Environmental Guidelines
on
Best Available Techniques (BAT)
for the
Production of Asphalt Paving Mixes

EAPA

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PREFACE

The European Asphalt Pavement Association (EAPA), in recognition of rapidly developing EU environmental legislation, decided in 1992 to proactively address the incoming environmental requirements of the industry in order to further enhance its reputation and record in this key area.

It was quickly identified that the focal point of this strategy would be the development of an industry-agreed document describing the technologies and emission limits that were currently accepted to be **reasonable, economic and proven in practice**. Under EU legislative terminology, this is described as Best Available Techniques, abbreviated as BAT.

The EAPA Committee on Health, Safety and the Environment took on the task of preparing this BAT document. It was published for wider industry discussion at the Helsinki Symposium in June 1994. Based on the feedback, the document was updated in 1996.

Since 1996 there have been several developments in Europe especially in the environmental area and therefore it was decided in 2006 to update the BAT document again.

As the title implies, the document is presented in the form of guidelines proposed to be voluntarily adopted by the asphalt industry in all EAPA Member Countries. It is written to be useful to those outside the industry also authorities. Hence it should be useful in promoting understanding and dialogue, as well as being a universal reference document in licensing, monitoring and auditing.

The document emphasises that BAT will have different interpretations in different countries, depending on the level of economic development. Interpretation will also vary according to plant location, depending for example whether the plant is located in a remote quarry or a city suburb. Decisions on specific limits for each particular plant will, as hitherto, remain a matter for local decision.

Any comments, queries or suggestions for improvement should be addressed to the EAPA Committee on Health, Safety and the Environment, through the Secretary-General at the EAPA Office in Brussels.

June 2007.

LAYOUT OF THIS DOCUMENT

Chapter 1 gives a brief introduction to EAPA and the European Asphalt Industry.

Chapter 2 outlines recent developments on the many EC environmental initiatives and describes the associated reasons for developing a BAT document for the asphalt industry.

Chapter 3 summarises the wide range of products coming from asphalt plants for those who might not be familiar with the industry.

Chapter 4 proceeds to outline the many types of asphalt mixing plants that are in use in Europe today.

Chapter 5 establishes in some detail the several possible environmental impacts of asphalt plants.

Chapter 6 then proceeds to describe the many corresponding abatement measures that are currently available to minimise the impact of any emissions.

Chapter 7 summarises the techniques for measuring emissions at asphalt plants and explains how to evaluate their magnitude.

Chapter 8 draws the conclusions from all the previous chapters into a set of key recommendations which are the kernel of this BAT guidelines document.

Finally Chapter 9 concludes with a list of relevant publications.

1. INTRODUCTION TO EAPA AND THE ASPHALT INDUSTRY

1.1. EAPA

The European Asphalt Pavement Association EAPA is the European industry organisation representing manufacturers of bituminous mixtures and companies engaged in asphalt road construction and maintenance.

The organisation was founded in 1973. In the beginning of 1990 a permanent office was opened in Breukelen, the Netherlands. In 2005 the EAPA office moved from Breukelen to Brussels (Belgium) to be closer to the European political centre.

At this moment national industry associations and companies from 18 countries are members of the EAPA and there are 5 associate members from non-European countries. The member associations are based in Austria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Netherlands, Norway, Poland, Slovakia, Slovenia, Spain, Sweden, Turkey and UK. Associate member companies come from Ireland and Germany. The 5 non-European associations are based in the USA, Canada, Australia, New Zealand and Japan.

The main aims and objectives of EAPA consist of:

- Promoting the good use of asphalt in the construction and maintenance of roads in Europe;
- Operating as a European industry organisation and representing the view of its members;
- Co-ordinating the common objectives of its member associations;
- Exchanging information and stimulating research and development on all aspects of the asphalt industry and executing common interest projects;
- Ensuring that the manufacture and use of asphalt for roads are of a high quality and in accordance with the environment and the health and safety of all people involved in production and laying.

1.2. The EAPA Committee on Health, Safety and Environment

The development of this document has been the initiative and the task of the EAPA committee that deals with Health, Safety and Environment issues. In this committee experts from all member countries co-operate in establishing documents, guidelines, information leaflets, etc. to help the industry in matters related to the above mentioned subjects.

The main purpose of this document is to address topics which affect the environmental impact from asphalt plants on the surroundings. While it is not the purpose of this document to establish guidelines for Health and Safety issues at the asphalt plant,, the implementation of many actions to reduce environmental impact from the production process will often also enhance working conditions on the plant site.

1.3. The EAPA Technical Committee

The EAPA Technical Committee promotes best practice in the design, production, laying and use of asphalt to contribute to sustainable developments by disseminating Best Practice Documents. This includes encouraging the reuse and recycling of reclaimed asphalt pavements and the development and adoption of European Standards for asphalt mixtures

1.4. The Asphalt Industry

In Europe in 2005 approximately 300 million tonnes of hot mix asphalt was produced. Table 1 indicates a breakdown per country. Since 1973 this figure has been decreasing but seems to have reached a more or less stable level in 2000, because of the volume of the maintenance works related to road construction. Today 90% of the roads in Europe are made of asphalt material.

Asphalt is a mixture of aggregate, sand, filler, bitumen and occasionally a number of additives. In an increasing number of countries old asphalt or demolition waste is recycled to replace virgin aggregate and part of the binder.

In Europe there are at the moment approximately 4,000 mixing plants. The production rate of these installations may vary between 50 and 800 tonnes per hour. Production may vary because of the size of the installation but also because of the number of different mix types which are produced. At a typical mixing plant 3 - 5 people will be employed, depending on the facilities.

Production takes place in a fixed or mobile mixing plant. There are two main production processes namely in batch plants and in continuous mixing or drum mixers.

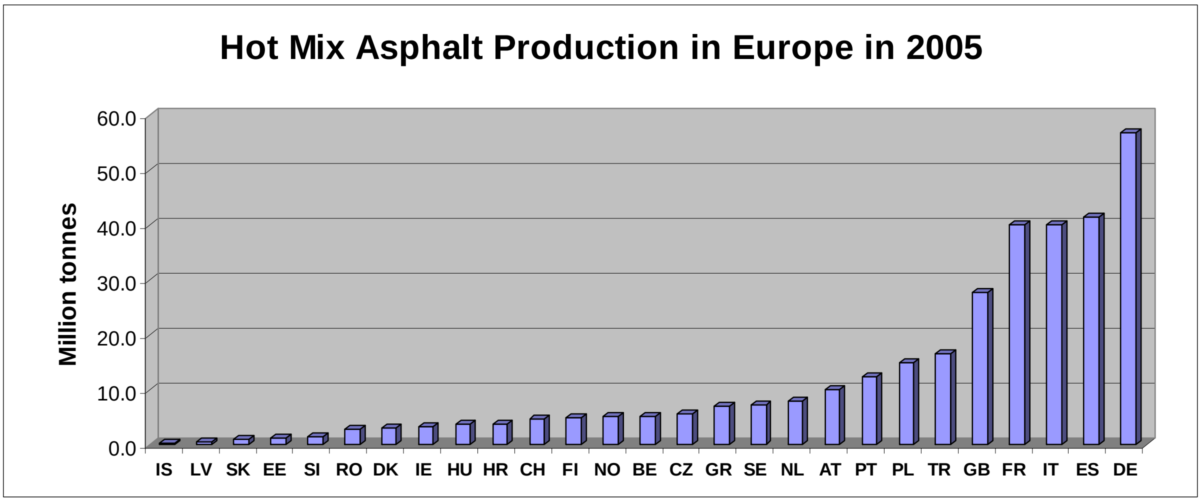


Table 1: Hot mix asphalt production in Europe in 2005 [1.]

