable amount of work in preparing test methods for characterising wastes has been carried out within CEN TC292, 'Characterisation of Wastes'. Some 38 standards either are in preparation or published as listed in Appendix 1. The basic criterion of TC292 standards seems to be to analyse the 'waste' for all possible elements irrespective of the potential for leachates to escape and then test the potential for leaching from the material in various size fractions. These tests are based on using de-ionised water as the extracting medium, excepting where acid extraction and/or microwave digestion is employed.

Analyses of PFA's show that the trace elements account for less than 2% of the total. The principle compounds, $SiO_2$, $Al_2O_3$, $Fe_2O_3$, are present in the glassy phase and as such are benign. The majority of the trace elements are encapsulated on the glass. Calcium is mainly present as gypsum. The PFA particles are predominantly silt sized and therefore when compacted it has a low permeability. The combination of encapsulation and the low permeability mean that the risk of release of toxic metals is very small.

For PFA, an accelerated percolation method is felt to be the most appropriate leaching test, as this reflects when PFA is used as a fill material. However, the CEN TC292 'Upflow Percolation' test was extensively tested and found not to be suitable for such materials. Compacted PFA naturally has a low permeability, typically ~1 x $10^{-7}$m/s and very little leachant will percolate through the material. Applying pressure tends to lead to the water escaping around the PFA sample rather than through it. These problems have been found in a number of studies, for example CIRIA report 167[19] found compacted PFA would not saturate with water within their large-scale permeameter. Therefore, they were unable to extract any leachate. Where gravity is used to extract leachates, such as in permeameters, no leachant may be found for periods of up to 3 years. It was for this reason that Dawson of the University of Nottingham developed the Dorlap test. This allows leachant to be forced through the material at high pressure without encountering problems of bypassing the sample. For PFA grouts, the permeability would be expected to be similar to compacted PFA fill, due to the high water content of grout mixes. Consequently, extraction of leachants from the bulk, solid material could prove very difficult using any of the CEN TC292 test methods.

One problem with these test methods is how repeatable or reproducible they are. TC292 was unable to harmonise many of the testing standards because data did not exist on the repeatability or reproducibility of the methods. At the time of writing a validation exercise in being carried out on these methods with the early data indicating some highly variable results. Values for the precision of leachates from EN12457 Part 1 to 4 for repeatability are being reported[20] ranging from 26 to 50% and reproducibility from 82 to 126%. Clearly, this could have a significant effect on the classification of materials should finite limits be set.

While CEN TC292 has developed a great number of test methods, various sectors of the materials industry do not accept tests for categorising wastes are appropriate for their products. The main problems are not those associated with the validity or applicability of the method, but relate to the test methods being entitled 'Characterisation of Waste'. Material producers and suppliers do not wish to have their products associated with the word 'waste'. It is for this reason that other CEN Technical Committees have developed their own test methods, even though this increases the number of standards.

## Test methods for construction materials

Both TC154 (Aggregates) and TC104 (Concrete) have produced draft standards or reports on leaching. TC154 published EN1744 Part 1[21], the method of chemical analysis, in August 1998. Part 3 of this standard relates to the extraction of eluates from an aggregate, which has been out for public comment but yet to be published.

TC104 produced a report[22] on the leaching method for concrete in ~1997 using a tank leaching test. In the development of the test method, experiments showed that concrete samples 'do not have significant leaching of environmental relevant elements' including mixes that contained PFA.

It would appear not only construction has such problems with parallel tests being developed. The CEN Technical Board reports[23] there are numerous standards for analysis of soils, sludges, treated biowastes, waste, fertilisers and water all covering various fields, the sampling, measuring the pH, the dry matter content, organic matter content, total nitrogen, ammonium-nitrogen, trace elements, polyaromatic hydrocarbons and polychlorinated biphenyls. These total 61 different standards with up to five duplications in each field where measurements are needed!

