PROCEDURES FOR IDENTIFYING HAZARDS IN COMPONENT MATERIALS FOR ASPHALT

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ABSTRACT

The use of secondary component materials and recycling in the production of asphalt generally results in no exceptional hazards for operatives, the general public or the environment. However, such materials need to undergo a wide range of investigations to check their suitability because of the properties of the material. The wider use could mean that the use or re-use of some non-standard materials may have health, safety and environmental implications. Various strategies to promote the use of by-products could be considered for adoption, but are not the subject of this investigation. The overall aim of the task, carried out within the SAMARIS project for the European Commission, was to produce a methodology of testing components for potential hazards. There are several materials known to have been used in pavements that require care should such pavements be used for recycling. However, for any procedure to be general and to allow for new hazards to be considered, the circumstances that maximise the risk during the extraction of the old pavement together with the manufacture, paving and use of the recycled material have to be included in the procedure. A procedure has been developed around two known hazardous component materials and four more general situations. Suitable tests have also been identified to check for such component material.

KEYWORDS

Bitumen, Recycling, Risk, Pavement

INTRODUCTION

SAMARIS was a European research project that was partially financed by the European Commission through the 5th Framework Programme under the GROWTH programme.
The SAMARIS project involved 23 partners and 12 subcontractors. It contained 11 Work Packages of which Work Package 4, Safety and Environment, had the objective of encouraging the use of recycled and secondary materials in pavements by detailing how such materials shall be selected and tested in order to secure satisfactory performance, environmentally as well as functionally. The work discussed below was Task 1 of Work Package 4.

The asphalt industry has long been a supporter of recycling. Recycling began on a large scale in the 1970s with the use of reclaimed asphalt (RA) and has grown ever since. The recycling of asphalt mixtures and the use of secondary and by-product materials (as new materials for road construction) fits into the trends towards (EAPA, 2004):

- Sustainable development.
- Minimizing environmental impact.
- Optimising the use of natural resources.
- Increased restrictions on dumping of re-usable material (landfills).
- Potential economic incentives to encourage the recycling and/or re-use of material.
- Alternative sources of recyclable material into asphalt mixtures.

However, when using secondary materials (as new materials for road construction) and recycled materials for sustainable road construction, information on health, safety and environmental (HSE) issues must be considered. As input to an HSE regulatory framework for testing, reporting, storage, treatment and disposal of materials, target criteria must be available. These criteria include:

- Identification of potential hazards posed by the use of the material,
- Identification of persons or media (air, water, soils) likely to be impacted by the identified hazard,
- Identification of the magnitude of the potential impact, where hazard (danger) is a physical situation with significant potential for human injury or damage to the environment, and risk is the likelihood of human injury or damage to the environment from a specified hazard.

Therefore, the need to optimise the engineering, economic and environmental viability of the final product requires a methodology of testing for hazards from alternative materials. Health and environmental risks are a function of both the degree of exposure and the nature and concentration of the chemicals. The first step of risk assessment is the substance-specific hazard identification. The known hazards that have been identified to have occurred in road materials, even if only under extreme occasions, have been reviewed from the available literature (Nicholls et al, 2004). The review confirmed that a proper and comprehensive risk assessment of the possible component materials during the whole life cycle is required.

PROCEDURE FOR DETECTING HAZARDOUS COMPONENTS

There are several materials that have been used in previous construction that require care should they be used for recycling. The most obvious materials are:
Coal tar, which has been used extensively in the middle of the last century, but now known to be carcinogenic.

Sulphur, which has been occasionally used during the 1970s and 1980s to partly replace the bituminous binder and, although its use was very limited, it needs to be treated with care in order to avoid forming dangerous derivative compounds.

Asbestos-like fibres, which might have been used before the dangers of the material (in terms of asbestosis, lung cancer and mesothelioma) were fully appreciated.

The situations during the life cycle of recycled asphalt where these materials could induce hazards were considered to be:

- Airborne particulates derived from pulverisation during milling off and crushing.
- Fumes arising from heating during mixing.
- Spontaneous ignition during heating.
- Leaching once installed.
- Reaction to fire in tunnels.