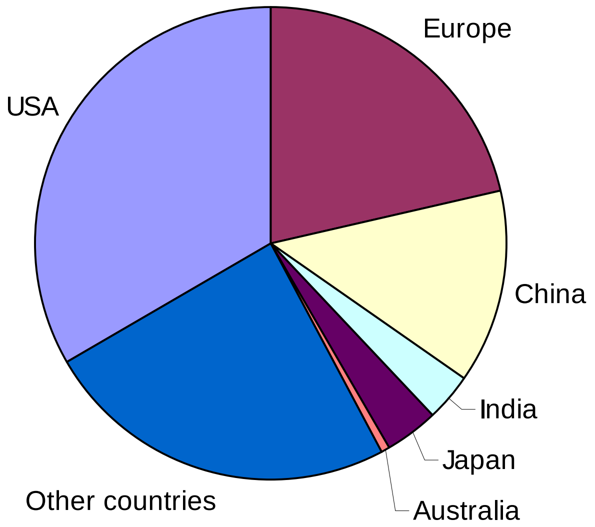
In addition to the different types of hot mix material there are also cold mixes, emulsion mixes, oil gravel and recycled mixes.

Raw materials may be transported over long distances. The finished asphalt however is normally applied within 30-50 km of the mixing plant. Distances up to 100 km may be involved and in the Nordic European countries even transport by ship is undertaken.

The laying of the asphalt on the road is done with special mobile equipment dedicated to spreading and compaction. A typical paving crew exists of 5-6 people. The environmental impact of the laying operation, consisting mainly of emissions and noise production, forms no part of this document. Also the legislative background for mobile construction sites is often different from that for stationary production sites.

The world production of asphalt is estimated to be about 1.500 million tonnes per year:

World Production Hot mix Asphalt



In million metric tonnes	
USA	500
Europe	320
China	200
India	50
Japan	57
Australia	8
Other countries including Russia, South America, Asia, Africa and Canada	365
Total	1.500

2. LEGISLATIVE BACKGROUND TO THE BAT DOCUMENT

2.1. Introduction

This chapter describes briefly the evolution of EC environmental legislation up to the present 6th Environmental Action Program (figure 2.1). As part of this Program several new instruments are being formulated with the purpose of encouraging industries of all types to work to "Best Available Techniques" (BAT) on a self-regulatory basis.

Figure 2.1. Relevance of BAT document to other EC and national initiatives.

BAT refers to abatement technology that is **reasonable, economic and proven in practice**. The following equivalent translations will help clarify the concept:

BAT = Best Available Techniques (defined in IPPC directive, see chapter 2.4)
= RACT, Reasonably Available Control Technology, as used in the US
= Den bedst tilgængelige teknologi, som er teknisk gennemførlig og økonomisk opnålig
= Stand der Technik, aber ohne unangemessenen Kostenaufwand
= Les meilleurs technologies existantes à un coût économiquement acceptable
= Las mejores tecnologias disponibles que no ocasionan costes excesivos
= Beste techniek, die beschikbaar is tegen acceptabele kosten.

The asphalt industry, through this document, is seeking to establish recommended BAT guidelines with the purpose of encouraging consistency of approach across Europe. The BAT document will also serve as a valuable reference for environmental authorities and the public at large, giving greater consistency throughout the industry. The BAT document therefore reflects the importance that the European asphalt industry attaches to good environmental performance.

It is significant to note that the asphalt industry is not specifically targeted in any of the below mentioned EC initiatives, because it is regarded as a low environmental impact industry. Similarly in the US the asphalt industry is categorised in the industry grouping of least environmental impact.

2.2. Legislative background

The Treaty of Rome as far back as 1957 established among the highest Community priorities the "constant improvement of the living and working conditions of its people". The first formal embracing of environmental protection as a Community objective came at the 1972 Paris meeting, leading to the First Environmental Action Program in 1973. This spanned to 1976, and was followed by the Second and Third such Programs covering from 1977 to 1981, and from 1982 to 1986 respectively. The Single European Act in 1987 amended the Treaty of Rome to provide more specific powers to implement environmental policy, leading to the Fourth Program spanning from 1987 to 1992. The Fifth Environmental Action Programme spanned from 1993 to 2000.

During these five Programs more than 200 Directives emanated from the EC on environmental legislation, which have (albeit at varying speeds) by and large been implemented in the Member State national legislations. While none of these Directives referred specifically to the asphalt industry, the broad parameters for its environmental performance could be inferred from requirements for other industries. This inference has however been fairly subjective, meaning that environmental requirements for the asphalt industry have hitherto varied significantly between the EU/EFTA member countries.

The EC Council Directive 84/360/EEC adopted on 28 June 1984 aimed at the provision of measures and procedures to prevent or reduce air pollution from stationary sources (i.e. industrial process or utility plant). The basis of the Directive was the requirement that a wide range of industrial processes should be subject to prior authorisation by the competent authorities of each Member State. A key element of the Directive was the concept of the "Best Available Technologies Not Entailing Excessive Costs (BATNEEC)" to prevent or reduce air pollution, which must be incorporated in a plant prior to the issue of the authorisation to operate.

With the introduction of the Integrated Pollution Prevention & Control Directive in 1996, this has been replaced by the concept of Best Available Techniques (BAT). Despite the absence of the NEEC qualification, the concept of avoiding excessive costs is effectively absorbed in the IPPC definition of availability (see Chapter 2.4 below).

2.3. Sixth Environmental Action Program

The Sixth Environmental Action Programme (6th EAP) was adopted by the European Parliament and Council in 2002 and runs until 2012. It focuses on areas where more action is needed and new European initiatives will make a difference. Thereby the European Commission is required to prepare Thematic Strategies covering seven areas:

- Air Pollution (adopted 21/09/2005)

- Prevention and Recycling of Waste (adopted 21/12/2005)
- Protection and Conservation of the Marine Environment (adopted 24/10/2005)
- Soil
- Sustainable Use of Pesticides
- Sustainable Use of Resources (adopted 21/12/2005)
- Urban Environment

The 6th EAP aims to promote the process of integration of environmental concerns into all Community's policies and activities and to contribute to the achievement of sustainable development throughout the current and future enlarged Community. The Programme provides the environmental component of the Community's strategy for sustainable development, placing environmental plans in a broad perspective, considering economic and social conditions. It also makes the link between environment and European objectives for growth and competitiveness. The Environment Action Programme takes a wide-ranging approach to these challenges and gives a strategic direction to the Commission's environmental policy over the next decade. It requires the Commission to "evaluate the progress made in its implementation together with associated environmental trends and prospects".

European-wide legislation continues to play an important part in achieving environmental objectives. National governments have an obligation to put environmental laws into effect.

2.4. The Integrated Pollution Prevention and Control (IPPC) Directive

The IPPC Directive is one of the EU's set of common rules on permitting for industrial installations.

This Directive of 1996 is about minimising pollution from various point sources throughout the EU. It is designed to prevent, reduce and eliminate pollution at source through the prudent use of natural resources.

Over the last decades tremendous improvements have been achieved in industry regarding several major polluting substances. Nevertheless, industrial production processes still account for a considerable share of the overall pollution in Europe and it is very important to further reduce their contribution to sustainability.
The IPPC contains basic rules for the integrated permits. 'Integrated' means that the permits must take into account the whole environmental performance of the plant, i.e. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, risk management, etc.

The asphalt industry is not covered by the IPPC Directive.

2.5. The Eco-Management and Audit Scheme (EMAS)

The Eco-Management and Audit Scheme is the EU management tool for companies and other organisations to report and improve their environmental performance on a continuous basis. The aim is to encourage industrial companies to establish and implement environmental protection systems.

The scheme has been available for participation by companies since 1995 (Council Regulation (EEC) No 1836/93 of 1993) and was originally restricted to companies in industrial sectors.
With Regulation of 2001 the European Parliament and the Council allowed voluntary participation by organisations of all economic sectors in a Community eco-management and audit scheme.
EMAS was strengthened by the integration of EN/ISO 14001 as the environmental management system required by EMAS.

2.6. The Eco-Label Regulation

In 1992, the EC adopted a council regulation on a Community eco-label award scheme (880/92). This regulation was revised in 2000 (1980/2000).

The Community eco-label award scheme is designed to:

- promote products which have a reduced environmental impact compared with other products in the same product group;
- provide consumers with accurate and scientifically based information and guidance on products.

The eco-label may be awarded to products available in the Community which meet certain environmental requirements and specific eco-label criteria.
The criteria are set and reviewed by the European Union Eco-Labelling Board (EUEB), which is also responsible for the assessment and verification requirements relating to them. They are published in the Official Journal of the European Union.