## Test methods for materials in contact with drinking water

BS6920, see appendix 2, prescribes the test methods with the criteria for any product that may come into contact with drinking water. The factors assessed are:

- Effects on odour and flavour.
- Effects on appearance.
- Effects on the growth of aquatic micro-organisms.
- Effects of cytoxicity (the potential to kill living cells).
- Extraction of metals.

The samples used to assess concrete are monolithic, but relatively small monoliths. Fresh concrete is used to construct storage systems in the drinking water infrastructure and two investigations have been carried out in the UK to assess its potential to leach. The first was in co-operation between the DWI and Quarry Products Association (QPA), using admixture-free ready-mixed concrete, and the second was between DWI and the Cement Admixtures Association (CAA) using reference concretes. The first one involved leaching of metals only whilst the second looked at the leaching of organics from admixtures. On the basis of the results, admixture-free fresh/in situ concrete has, since October 2000, been granted a generic authorisation/approval provided that the concrete and the structure are specified in accordance with BS 8007:1987 'Code of practice for the design of concrete structures for retaining aqueous liquids'. Conversely, the individual components of admixtures must gain entry to an 'authorised list' after subjection to a new DWI leaching protocol using the admixture at 110% dosage level in a reference concrete. The species to be determined vary with the composition of the admixture. Many traditional admixture components gained entry to the list during the aforementioned research investigation. Again, concrete containing the admixtures/components must comply with BS 8007.

After October 2000, any factory-made cementitious pipelines (concrete or mortar lined) require individual applications and approval. Information on the product formulation/composition, the technical specification, evidence of the effects on water quality as per BS6920 and toxicological data (if any) should be provided for any approval to be given. The Committee on Products and Processes for use in the public water supply (CPP) may require additional leaching testing particularly if the pipe product contains added organics not on the 'authorised list'; a Gas Chromatograph Mass Spectrometry (GCMS) scan and further toxicological testing may need to be carried out. In contrast, admixture/polymer-free site-applied cement : sand mortar linings have been granted a generic approval based on leach testing a single example of the type.

Within the rest of Europe, the situation is varied. Currently every country has its own requirements, some of which are very demanding and expensive to comply with, which CEN considers a technical barrier to trade. Consequently, CEN used the Drinking Water Directive[24] coupled with the Construction Products Directive[25] to create a mandate (*Construction products in contact with water intended for human consumption*) which forms the basis of a European Acceptance Scheme (EAS) for assessing products/materials/substances for use in the distribution system. This is designed to create a level playing field to allow the free passage of goods throughout Europe for such products. The notable difference between current UK requirements and the EAS is that there will be no place for broad/generic approvals for materials and each product will have to be tested separately. The resulting costs could be very extensive; e.g., one UK admixture manufacturer estimates spending £50,000 on testing to get one product approved. Yet again, a separate suite of testing standards is to be created under TC164/WG 3/AHG 6 'Influence of cementitious products on water intended for human consumption (Test methods)'.

In view of the difficulties and costs of testing concrete to the proposed requirements of the EAS, TC104 is proposing a different approach using an approved material list. Concrete, mortar and grout made entirely from materials on this list will not require testing. TC104 is proposing that most constituent materials for concrete should be added to this proposed list without further testing and that the European list can be supplemented by local materials, e.g. in the case of the UK, Portland cement, PFA, ggbs, metakaolin etc.

As stated above, many of the test methods and procedures used throughout Europe differ widely. TC164/WG3 found there are major problems with the treatment of the samples for testing which affects the result. Unfortunately, leaching from cementitious materials is influenced by type of preconditioning and the chemical nature of the water used to extract the leachants. Consequently, a range of test conditions[26] was assessed in detail by EU research for WG3. They concluded:

1 Preconditioning – this has a significant effect on the migration behaviour of the material with water.

2 Liquid preconditioning with medium mineralised water and gaseous preconditioning decreases exchanges between the material and water by stabilising the material.

3 Liquid preconditioning with low mineralised water increases the exchange between the material and water and the range of pH and aluminium increases during preconditioning. There is no stabilisation with such preconditioning water.