Having identified this series of tests, a simple procedure had to be developed around them to provide a consistent approach to assessing the health and safety implications of using recycled and/or secondary components. This procedure set out in Figure 1. However, the use of the procedure will be precautionary because, in most cases, there will be no hazards present. It is envisaged that the procedure should be used for type testing possible new component materials and/or combinations of components. It is not envisaged that the procedure will be part of the mix design procedure for routine mixtures. When hazards are found, the potential hazard should not necessarily mean that the component material cannot be used in asphalt. The appropriate actions to be taken (risk management) range from taking additional precautions to the complete avoidance of that component in any asphalt mixture, with the choice depending on the nature and extent of the hazard.

It is appreciated that evaluations of other components in recycled asphalt may also need to be incorporated. For example, the content of heavy metals in recycled steel slag and fly ash from power stations could, potentially, be hazardous. Furthermore, these products are more often used than, say, sulphur in some countries and investigations for analysing such components are being done in various studies. Other waste products, such as moulding sand and discarded railroad ballast, are also used. However, these other materials were not covered in the proposed procedure because of limited resources. If the procedure is taken up, it is anticipated that such products would be considered and, if appropriate, added to the procedure.

Once a material has gone through the procedure in Figure 1, any material with a nil classification, expected to be the most common scenario, can be used without any particular care over and above that used normally. Other materials will require the additional care, advice on which is identified in:

- Section 3.5 of SAMARIS D23 (Nicholls et al, 2005) for materials with “T” in the classification
- Section 4.5 of SAMARIS D23 (Nicholls et al, 2005) for materials with “S” in the classification.
- Section 5.6 of SAMARIS D23 (Nicholls et al, 2005) for materials with “P” in the classification.
- Section 6.5 of SAMARIS D23 (Nicholls et al, 2005) for materials with “F” in the classification.
- SAMARIS D16 (François, 2005) for materials with “L” in the classification.
Figure 1: Proposed Methodology of Testing for Hazards from Alternative Components

The work in SAMARIS on leaching (François, 2005) and on reaction to fire (Colwell, 2005) were covered by separate reports whilst the final report on this subject (Nicholls et
includes full details of the other proposed test methods, results from the trials undertaken with them and advice on how to interpret those results from the tests. The SAMARIS reports are published on [http://samaris.zag.si/documents](http://samaris.zag.si/documents).

**TEST FOR COAL TAR**

Coal tar is a complex liquid mixture of hydrocarbon compounds that is derived, along with coke, from the destructive distillation of coal in cooking ovens. The hazards of coal tar are now well documented and relate to the hazards from its constituents. Coal tar consists of a mixture of many organic compounds including benzene, toluene, phenol, naphthalene and anthracene. It is the aromatics that pose the most danger to both humans and wildlife. Chronic effects of some of the constituents in coal tar include changes in the liver and harmful effects on the kidneys, heart, lungs and nervous system.

The polycyclic aromatic compounds (PACs) that are found in coal tar at high levels (from 20 % to 50 %) are often carcinogenic and possibly phototoxic. They consist of condensed aromatic rings and constitute a group of several hundred compounds, differing in chemical/physical properties and toxicity. There is not only a difference in toxicity between kinds of polycyclic aromatic hydrocarbons (PAHs) but also between exposed types of organism. One of the best known PAHs is benzo(a)pyrene (BaP), which is an established human carcinogen. In coal tar pitch, the BaP content is 1000 to 10 000 times higher than in bitumen.

The main exposure routes to PAHs from coal tar in road construction are the inhalation of PAH-containing fumes or dust and skin-contact with PAH-containing materials such as coal tar or fume condensates present on surfaces exposed to the fumes of hot coal tar containing products. There is also a possibility of PAHs leaching out of the pavement after construction as a result of contact with moisture/water, particularly in case of pavement cracking.

The choice of available test methods depends on the objective of analysis (use in the field or analysis in the laboratory) with the test being categorised as follows:

- **Screening tests**
  - PAK-Marker® test (Figure 2)
  - Staining Test (Figure 3)
- **Semi-quantitative detection method**
  - Thin layer chromatography
- **Quantitative detection methods**
  - Gas chromatography with mass spectrometric detection
  - High pressure liquid chromatography
  - Vacuum sublimation test

The screening tests are “rough”, quick and qualitative field tests to detect the presence or absence of coal tar. They are easy to use and quick to deliver results (in a few minutes). However, these “rough” tests present a minimum detection limit of only approximately 5 % by weight of the coal tar present in the binder (Vansteenkiste and Verhasselt, 2004).
Moreover, the reliability of the procedures is poor and there are doubts about whether the detection limits exceed restrictions set by legislation.