2.7 Integrated Product Policy (IPP)

All products cause environmental degradation in some way, whether from their manufacturing, use or disposal. Integrated Product Policy (IPP) seeks to minimise these by looking at all phases of a products' life-cycle and taking action where it is most effective.
Because of the wide variety of different products and actors there can not be one simple policy measure for everything and therefore there is a whole variety of tools that can be used to achieve this objective.

2.8. Environmental Liability Directive

The aim of the Environmental Liability Directive is to preventing environmental damage by forcing industrial polluters ("operators") to pay prevention and remediation costs.
The Directive aims to establish a framework that would prevent "significant environmental damage" or rectify damage after it has occurred. The Directive provides specific criteria to assess when damage is "significant".
Operators carrying out certain identified activities will be held strictly liable (i.e. no need to show fault or negligence) for preventing or restoring any damage caused by those activities to land, water and protected habitats and species. More information: **Environmental Liability Directive (2004/35/CE - 21 April 2004)**

2.9. EU Waste Legislation

2.9.1. European Waste Catalogue

Council directive 75/442 on Waste and its amendment 91/156 define the term "waste" as "any substance or object in the categories set out in Annex 1 which the holder discards or intends or is required to discard".

The commission had to draw up a list of waste belonging to the categories listed in its Annex 1. This list is commonly referred to as the European Waste Catalogue (EWC).

Directive 75/442 is addressed to the Member States. This means that Member States are required to take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment, and in particular:

- without risk to water, air, soil and plants and animals,
- without causing a nuisance through noise or odours,
- without adversely affecting the countryside or places of special interest.

Member States are also required to take the necessary measures to prohibit the abandonment, dumping or uncontrolled disposal of waste.

In 2000 the European Commission decided (2000/532/EC) to replace Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste (notified under document number C(2000) 1147). *Official Journal L 226 , 06/09/2000 P. 0003 - 0024*

2.9.2 Framework new Directive on Waste

The strategy on waste prevention and recycling is one of the seven thematic strategies set out in the Sixth Action Programme for the Environment adopted in 2002.

On 21 December 2005 the European Commission adopted a Communication on "Taking sustainable use of resources forward: A Thematic Strategy on the prevention and recycling of waste" [COM(2005) 666].
This strategy sets out guidelines for European Union (EU) action and describes the ways in which waste management can be improved.

The aim of the strategy is to reduce the negative impact on the environment that is caused by waste throughout its life-span, from production to disposal, via recycling.

The strategy provides for existing legislation to be simplified. This will mainly be done by merging the framework Directive on waste with the Hazardous Waste Directive and the Waste Oil Directive.

The main focus of the strategy for **preventing waste production** is on reducing the environmental impact of waste and products that will become waste.

The strategy aims **to promote the recycling** sector in order to reintroduce waste into the economic cycle in the form of quality products, while at the same time minimising the negative environmental impact of doing so.

Recycling could be encouraged by amending the regulatory framework, in particular to include the option of introducing efficiency criteria for recovery operations as well as criteria for distinguishing waste and products, criteria which would lead to minimum quality standards and which would facilitate the dissemination of best practice in Europe.

EAPA is monitoring developments to ensure that waste categorisation or regulations do not inhibit recycling of asphalt or use of secondary materials in asphalt mixes.

2.10. Environmental Management Systems

The Environmental Management Systems is a series of international standards on environmental management. It provides a framework for the development of both the system and the supporting audit program.
ISO 14001 was first published in 1996 (and revised in 2004) and specifies the actual requirements for an environmental management system.
It applies to those environmental aspects for which the organization has control and over which it can be expected to have an influence.

ISO 14001 is the corner stone standard of the ISO 14000 series. It is only ISO 14000 standard against which it is currently possible to be certified by an external certification authority. It does not itself state specific environmental performance criteria.

This standard is applicable to any organization that wishes to:

- implement, maintain and improve an environmental management system
- assure itself of its conformance with its own stated environmental policy (those policy commitments of course must be made)
- demonstrate conformance
- ensure compliance with environmental laws and regulations
- seek certification of its environmental management system by an external third party organization
- make a self-determination of conformance

It is widely used in the asphalt industry.

2.11. National legislation

Apart from the above European legislation, it is recognised that a wide range of planning and environmental legislation exists in the Member States. Under the subsidiarity principle, the European legislation will give appropriate recognition to these national legislations. Therefore the precise interpretation of BAT requirements will vary somewhat from country to country.

These national differences will be reflected in the operating permits given to individual asphalt plants.

2.12. Industry responsibility

The above Sections demonstrate the various reasons and purposes behind the development of the BAT document. However, more importantly, the asphalt industry views environmental developments very responsibly. Therefore it promotes the spirit and content of this BAT document very proactively, and through it wishes to signal its determination to continue and excel as an environmentally responsible industry.

3. Asphalt Mixtures

3.1. Introduction

Conventional asphalt is basically a mixture of natural raw materials: sand, aggregate, filler and bitumen. In addition to these "standard" materials from natural sources, some additives may be incorporated to influence the performance of the product. Examples are adhesion agents, modifiers and fibres.

Hot mix asphalt is a mixture of approximately 95% of well graded aggregates, together with filler and sometimes additives. Bitumen makes up the remaining less than 5% of the mixture. Bitumen is the black, sticky component (binder) that "glues" the aggregate together. Polymer modified bitumens are increasingly used to modify the performance of the asphalt mixtures in special applications. Filler is used in asphalt to fill out the smallest voids and to stabilise the binder.

In a number of applications bitumen emulsion is used as binder in the mixture with sand and aggregate. Bitumen emulsions are heterogeneous two-phase systems consisting of bitumen and water. The bitumen is dispersed throughout the continuous water phase in the form of discrete globules, which are held in suspension by electrostatic charges stabilised by an emulsifier. An emulsifier consists of a long hydrocarbon chain which terminates with either a cationic or an anionic functional group. The emulsifier is not only a stabilising agent but also an adhesion promoter. Emulsion based mixtures are referred to as "cold mixes".

Next to “hot mixes” and “cold mixes” it is also possible to produce “warm mixes”. This is a new technology and several techniques have been developed to produce “warm mixes”. Sometimes they are known as “Low Temperature Asphalt” i.e. low temperature compared with Hot Mix Asphalt.

From the outset a clear distinction must be drawn between bitumen and tar. Bitumen is derived as a residual product from the refining of crude oil. Tar is derived from the pyrolysis of coal. Because of known health and safety concerns regarding tar, its usage as a primary material was terminated in most countries many years ago.

The most commonly used hot, warm and cold mixes are described below:

3.2. Hot Mixes

3.2.1. Asphaltic Concrete

“Asphalt in which the aggregate particles are continuously graded or gap-graded to form an interlocking structure” [2.]. (The inverted commas indicate definitions taken from the European Asphalt Standards EN 13108 – 1 to 7. [2. to 8.]).

3.2.2. Asphalt Concrete for very thin layers

“Asphalt for surface courses with a thickness of 20 mm to 30 mm, in which the aggregate particles are generally gap-graded to form a stone to stone contact and to provide an open surface texture” [3.].

3.2.3. Soft Asphalt

“Mixture of aggregate and soft bitumen grades” [4.].

3.2.4. Hot Rolled Asphalt

"Dense, gap graded bituminous mixture in which the mortar of fine aggregate, filler and high viscosity binder are major contributors to the performance of the laid material" [5.]. Coated chippings (nominally single size aggregate particles with a high resistance to polishing, which are lightly coated with high viscosity binder) are always rolled into and form part of a Hot Rolled Asphalt surface course.

3.2.5. Stone Mastic Asphalt

"Gap-graded asphalt mixture with bitumen as a binder, composed of a coarse crushed aggregate skeleton bound with a mastic mortar" [6.].

3.2.6 Mastic Asphalt

"Voidless asphalt mixtures with bitumen as a binder in which the volume of filler and binder exceeds the volume of the remaining voids in the mixed" [7.]. For this mixture a relatively hard bitumen is used and therefore it is produced (in an asphalt plant) at a significant higher temperature than the other asphalt mixtures. The storage of mastic asphalt differs from other asphalt mixtures because the mastic asphalt has to be stirred during storage.