4 Gaseous preconditioning is less practicable and less representative of service conditions.

5 Liquid preconditioning with medium mineralised water is efficient because:

 5.1 It improves test reproducibility.

 5.2 It minimises the effect of ageing time of the material.

6 The alkalinity, aggressivity (free $CO_2$) and silica concentration of the migration test water have a major influence on the test results.

7 Soft water is more aggressive than medium mineralised water.

8 The addition of $CO_2$ makes the water more aggressive; however, dissolved $CO_2$ is unstable in contact with the atmosphere.

9 The presence of dissolved silica in the test water has a major effect on aluminium leaching.

Taking these findings into account TC164/WG3 now has the task to produce standardised test methods for a range of parameters/species acceptable to all EU members. However, research work continues in order to be able to standardise methods for the full range of organic parameters.

## Conclusions

There is a considerable number of environmental test methods, both existing and in preparation throughout Europe. Many methods are being prepared in parallel between various committees for very similar applications. In addition, there are no clear National or European definitions of terminology or suitable limits set by which a material may be classified. Hence, decisions about many materials are being taken on a case-by-case basis with differing results throughout the UK and Europe.

Even with standardised/unified test methods, there is considerable doubt about the accuracy of the testing regimes. Repeatability and reproducibility values are being found that are high, making the precision analysis of data both difficult and potentially expensive with the potential to cause uncertainty when comparing test results with acceptance/specification limits.

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## Appendix 1: List of TC292 European Standards on characterising waste.

| Title of document | Date effective | Comments |
|---|---|---|
| Characterisation of waste – Sampling of liquid and granular waste materials including paste-like materials and sludges – Part 1: A framework for sampling plan preparation. | Dec 2003 | Proposed formal vote date |
| Characterisation of waste – Sampling of liquid and granular waste materials including paste-like materials and sludges – Part 2: Selection and application of criteria for sampling under various conditions. | Dec 2003 | Proposed formal vote date |
| Characterisation of waste – Sampling of liquid and granular waste materials including paste-like materials and sludges – Part 3: Sampling techniques | Dec 2003 | Proposed formal vote date |
| Characterisation of waste – Sampling of liquid and granular waste materials including paste-like materials and sludges – Part 4: Sample pre-treatment in the field. | July 2003 | Proposed formal vote date |
| Characterisation of waste – Sampling of liquid and granular waste materials including paste-like materials and sludges – Part 5: Procedure for sample packaging, storage, preservation, transport and delivery. | April 2003 | Proposed formal vote date |
| Characterisation of waste – Pre-treatment of the laboratory sample prior to digestion and/or elemental analysis | Nov 2004 | Proposed formal vote date. |
| Characterisation of waste – Assessment of monolithic character | Nov 2004 | Proposed formal vote date. |
| Characterisation of waste – Compliance leaching test for monolithic material | Nov 2004 | Proposed formal vote date >40mm particle size. Multi-stage test over 48 hours. |
| Characterisation of waste – Methodology guideline for the determination of the leaching behaviour of waste under specific conditions. | ENV Published | ENV 12920: 1998 |
| Characterisation of waste – Leaching – Compliance for leaching granular waste materials and sludges – Part 1: One stage test at a liquid to solid ratio of 2l/kg with a particle size below 4mm (with or without size reduction) | Nov 2002 | Published as BS EN12457 Part 1: 2002 |
| Characterisation of waste – Leaching – Compliance for leaching granular waste materials and sludges – Part 2: One stage test at a liquid to solid ratio of 10l/kg with a particle size below 4mm (with or without size reduction) | Nov 2002 | Published as BS EN12457 Part 2: 2002 |
| Characterisation of waste – Leaching – Compliance for leaching granular waste materials and sludges – Part 3: Two stage batch test at a liquid to solid ratio of 2l/kg and 8l/kg with a particle size below 4mm (with or without size reduction) | Nov 2002 | Published as BS EN12457 Part 3: 2002 |
| Characterisation of waste – Leaching – Compliance for leaching granular waste materials and sludges – Part 4: One stage batch test at a liquid to solid ratio of 10l/kg with a particle size below 10mm (without or with limited size reduction) | Nov 2002 | Published as BS EN12457 Part 4: 2002 |
| Characterisation of waste – Analysis of eluates – Determination of pH, As, Cd, Cr VI, Cu, Ni, Pb, Zn, Cl-, $NO^2$, $SO_4{}^{2-}$ | Jan 2000 | DD ENV 12506:2000. Does not give any test methods but refers to a number of other ISO standards for the tests. |
| Characterisation of waste – Analysis of eluates – Determination of Ammonium –N, AOX, conductivity, Hg, phenol index, TOC, $CN^-{}_{\text{easily liberatable}}$, $F^-$ | Jan 2000 | DD ENV13370: 2001 published August 2001. |
| Characterisation of waste – Microwave assisted digestion with | June 2001 | Proposed formal vote date. |