![Figure 2: Spray to identify presence of tar](image)

![Figure 3: Identification of tar by staining](image)

The semi-quantitative method thin layer chromatography is suitable for a rapid determination in the laboratory of the presence of PAHs. However, the test does not provide information about the exact content of PAHs and, consequently, the detection limit can exceed restrictions set by legislation.

The quantitative detection methods permit a precise, reliable and sensitive quantification of individual PAHs. However, such laboratory PAH-analysis is expensive, time-consuming and requires well-trained staff. Moreover, they are not suitable as field measurement techniques.

A false identification that RA contains coal tar has a huge economical consequence because it restricts reuse. Therefore, the preferable testing protocol has to be reliable in identifying the hazard linked to the presence of coal tar, namely PAHs content. Moreover, some countries impose limiting values for individual PAHs, in particular those that are well known for their carcinogenic properties such as BaP. Thereby, it is better to have a test for the hazardous chemicals themselves (PAHs) with respect to the relevant
national legislation rather than simply for the presence or absence of coal tar. Consequently, research was undertaken on the development of an approach combining a fast preparation of samples and a precise quantification of individual PAHs (determination of PAHs levels).

In order to ensure suitability of the material with respect to the hazardous chemical compounds present in the coal tar (PAHs), the option selected is to collect samples from the source and, after recovering binders from RA, to test the recovered binders in the laboratory to precisely assess the environmental acceptability of the material. The test procedure involves extracting and preparing the binder before placing it onto a thin layer chromatography (TLC) plate for scanning the fluorescent spots. The entire process of this sample preparation step can be completed in 2 h. After that, the precise quantity of individual PAHs is determined by high pressure liquid chromatography (HPLC) in 1 h. Moreover, the use of a combining UV diode array and fluorescence detection with HPLC allows a decrease in the detection limit. The detection threshold on a typical PAHs analytical column is:

- 35 ng of total PAHs and 0.8 ng of BaP with UV light detection.
- 3 ng of total PAHs and 0.05 ng of BaP with fluorescence detection.

These detection thresholds depend on the quality of the PAHs extraction and dilution levels.

This laboratory test method performs well as a rapid, practical, efficient and suitable method of determining PAHs levels in asphalt.

**TEST FOR SULPHUR**

Sulphur is an element that has been well-known since antiquity. It is present in two crystalline forms, \( \alpha \) (octahedral) and \( \beta \) (prismatic). The sulphur is stable up to a temperature of 95.5 °C, when it turns into sulphur \( \beta \) that melt at 119 °C. The viscosity of sulphur in solution decreases until around 160 °C. Above this temperature, the sulphur becomes very viscous. The \( \beta \) transformation is reversible when the temperature falls back to 95.5 °C with a sudden increase of volume.

Sulphur can be found in the natural state in several forms:

- virgin state in different volcanic rocks and some sedimetary soils (Louisiana, Texas),
- by extraction of sulphides: hydrogen sulphide (15 % of Lacq gas), FeS\(_2\) (pyrites), ZnS, PbS and sulphates (gypsum \( \text{CaSO}_4 \)).

Elemental sulphur (solid) in itself is not a danger. It is not water soluble, so that sulphur is protected from leaching although it could release sulphate over a period of time. Elemental sulphur is found in everyday objects from food and medicine to plastics and black gunpowder.

Sulphur is naturally present in bituminous binders in different forms (thiophenic and sulphide compounds). Its content depends on the origin of crude oil used for the manufacturing (Traxler, 1961). Desulphurisation of oil refinery streams is an important step, and has received increasing attention over the last 30 years because oils high in
sulphur give rise to exhaust gases containing SO₂, a major contributor to air pollution and acid rain. During the seventies and eighties, several test programmes were undertaken worldwide on the use of sulphur in road materials. Examples are a process using a bitumen-sulphur binder (based on 30 to 40 % elemental sulphur adding) and a process in which sulphur was added to hot rolled asphalt (Denning and Carswell, 1981) or asphalt concrete during the mixing process.

The main hazard linked to the presence of added sulphur in bitumen or asphalt is related to the temperature at which the binder or asphalt is heated. Indeed, if the temperature reaches or exceeds about 150 °C, there is a risk of a reaction of sulphur on bitumen (Abraham, 1960) and the release of hydrogen sulphide (H₂S) into the air that poses the most danger to humans. H₂S is a gas that is heavier than air, highly poisonous, colourless and has a distinct odour. At low levels, it can cause eye irritation, dizziness, coughing, and headache and at higher levels, hydrogen sulphide gas can paralyze the lungs so that the victim is unable to escape from the toxic gas without assistance.