3.2.7. Porous Asphalt

"Bituminous material with bitumen as a binder prepared so as to have a very high content of interconnected voids which allow passage of water and air in order to provide the compacted mixture with drain and noise reducing characteristics" [8.].

3.3. Warm Mixes

Recently new technologies have become available to reduce the production and application temperature of hot mixes. Although in their infancy, these technologies allow the production of the asphalt mixes at reduced temperatures compared to the conventional / comparable Hot Mixes by reducing the viscosity of the bitumen. Depending on the chosen technology, a reduction in the mixing temperature of up to 30^{o} C can be anticipated and even more for mastic asphalt. [12]

3.4. Cold Mixes

Cold mixes are produced without heating the aggregate. The binder is a bitumen emulsion. The emulsion breaks either during mixing or compaction, to coat the aggregate, after which there is an increase in strength over time. The strength development is a result of expulsion of water from the aggregate matrix and the coalescence and subsequent cohesion of the bitumen particles.

Cold mixes can be used for strengthening and reprofiling lightly trafficked roads. They have several advantages. There is no need to heat the aggregate and by using emulsion no fumes will be generated. The disadvantage is that the water used in producing the emulsion needs to be expelled from the mix after breaking of the emulsion.

Another cold technique is the use of foamed bitumen. With this technique the bitumen is foamed and injected directly into the mixer with the mineral aggregate with some additional moisture. Cold mixes with foamed bitumen can be used in thick layers (40 - 50 mm) as surface layer for lightly and medium trafficked roads. `

3.5. Use of reclaimed asphalt

The industry strongly supports all efforts to increase the percentages of reclaimed asphalt into new hot mix asphalt. It is the aim of the industry to reuse reclaimed asphalt at the highest possible level. This is economically (because of the reuse of the bitumen as well as the aggregates) and environmentally desirable.

If a reclaimed asphalt contains more PAH’s and/or phenol than a certain limit value, it is considered as “asphalt containing tar”. According to the definition in the EURAL waste list:
“Reclaimed Asphalt containing more than 0,1 % coal tar should be regarded as hazardous waste. In case of asphalt containing tar, the waste is considered hazardous and the hot recycling is not allowed. In some countries it is allowed to rely on cold techniques with or without binders (emulsion, foam bitumen, and or hydraulic binders)”.

Reclaimed asphalt can also be used as road base material. For this use the broken asphalt granulate is usually stabilised with bitumen emulsion and/or cement. In some cases sand and/or water are added.

3.6. Processes not covered by these guidelines

Asphalt mixing plants may be used for other purposes than the production of the asphalt products listed in section 3.2, 3.3 and 3.4, e.g. for soil remediation. These guidelines are not applicable to such production..

4. PLANT TYPES AND PROCESS DESCRIPTIONS

4.1. Introduction

This chapter explains the basic processes that are involved in the production of hot mix asphalt. The concept for asphalt mix plants has more or less been the same during the last 25 years. Today they are divided into two main types: Drum mix plants and batch mix plants. Currently batch mix plants, in which mixing is carried out in a special mixer unit (often referred to as the pug-mill), predominate in Europe. In drum mix plants the mixing process takes place in the drum. A description of the mode of operation of the batch and drum processes includes a brief mention of the most common configuration variations with emphasis on recycling of reclaimed asphalt (RAP).

A brief introduction to in-situ recycling, warm mix technology and cold mix asphalt processes finishes the chapter.

The diagrams included in this chapter should be considered as schematic and do not give all possible process combinations.

4.2. Basic process description, including both stationary and mobile plants

Generally an asphalt plant can be divided into the following main parts:

- hoppers of the cold feed unit;
- aggregate drying unit and connected bag filter;
- bitumen storage tanks and filler silos;
- mixing tower: mixing unit, (add. in batch plant: hot screening and hot aggregate storage bins)
- silos for storing hot asphalt (not necessarily).

The asphalt mixing process consists of heating and drying aggregates which then are mixed with filler and bitumen. The mixed asphalt is then transferred directly to waiting delivery trucks or to silos for short-term (surge) storage or for up to 48 hours long-term storage before loading into trucks for transportation to the paving site.

The complete plant operation is monitored from the control house of the plant. The degree of automation and electronic control varies between plants, depending mainly on plant mobility and age. Small plants can be operated through simple control mechanisms. A fully computerised process control can monitor for example: burner combustion, fuel consumption, process air volumes, drum pressures, exhaust gases, baghouse pressure, flow rates for used materials and finished mix transfer, discharge and storage selection.

The typical energy consumption of an average asphalt plant is approximately 70 - 100 kWh per tonne for the burner (depending on the type and temperature of the mixture, the moisture content of the aggregate, etc.) and 5-8 kWh per tonne for transport and storage heating of the materials. Lowering the manufacturing temperature reduces the energy need. For example if the mix temperature is lowered 35 ^{o}C, energy consumption reduces approximately 10 kWh/tonne of asphalt (equivalent 1 litre Oil/tonne of asphalt). These kinds of temperatures are possible to reach when using warm mix technologies. Using dry aggregate, properly working equipment and appropriate work methods can also reduce energy consumption.

Most asphalt plants are permanently sited installations (static plants). However in some cases it is advantageous to move an asphalt plant from site to site to supply major works.

This requires availability of mobile plants. A further variation is the limited use of driven asphalt plants where the mixing and laying of asphalt is unified in a continuous process on the job site. Regardless of degree of mobility (stationary, mobile, driven) the principles of asphalt production stays the same.

Typical plant capacities are 100-300 tonnes per hour.

In some countries, asphalt plants are located near or in a quarry. However, this document does not cover quarrying operations.

In last decade there has been an increasing tendency to design plants to recycle old asphalt pavements. This is important for environmental reasons and to utilise the growing stocks of RAP. In turn this has meant supplementing the general process with a few additional steps. Recycling means that the use of virgin aggregate and bitumen can be reduced.

4.3. Batch mixing plants

4.3.1. Batch configuration, diagram, description

Today in Europe most asphalt plants are of the batch type. A common variation of batch type plant is the tower plant. Figure 4.1 shows a flow diagram of the process.

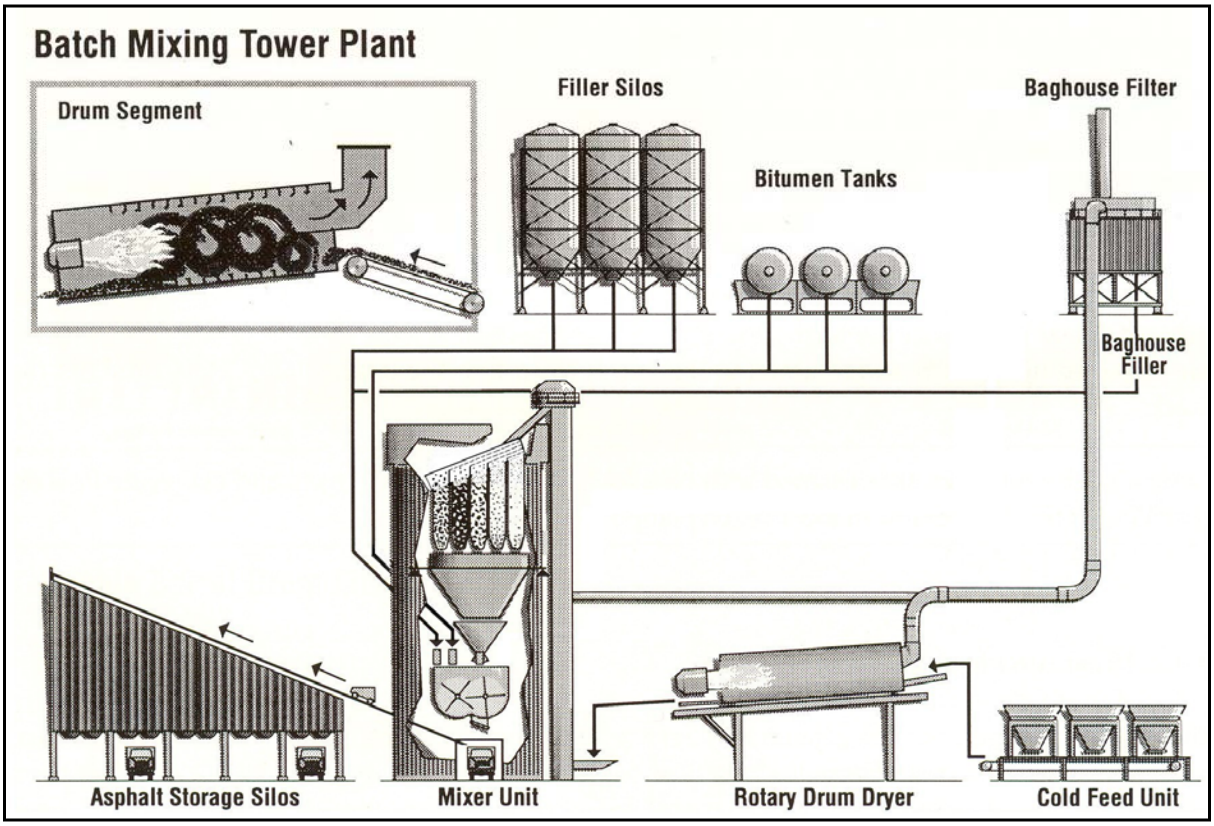


Figure 4.1.