| Title of document | Date effective | Comments |
|---|---|---|
| hydrofluoric (HF), nitric ($HNO_3$) and hydrochloric (HCl) acid mixture for subsequent determination of elements in waste. | | PrEN13656. |
| Characterisation of waste – Digestion for subsequent determination of aqua regia soluble portion of elements in waste | August 2001 | Proposed formal vote date. PrEN13657 |
| Characterisation of waste – Terminology – Part 1: Material related items and definitions | May 2001 | Proposed formal vote date. CEN enquiry Oct 2000. PrEN13965-1 |
| Characterisation of waste – Terminology – Part 2: Management related items and definitions | Feb 2002 | Proposed formal vote date. PrEN13965-2 |
| Characterisation of waste – Determination of total organic carbon (TOC) in waste, sludges and sediments | Dec 2002 | BS EN 13137: 2001 published August 2001. Note: In the Scope it says ‘ this standard can be applied to sludges, sediments and comparable materials’ – which would appear to be outside that scope of the TC292 Mandate. |
| Characterisation of waste – Determination of hydrocarbons ($C_{10}$ to $C_{40}$) by gas chromatography (GC). | Oct 2001 | Proposed formal vote. CEN enquiry Sept 2000. PrEN14039 |
| Characterisation of waste – Determination of halogen and sulfur content; oxygen combustion in closed systems and determination methods. | Dec 2002 | Proposed formal vote date. |
| Characterisation of waste – Determination of dry residue and water content | March 2003 | Proposed formal vote date |
| Characterisation of waste – Determination of hydrocarbons by gravimetry | Dec 2002 | Proposed formal vote date |
| Characterisation of waste – Leaching behaviour test – Part 1: ANC test | Dec 2003 | Proposed formal vote date. |
| Characterisation of waste – Leaching behaviour test – Part 2: pH static test | Dec 2003 | Proposed formal vote date. |
| Characterisation of waste – Leaching behaviour test – Influence of pH under steady state conditions | Jan 2003 | 10:1 Leachate extraction test. |
| Characterisation of waste – Leaching behaviour test – Leaching behaviour of a waste material under standardised percolation conditions – Up flow percolation test. | June 2003 | Proposed formal vote date. Column leaching test. |
| Characterisation of waste – Leaching behaviour test – Leaching behaviour of a waste material under specific conditions – Down flow percolation test. | Nov 2004 | Proposed formal vote date. |
| Characterisation of waste – Determination of hydrocarbons by gravimetry. | Sept 2002 | Proposed formal vote date. |
| Characterisation of waste – Preparation of waste samples for ecotoxity tests. | Sept 2002 | Estimated formal vote date. |
| Characterisation of waste – Ecotoxity test for raw waste and water extracts from waste. | Dec 2003 | Proposed formal vote date. |
| Characterisation of waste – Determination of polychlorinated biphenyls (PCB) in waste. | May 2004 | Proposed formal vote date. |
| Characterisation of waste – Determination of Cr (VI) in waste – state of the art document | Dec 2004 | Proposed formal vote date. |
| Characterisation of waste – Determination of Cr (VI) in waste – Analysis method | Dec 2004 | Proposed formal vote date. |
| Characterisation of waste – Determination of elemental | Dec 2004 | Proposed formal vote date. |

| Title of document | Date effective | Comments |
| --- | --- | --- |
| composition by X-ray fluorescence. | | |
| Characterisation of waste – Determination of loss on ignition in waste, sludge and sediments. | Dec 2004 | Proposed formal vote date. |
| Characterisation of waste – Dynamic leaching test for monolithic wastes | Dec 2004 | Proposed formal vote date. |