Another possible hazard can be the production of sulphur dioxide gas (oxidation of sulphur by oxygen) when the bituminous binder is overheated. Sulphur dioxide (SO₂) production is generally linked to the presence of elemental sulphur added at high proportions to the binders. SO₂ is a colourless and non-flammable gas with a penetrating and suffocating odour. It is a dangerous air pollutant because of its corrosive properties; it irritates the eyes, nose, and lungs. The major health concerns associated with exposure of humans of high concentrations of sulphur dioxide include effects on breathing, respiratory illness, alterations in pulmonary defences and aggravation of existing cardiovascular disease. Moreover, in the atmosphere, sulphur dioxide mixes with water vapour producing sulphuric acid. This acidic pollution can be transported by wind over many hundreds of miles, and then deposited as acid rain.

A literature survey indicated that there are few available methods for the detection of sulphur in bitumen and asphalt. Two options are atomic absorption and plasma emission spectrometries, which determine organo-metallic compounds (such as nickel, vanadium, sulphur, iron and magnesium) in bitumen but with a lot of technical problems and requiring a long sample preparation time. For petroleum products, the sulphur content can usually also be determined by X-ray fluorescence spectroscopy. The principle of this technique is that X-ray fluorescence gives rise to a radiation (of specific energy and wavelength) characteristic of individual elements, the intensity of which is proportional to the amount of that element within a sample. Therefore, measuring either the wavelength or energy of the radiation emitted from an ionised sample allows accurate determination of the quantity of an element (e.g. sulphur) within a sample. An alternative method to determine the amount of sulphur in petroleum products is to measure the emission of sulphur dioxide gas during the burning of a known quantity of sample in a oven (between 1300 and 1500 °C) under air using an infrared cell.

A false identification of a high sulphur content in RA may have some important consequences because it imposes appropriate temperatures at which the RA could be heated without any risk of releasing of toxic hydrogen sulphide and sulphur dioxide gas in the air. Consequently, research focused on the development of a rapid and simple way to
quantify sulphur by inductively coupled plasma – atomic emission spectrometry (ICP-AES), one of the most common techniques for elemental analysis. This approach was taken in order to simplify the sample preparation that usually involves a long and painstaking mineralization process, entailing risks of splashing and pollution.

In order to facilitate the sample preparation prior to ICP-AES analysis, one possible option is to dissolve the binder in an appropriate aromatic solvent. However, the resulting matrices disturb the sources (flame or plasma) and generate a considerable continuous background and emission of a large number of carbon lines. Therefore, it is necessary to have non-aqueous equipment with costly Viton solvent-resistant tubing and a specific type of nebuliser for organic media. Hence, the apparatus cannot be used for any other purpose. Finally, calibration always presents difficulties.

Consequently, a new way to prepare the binder for classical ICP-AES analysis was developed. It consists of emulsifying the binder in water and optimising the settings on the classical apparatus for the normal aqueous medium without modifying the apparatus itself. A plasma source is used to make specific elements emit light, after which a spectrometer separates this light in the characteristic wavelengths. A solid sample is normally first dissolved and mixed with water but, in the case of a bituminous binder, it is emulsified in water, made of two phases: xylene and distilled water with a non-ionic surfactant (Triton X® 100). The stabilised bitumen emulsion is then transformed into an aerosol by a nebuliser. The bigger droplets are separated from the smallest in a specially designed spray-chamber. The smallest droplets (1-10 μm) are transferred by an argon flow into the heart of the ICP-AES, the argon plasma. The bigger droplets (>90 %) are pumped to waste. The bitumen/water emulsion avoids the use of aromatic solvent in ICP-AES, which can result in specific analysis conditions and special pump tubing that are not easy problems for a typical laboratory to overcome. Moreover, the ICP-AES is robust enough to allow direct analysis of liquids.

In the plasma, a lot of energy is transferred to the nebulised sample that is decomposed, atomised and ionised, promoting the excitation of atoms and ions electrons to higher energy levels. When these excited atoms and ions return to their ground state or to lower excitation states, they will emit electromagnetic radiation in the ultra-violet/visible range of the spectrum. Each excited element emits specific wavelengths, i.e. has a typical emission spectrum. The intensity of the radiation is proportional to the element concentration. Commercially available standards can be used to calibrate the ICP-AES, which enables a highly quantitative analysis.