Raw aggregate used for the production of asphalt is normally stockpiled near or at the actual plant site. It is advantageous for energy economy to store the raw material at a location where bulk moisture content can be kept at a minimum.

From the storage piles the aggregate is hauled and placed in the appropriate cold feed hoppers. Here the different sizes of aggregate are metered on to a conveyer belt in specific portions, depending on the type of asphalt mixture required (see Chapter 3), and transported to the intake of the rotary drum dryer. The rotary dryer is a steel cylinder with flights placed on the inside. As the drum rotates, the flights lift the material and let it fall down through the hot air stream in the drum. At the same time the aggregates slowly flow forward because the drum is placed with a slight inclination. Usually the counter flow process is followed (i.e. where the gas flow direction is opposite to the material flow).

Important control parameters for the drum are angle of inclination, rotational velocity, and flight design. For the heating and drying of aggregates a gas-, coal- or oil-fired burner is placed at one end of the drum. Heat is thus mainly transferred by convection.

As part of the abatement technique, water vapour and exhaust air are sucked out at the cold end of the drum from where it is led through a dust separator. The cleaned air is finally exhausted to the atmosphere through a smoke stack. Most often baghouses are used for dust separation.

The dust collected in baghouses (filler) is continuously- or batch-fed back to the mixing process or goes to a separate silo.

After leaving the dryer the hot aggregates (temperature 135-180°C) drop into a bucket elevator and are conveyed to the top of the mixing tower. In tower plant type (hot-stock principle) the drying process constitutes a separate part of the overall process and can to some extent be carried out independently of the mixing of asphalt (see figure 4.1). Instead of entering the pug mill immediately after heating and drying, the aggregates are transferred onto vibrating screens and separated into different grades in individual hot aggregate storage bins. Alternatively these may be stored in a by-pass bin for direct coating. When a recipe is chosen the aggregates are promptly dropped into the weigh hopper. From the weigh hopper the aggregate goes into a pug mill (mixer) where it is coated with bitumen which is pumped from a heated storage tank, weighed and injected into the mixer. At this stage also the specified amount of filler is added to the mix. Mixing time varies between 25 and 90 seconds, depending on plant and mix type. Hot stock principle enables a rapid supply of different asphalt mixtures.

The finished asphalt mix is then transferred either directly to a waiting truck for immediate delivery to the job site or by a conveyer to heated asphalt storage silos.

One type of batch plant, although rarely used, is a screen drum plant. In this plant type the drum operates as a counter flow drum dryer. At the end of the drum the heated aggregates fall onto a screen which surrounds the dryer drum. The screen separates aggregates in to 4 or 5 different grades which are stored in hot bins. From this stage the plant operates like a normal batch mixing plant.

4.3.2 Batch plants designed for recycling

The general configuration of an asphalt plant using the batch principle is described above, but the increasing use of RAP sets additional requirements for the plant., The most common plant variations for recycling are introduced in the following text.

The recycling techniques include cold, hot and recycling ring methods. For all methods the broken up material must be of the correct size and may need to be screened into correct sizes before further processing.

Cold methods refer to the addition of the RAP either at the discharge of the dryer into the hot elevator where the material is heated by virgin aggregates before entering the pug mill (see figure 4.2) or directly into the pug mill. Here the appropriate amount of new bitumen is added to the mixture according to the required properties. It is important to pay attention to avoid heating added raw materials too much. Cold methods employ recycling percentages of 10-30%, depending on moisture content of the recycled materials, the quality of the reclaimed asphalt in relation to the required specification of the new hot mix and the technical process limitations regarding maximum permitted temperatures.

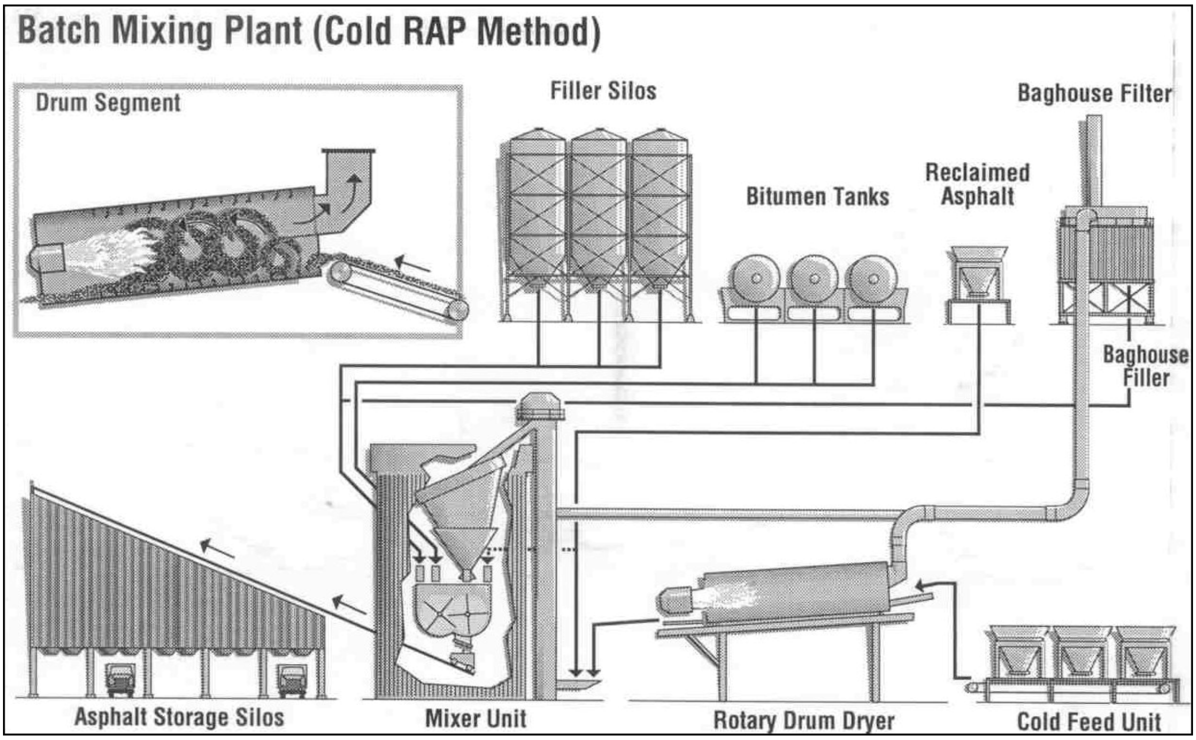


Figure 4.2.