## Appendix 2: List of UK Standards and other documents on environmental leaching testing.

| Title of document | Date effective | Comments |
|---|---|---|
| DIN 38414 Part 4 – German standard method for the examination of water, wastewater and sludge - Sludge and sediments (Group S). Determination of leachability by water. | Current | 10:1 water/solids ratio. |
| UK Environmental Agency Extraction Method | Current | Based on DIN 38414 test |
| Harwell test – Testing of hazardous waste to assess their suitability for landfill disposal, AERE Report R10737, Young P J & Wilson D C, 1987 | ~1987 | CIRIA report compares this to CEN methods. Found to give similar results. |
| Double Ring Leachate Permeameter (DoRLaP) – Andrew Dawson, Notts. University. | | Designed to reduce leaching around edge of ash and column – also very high pressure |
| BS 6920 Part 1 - Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water. Specification | May 2000 | |
| BS 6920-2.1:2000 - Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water. Methods of test. Samples for testing | 2000 | |
| BS 6920-2.2.1:2000 - Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water. Methods of test. Odour and flavour of water. General method of test | 2000 | |
| BS 6920-2.2.2:2000 - Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water. Methods of test. Odour and flavour of water. Method of testing odours and flavours imparted to water by hoses and composite pipes and tubes | 2000 | |
| BS 6920-2.2.3:2000 - Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water. Methods of test. Odour and flavour of water. Method of testing odours and flavours imparted to water by hoses and composite pipes and tubes | 2000 | |
| BS 6920-2.3:2000 - Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water. Methods of test. Appearance of water | 2000 | |
| BS 6920-2.5:2000 Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water. Methods of test. The extraction of substances that may be of concern to public health | 2000 | |
| BS 6920-2.6:2000 Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water. Methods of test. The extraction of metals | 2000 | |
| BS 6920-3:2000 Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water. High temperature tests | 2000 | |

| Title of document | Date effective | Comments |
|---|---|---|
| BS 6920-4:2001 - Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water. Method for the GCMS identification of water leachable organic substances | 2001 | |
| BS EN 1744-1:1998. Test for chemical properties of aggregates Chemical analysis. | Published Aug 1998 | Specifies reference procedures and, in certain cases an alternative method, for the chemical analysis of aggregates |
| PrEN 1744-3:Jan 2000. Test for chemical properties of aggregates – Part 3-. Preparation of eluates by leaching of aggregates. | | TC154 – draft for comment March 2000 – however, there are problems with test method and lightweight aggregates. |
| Development of a leaching method for the determination of the environmental quality of concrete. Final report. | ~1997 | EUR 17869 EN – report prepared by TC104 contains specification for tank leaching test. |