This laboratory test method performs well for a rapid, practical, efficient and suitable determination of sulphur content in binders recovered from RA.

**TEST FOR AIRBORNE PARTICULATES (INCLUDING FUMES)**

The pavement construction process comprises operations such as material storage, handling, production, placement, demolition, excavation, and disposal or recycling.
operations. Potential dust or volatile emissions or liquid discharges from these operations can have an impact on the air, surface or groundwater, soils or worker environment.

A particular hazard at an asphalt production facility is the emission of dust which can affect the local air quality. Dust can be classified as total and respirable. Total dust includes any type of dust particle that can or cannot be inhaled. Respirable dust is a subset of total dust and includes any type of dust particle that can be breathed into the body. The American Conference of Governmental Industrial Hygienists (ACGIH) has classified the airborne particulates as follows (ACGIH, 1993):

- **Inhalable particulate mass**
  Materials that are hazardous when deposited anywhere in the respiratory tract. Inhalable samplers were defined as having a collection efficiency of 50 % (50 % cut point) at 100 μm.

- **Thoracic particulate mass**
  Materials that are hazardous when deposited anywhere within the lung airways and the gas-exchange region. Thoracic samplers were defined as having a collection efficiency of 50 % (50 % cut point) at 10 μm.

- **Respirable particulate mass**
  Materials that are hazardous when deposited in the gas-exchange region including the respiratory bronchioles and alveoli. The 50 % cut point is at 3.5 μm to 4 μm and particulates can have sizes up to 8.5 μm.

Sometimes, reference is also made to the 50 % cut point at 2.5 μm: particulate matter PM2.5.

In the ACGIH/ISO/CEN health related sampling convention for aerosols, the three ranges are represented by curves in which the percentage collected is given as a function of the aerodynamic diameter in micron.

Air sampling is taking a known volume of air through a filter medium where the contaminant (in solid form or gas form) is captured. The volume of air is calculated as the flow rate through the filter medium multiplied by the sampling time. There are different methods of taking air samples, but mostly personal sampling is carried out using a battery-operated pump connected to a filter medium. The pump should be capable of maintaining a constant airflow rate of a time in excess of 8 h, even in adverse conditions. Short-term sampling presents usually no problems for the pump sampler. The longer period sampling is required for determining the 8 h time weighted average values.

The Occupational Safety and Health Administration air quality standards for dust are based upon the proportion of crystalline silica that is in the dust. Silica is a very hazardous ingredient in dust because it is known to cause silicosis, a lung disease. An established test for determining metals in particulate matter from ambient air sources is using inductively coupled plasma spectroscopy in combination with atomic emission spectrometry (ICP-AES) or mass spectrometry (ICP-MS). The material collected in the sampler is dissolved in nitric acid digestion or microwave digestion using hydrochloric acid/nitric acid. Once digested, the sample is analysed for metals using ICP techniques.
In ICP-AES, a plasma source is used to dissociate the sample into its constituent atoms or ions, exciting them to a higher energy level. They return to their ground state by emitting light of a characteristic wavelength depending on the element present. This light is recorded by an optical spectrometer. When calibrated against standards, the technique provides a quantitative analysis of the sample.

Another well known method for the determination of metals in ambient particulate matter is using X-ray fluorescence (XRF) spectroscopy. This method is applicable to the analysis of a broad range of suspended particulate matter for metals using energy dispersive X-ray fluorescence. The XRF spectrometry is used to identify elements in a substance and quantify the amount of those elements present to determine the elemental composition of the material. After collection of the total and/or respirable dust, both qualitative and quantitative analysis can be carried out (depending on the complexity of the particulate composition). Reference materials are required to establish a calibration for quantitative analysis. A range of chemical elements can be analysed.

The laboratory option selected for further investigation to measure airborne particles, including condensed vapours, is as follows. A measured mass of material (e.g. 1 kg) is placed into a 5 L mixer where it is agitated by the action of the stirrer (at a set speed) for a set period of time at ambient temperature (Figure 4). The airborne particulates (mainly dust at this temperature) released into the air space above the mixer are collected using sampling equipment as used for field exposure measurements (Figure 5). Further tests can be carried out at temperatures up to 180 °C. The airborne particles (including organic vapours) released into the air space above the mixer are collected using specially prepared sampling devices. The masses of the collected airborne particulates are determined by weighing the filters before and after the measurement run. The collected airborne particles can also be used for subsequent analysis for hazardous components.