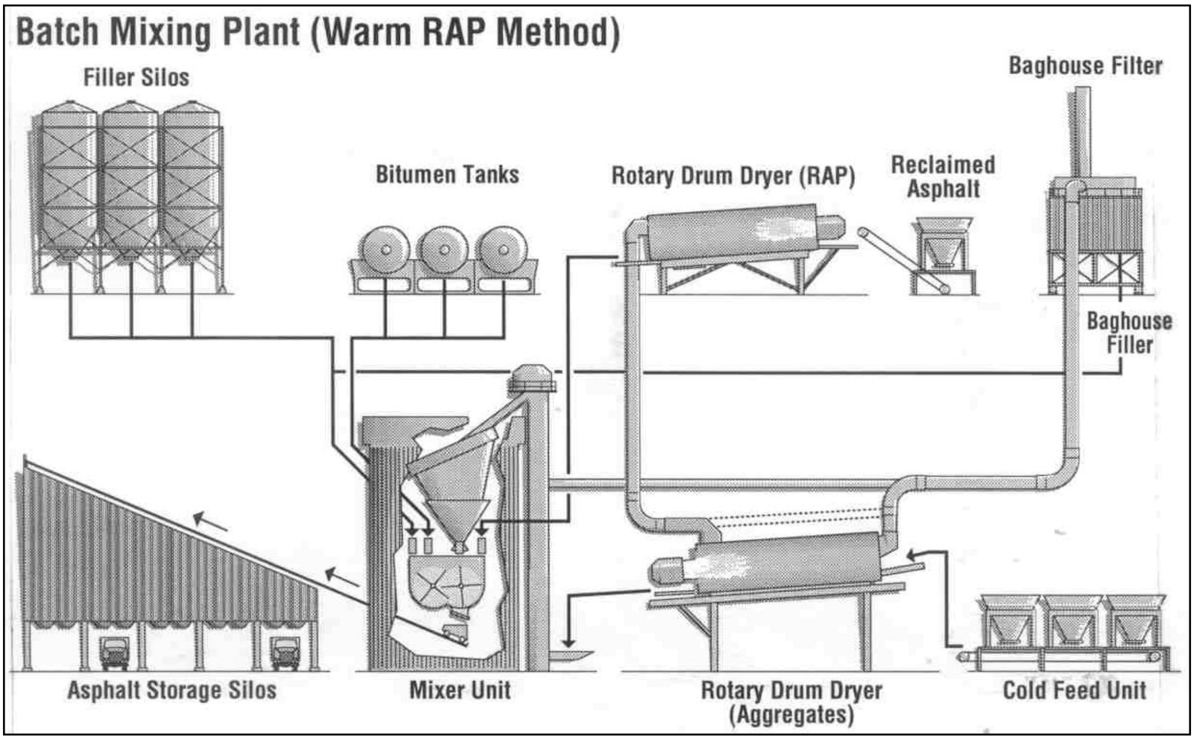


Figure 4.3.

Employing the hot method means that the reclaimed material is directly preheated (see figure 4.3). This is usually done by using an extra dryer (tandem drum). The reclaimed material is metered and heated and dried in the second drum and transferred via a buffer silo to the mixer.

Virgin aggregates are heated in the first drum and conveyed to the mixer by following the steps described in the previous section. The hot gases from the recycling drum are led either directly to the virgin aggregate dryer drum as secondary air near the burner or to the baghouse filter. Recycling percentages for the hot method are typically 30-70%. The upper limit is determined by the quality requirements of the mix specification in relation to the properties of the RAP.

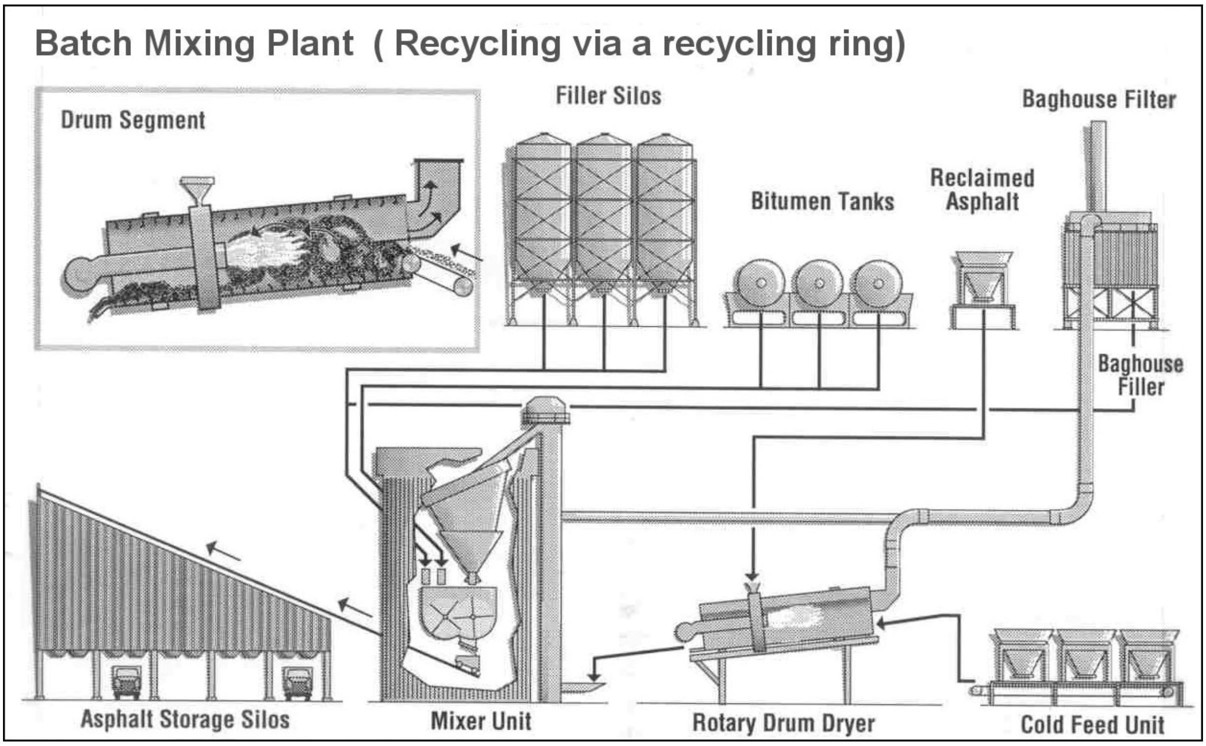


Figure 4.4.

Another variation on hot recycling is the recycling ring system (see figure 4.4). In this variation the virgin aggregates and recycled material are introduced in the same drum but in two different places. The heating of recycled asphalt takes place behind the flame, ensuring that the recycled materials do not become overheated. This method allows 35-50 % recycling depending on the system.

4.4. Drum mixer plants

4.4.1. Drum configuration, diagram, description

In a drum mixer both heating and drying of aggregates and mixing of aggregate, filler and bitumen takes place inside the drum (or sometimes externally). It simplifies the mixing process as vibrating screens, hot aggregate storage bins and the mixer are replaced by proportional feed controls into the drum mixer. In certain so-called twin drum plants, however, the heating and drying takes place in one drum and mixing in a second drum. Drum mix plants are somewhat less flexible in changing between different mixes, hence the predominance of batch plants in Europe today.

The configuration of a traditional drum mix plant is depicted in figure 4.5. Basically only the mixing process differs from the batch process. Aggregates are fed into the revolving drum and heated and dried by hot burner gases in the drying zone of the drum. About midway filler and liquid bitumen are injected along the drum where these mix with and coat the other constituents (mixing zone). Flights inside the rotating drum ensure that drying and mixing is done properly before the finished asphalt is discharged to a conveyer and carried to the top of the heated storage bins or directly into a truck.

Combustion gases and water vapour from the heating and drying process are drawn out by an exhaust fan at the end of the baghouse. A large portion of the dust particles are collected in the filter and returned to the mix in the drum. The cleaned air is exhausted out the stack.