## Appendix 3: List of water quality ISO, DIN or European standards and other documents.

| Title of document | Date effective | Comments |
|---|---|---|
| EN26595:1992 – Water quality – Determination of total arsenic – silver diethyldithiocarbonate spectrophotometric method (ISO 6777:1982) | 1992 | Referred to by DD ENV12506:2000 |
| EN26777:1993 – Water quality – Determination of nitrite – Molecular absorption spectrometric method (ISO 6777:1984) | 1993 | Referred to by DD ENV12506:2000 |
| EN5667-3:1995 – Water quality – Sampling – Part 3: Guidance on the preservation and handling of samples (ISO 5667-3:1994) | 1995 | Referred to by DD ENV12506:2000 |
| EN ISO 10304-1: 1995 – Water quality – Determination of dissolved fluoride, chloride, nitrite, orthophosphate, bromide, nitrate and sulfate ions using liquid chromatography of ions – Part 1: Method for water with low contamination (ISO 10304-1:1992) | 1995 | Referred to by DD ENV12506:2000 |
| EN ISO 10304-2: 1996 – Water quality – Determination of dissolved anions by liquid chromatography of ions – Part 2: Determination of bromide, chloride, nitrate, nitrite, orthophosphate and sulfate in waste water (ISO 10304-2:1995) | 1996 | Referred to by DD ENV12506:2000 |
| EN ISO 11885:1997 - Water Quality – Determination of 33 elements by inductively coupled plasma atomic emission spectrography (ISO 11885:1996) | 1997 | Referred to by DD ENV12506:2000 |
| EN ISO 11969:1996 - Water Quality – Determination of arsenic – Atomic-absorption spectrometric method (hydride technique) (ISO 11969:1996) | 1996 | Referred to by DD ENV12506:2000 |
| EN ISO 13395:1996 – Water quality – Determination of nitrite nitrogen and nitrate nitrogen and the sum of both by flow analysis (CFA and FIA) and spectrometric detection (ISO 13395:1996) | 1996 | Referred to by DD ENV12506:2000 |
| ISO 8288:1986 – Water quality – determination of cobalt, nickel, copper, zinc, cadmium and lead – flame atomic spectrometric methods. | 1986 | Referred to by DD ENV12506:2000 |
| ISO 9280:1990 – Water quality – determination of sulfate – Gravitation method using barium chloride | 1990 | Referred to by DD ENV12506:2000 |
| ISO 9297:1989 – Water quality – determination of chloride – Silver nitrate titration with chromate indicator (Mohr's method) | 1989 | Referred to by DD ENV12506:2000 |
| ISO 10523: 1994 – Water quality – Determination of pH | 1994 | Referred to by DD ENV12506:2000 |
| ISO 11083: 1994 – Water quality – Determination of Chromium (VI) – Spectrometric method using 1,5- diphenylcarbazide | 1994 | Referred to by DD ENV12506:2000 |
| ENV ISO 13530 – Water quality – Guide to analytical quality control for water analysis (ISO TR 13530:1997) | 1997 | Referred to by DD ENV12506:2000 |
| ANSI/NSF (1997), Standard 61 – 1997b – Drinking water system components – health effects. | 1997 | |
| AWWA/DVWG – Internal corrosion of water distribution systems, second edition, AWWA, Denver , USA | 1996 | |
| BS 7766: 1994 Specification for the assessment of the potential for metallic materials to affect adversely the quality of water intended for human consumption, BSI | 1994 | |

| Title of document | Date effective | Comments |
|---|---|---|
| DIN (1999), Standard 50931-1 Corrosion of metals – corrosion test with drinking water – Part 1: Testing of change of the composition of drinking water | 1999 | |
| European Consortium (P Buijs et al) Developing a new protocol for the monitoring of lead in drinking water – European Study | 1998 | |
| Guidelines for drinking water quality, WHO, Second Edition, Vol. 1 Recommendations | 1998 | |


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- Richard Foreman of the Electricity Association – general information on the practical and legal aspects of PFA.


## Further reading:

Handbook for Implementation of EU Environmental Legislation, November 2000 – this is the handbook for governments to use to ensure compliance with EU directives.

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SGV1: Soil Guideline values for Arsenic.
SGV3: Soil Guideline values for Cadmium.
SGV4: Soil Guideline values for Chromium.
SGV5: Soil Guideline values for Mercury.
SGV7: Soil Guideline values for Nickel.
SGV9: Soil Guideline values for Selenium.
SGV10: Soil Guideline values for Lead.

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CLR 9 – Contaminants in soil: Collation of toxicological data and intake values for humans, May 2002.
SGV1: Soil Guideline values for Arsenic.
SGV3: Soil Guideline values for Cadmium.
SGV4: Soil Guideline values for Chromium.
SGV5: Soil Guideline values for Mercury.
SGV7: Soil Guideline values for Nickel.
SGV9: Soil Guideline values for Selenium.
SGV10: Soil Guideline values for Lead.

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