![Figure 4: Laboratory set-up to collect airborne particulates](image)

![Figure 5: Particulate and semi-volatile collection](image)
TEST FOR SPONTANEOUS IGNITION

Whenever combustible material is present at a construction site, or as a component material of any pavement layer, there is a potential for fire to occur. This can happen either during the heating process involved, during construction or afterwards and this depends on a number of parameters including the amount of combustible material present.

Spontaneous combustion occurs when the temperature of a material increases until it reaches its ignition temperature, without drawing heat from the surroundings. Often, this point occurs when the material undergoes oxidation with the air, resulting in the evolution of heat. However, most substances which are susceptible to oxidation do not spontaneously combust if this process is slow and the heat generated is so small. An example of this lack of spontaneous ignition is the rusting of iron. Under normal temperatures, this oxidation process will not result in spontaneous combustion.

Three conditions have to be examined to determine whether an oxidation reaction will result in spontaneous ignition (Lake, 1968). These conditions are the presence of combustible material, oxygen and a source of heat. Occasionally, additional heat generated from the surroundings can also lead to an increase in the rate of oxidation, initiating spontaneous ignition, which otherwise would not be subject to this process at normal temperatures. Coal and charcoal are some of the materials subject to spontaneous combustion.

A literature review revealed that ignition has occurred in the following situations:
- When constructing a road through a contaminated site.
- When using colliery spoil as a sub-base or fill material.
- When using a material that can ignite during the heating process involved in recycling or mixing bitumen.

Many countries have identified the combustion problems associated with contaminated land and produced guidelines to avoid combustion. The review revealed that colliery spoil is the only permitted road building material which possesses the property of spontaneous combustion. Therefore, existing guidelines and specifications only allow the use of colliery spoil at specific circumstances due to spontaneous combustion. However, in order to provide advice on the ignition potential of a material under maximum temperature and to avoid such occurrences, available screening tests and detailed tests were gathered and investigated.

The ramped basket test was selected for the following reasons:
- The test approach has been used successfully for many years.
- No potential risks involved in conducting the test.
- An automated data acquisition system captures the data automatically at 20 s intervals.
- Relatively simple.
- This test can be used to determine both the potential of fire and the isothermal behaviour of the material.
- This is similar to the aerated powder test which simulates the condition in dryers.
The test involves a wire mesh basket being filled with the prepared test sample and suspended in the oven. The temperature is increased at 30 °C/h from ambient to 400 °C. The temperature at the centre of the test sample is monitored at 20 s intervals (Figure 6) to determine whether the material underwent self-heating and, if, the temperature at which self-heating commences (i.e. when the temperature rises at rate greater than 30 °C/h). The test takes approximately 24 h.

Trials were undertaken with four indicative mixtures which were ranked in the order (with the material reaching the highest peak temperature first) coal asphalt, porous asphalt, mastic asphalt and dense bitumen macadam (a type of asphalt concrete). The coal asphalt was a specially prepared mixture with coal aggregate and 100/150 pen bitumen fluxed with 5 % white spirit to produce a mixture that would be expected to have unsatisfactory properties. The order was consistent with expectations.

Figure 6: Typical ramped basket test results

CONCLUSIONS

The wider use of secondary component materials and recycling in the production of asphalt means that the health and safety implications of any hazards that could result from the use or reuse of non-standard materials becomes more necessary. In order to encourage the acceptance of the routine assessment of materials, a procedure has been developed and the series of test methods needed for that procedure identified and defined.

The test methods identify the presence of coal tar, the presence of sulphur, the presence of airborne particulates, including condensed vapours, the potential for spontaneous ignition at maximum temperature, the potential for leaching and the reaction to fire. Four of the relevant tests are given in CEN format as Appendices to the full report (Nicholls et al, 2005) so that they can be extracted should a decision be made to standardise them. The last two tests are covered by separate reports produced by the SAMARIS project (François, 2005; Colwell 2005).

The procedure is intended to provide a consistent approach to assessing the health and safety implications of using recycled and/or secondary components. It is envisaged that the procedure should be used for type testing possible new component materials and/or combinations of components. It is not envisaged that the procedure will be part of the mix design procedure for routine mixtures. Finding a potential hazard should not necessarily
mean that the relevant component material cannot be used in asphalt. Depending on the
nature and extent of the hazard, the appropriate action to be taken (risk management)
range from taking additional precautions to the complete avoidance of that component in
any asphalt mixture. An important feature of the procedure is that analyses and risk
evaluations can be made before starting the recycling work.

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