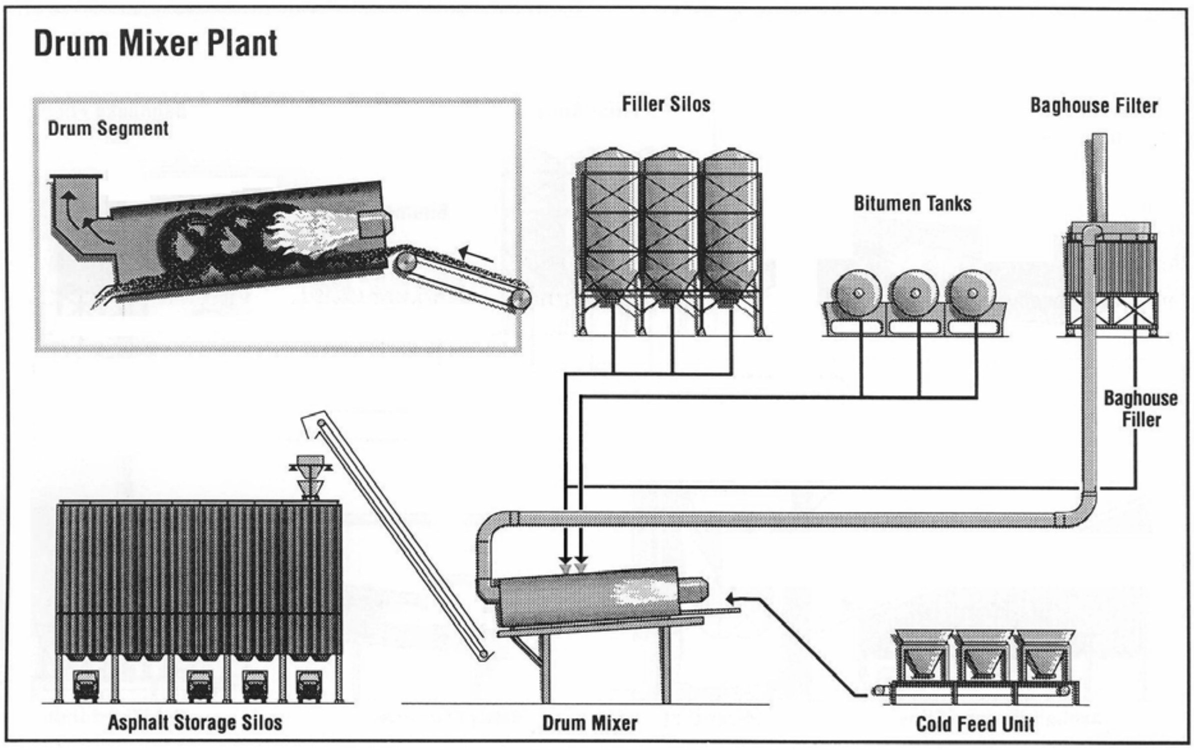


Figure 4.5.

Generally, drum mixers are designed with parallel flow for hot burner gases and aggregate flow (in comparison to counter-flow in most batch plants).

4.4.2. Drum variations, including recycling

This section first outlines the general principles of drum mix recycling. Succeeding paragraphs deal with the most common and popular modifications of the drum mix process which mainly has been spurred by recycling considerations. Therefore recycling also constitutes an integral part of these sections.

Basically it is possible to identify three different methods of heating recycled material before the bitumen is added: Direct flame heating, indirect flame heating, and heated aggregate.

The most common design for drum mixers today uses both the direct flame heating and heated aggregate principle. In so-called split feed drum mixers the processed reclaimed asphalt is introduced at about the midpoint of the drum (see figure 4.6). The asphalt is then heated by both the heated virgin aggregate and the hot burner gases.

Double barrel drum mixer plant

Another method used is the double barrel drum mixer (see figure 4.7). The system consists of an ordinary revolving counterflow (explained below) drum surrounded by a fixed outer drum. Recycled material is introduced in the outer shell outside the hot gas stream. The virgin material is dried and heated in the inner drum. It then enters the outer drum by falling through openings in the inner drum. Virgin aggregate then travels in opposite direction to be mixed with injected bitumen and recycled material. Mixing thus takes place in the space between the two drums as blending blades are mounted on the exterior shell of the inner drum.

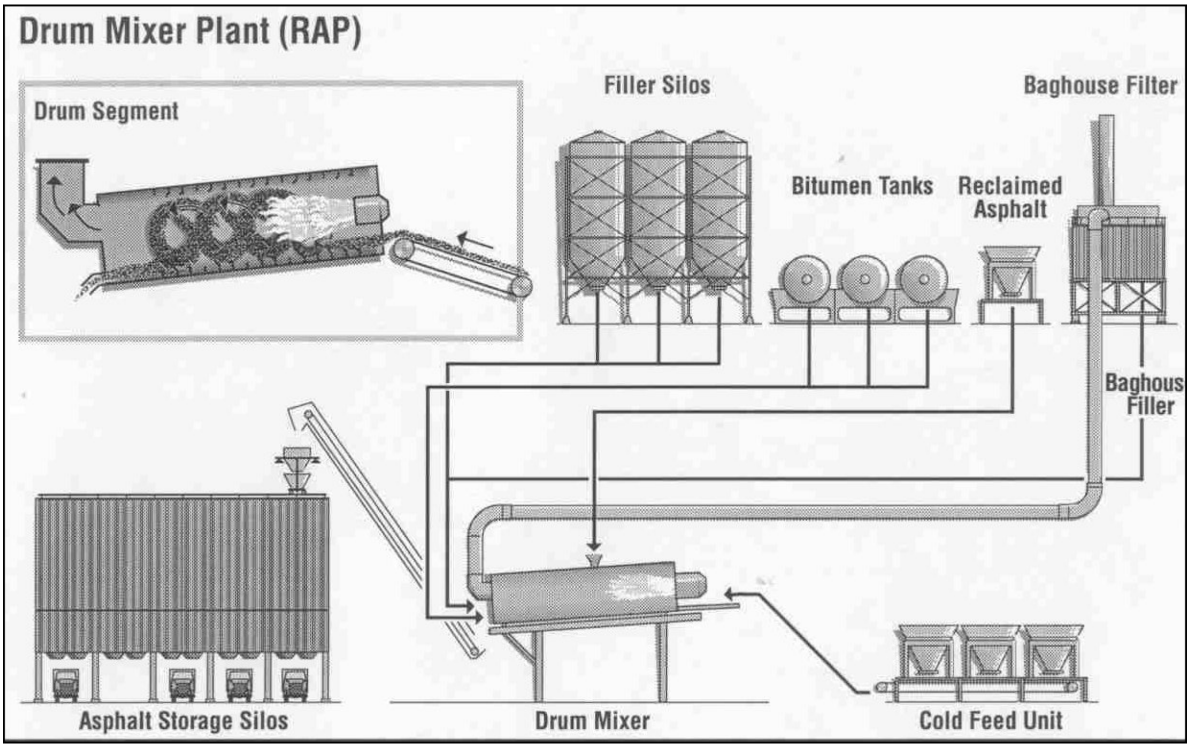


Figure 4.6.

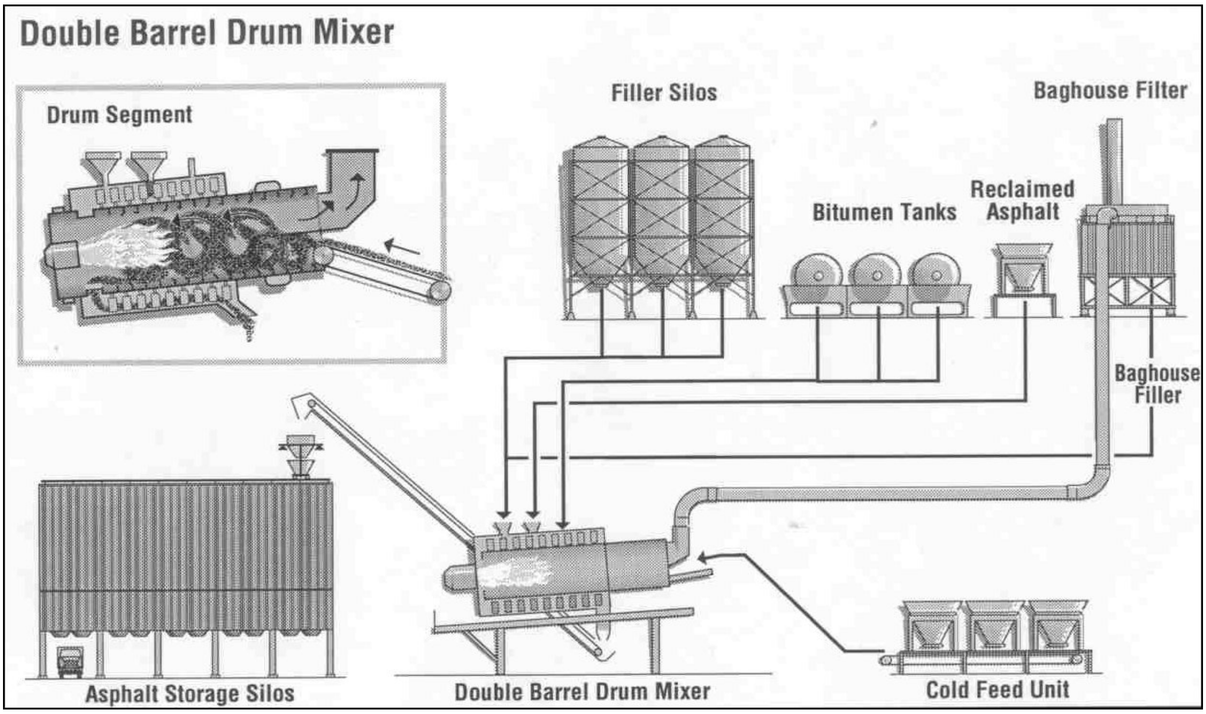


Figure 4.7.

Other measures of indirect flame heating principally comprise arrangements with heat exchanger tubes preventing the mixture of reclaimed asphalt and virgin aggregate from coming into direct contact with the flame.

Counterflow drum mixer plant
Counterflow mixers differ from traditional parallel flow plants in that the flow of hot burner gases and aggregates occur in opposite direction (see figure 4.9). Technically the counterflow principle enables a reduction of temperature of the hot gases and improved environmental performance through less heating of the recycled asphalt.

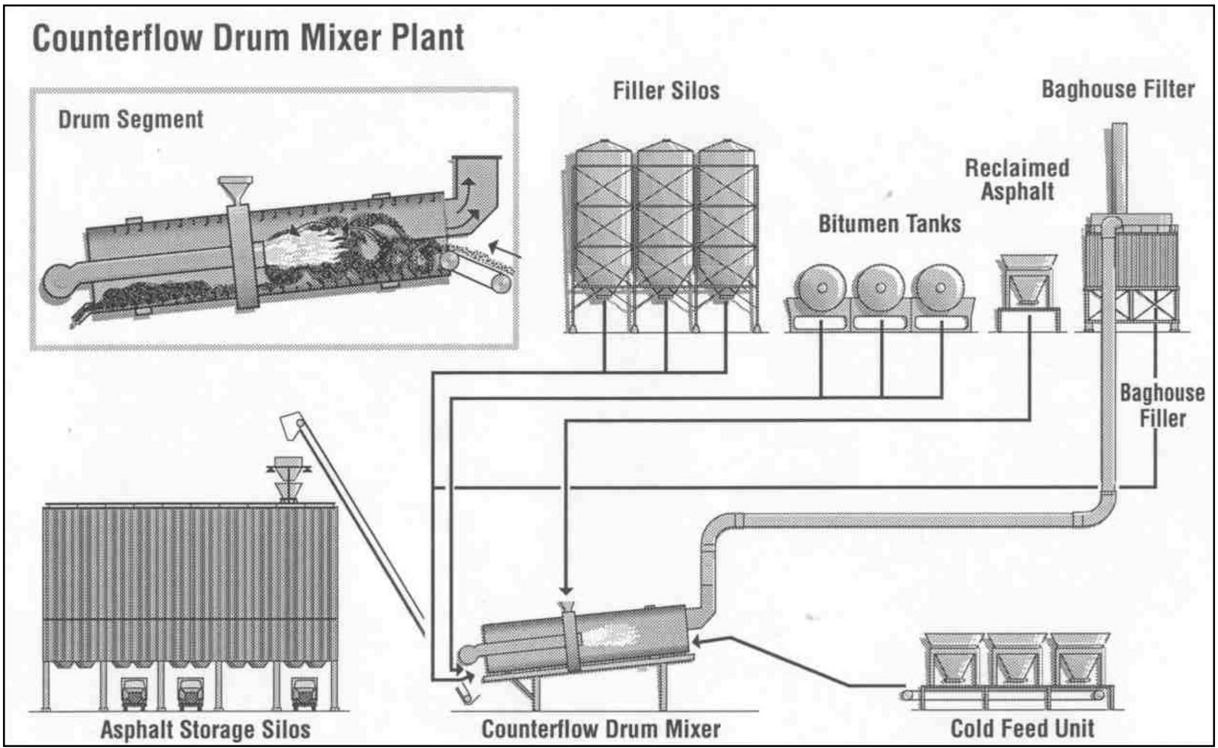


Figure 4.8.

Virgin aggregate is introduced in one end of the drum (opposite burner). Recycled material is introduced into the drum about midway. The burner nozzle is extended, by aid of a tube, well into the drum so that preheating of recycled material takes place behind the flame before entering the mixing zone. Consequently bitumen and recycled material are never in direct contact with the flame and heated gases. Under optimal conditions this process allows up to 50% recycling.

4.5 Hot mix in-situ recycling

There are basically two main techniques to use RAP in-situ. These methods are important maintenance tools when successfully established. Among their advantages are a reduction in transportation of RAP and rapid re-opening of the road to traffic. The finished pavement often contains more than 90% recycled material.

In the Remix-method, the existing pavement is preheated, usually with gas heaters, loosened and some new asphalt and, in some cases, new binder is added. The mixture is then spread and rolled to form the new pavement.

An Asphalt Recycling Travelplant consists of a traditional parallel flow drum mixer on wheels supplemented with an asphalt finisher. The existing asphalt pavement is milled of and placed in a windrow to which virgin aggregates are added. After that materials are transferred to the drum mixer where heating, mixing and addition of bitumen takes place. The mixed asphalt is then laid and rolled to form the new pavement. With this method the dusty air inside the drum mixer is emitted uncleaned to the surroundings.

4.6. Warm mix technology

Nowadays, for health and environmental reasons and because of high energy prices, means of lowering asphalt production temperatures are under strong development in the asphalt industry. Different methodology is used among these techniques. In this text terms warm mix and low temperature asphalt are used and they mean the same. However, it should be noted that warm mix technology is different to cold mix technology.

Lowering the temperature of the asphalt mix also has significant impact on the emissions and fumes. Tests indicate that the energy consumption in the production process can be reduced by 10 kWh/tonne of asphalt (equivalent 1 litre Oil/tonne of asphalt) if the mix temperature is lowered 35^{o}C. In addition to fewer emissions, less fumes and less energy consumption, other advantages of Warm Asphalt are less wear of the asphalt plant, less aging of the binder and earlier opening of the road for traffic. However this product could be more expensive due to the additives, etc. and the technique is still developing.

In principle, there are several methods for the production of low temperature asphalt. These methods are based on process engineering, aerogenous agents or special bitumen and additives. Usually implementing these methods won’t require large technical changes to the plant. In most cases changes are limited to adding a foaming unit or extra silos. The following techniques for Warm Asphalt are available [12.]:

4.6.1 Process engineering

The present process engineering techniques are the addition sequence method (also known as the KGO method), the double-coating or 2-phase mixing method and the addition of moist or moisture-retaining aggregate. Compared to conventionally produced asphalt, asphalt produced according to this mixing method could be mixed, laid and compacted at approximately 10-30^{o}C lower temperature.

4.6.2 Foam bitumen

Warm Foam asphalt is produced at temperatures between 90-100^{o}C. Foam asphalt can be used in surface layers and in base layers and has the same properties as hot mix asphalt.

4.6.3 Aerogenous Agents

The method with the aerogenous agents is based on chemically bound water that is released during asphalt mixing. The aerogenous agent technology is currently limited to the exclusive addition of zeolites during the mixing process. By adding zeolites the asphalt temperature of rolled asphalts is lowered by approx. 30^{o}C.

4.6.4 Special Bitumen and Additives

Organic additives, such as Fischer-Tropsch paraffin wax and low molecular weight ester compounds, reduce the asphalt viscosity within the working temperature range and enable temperatures to be reduced up to 30 – 40^{o}C during mixing, laying and compaction of mastic asphalt and rolled asphalt.

4.6.5 Warm Emulsion Technique

Here a high residue emulsion is used together with a chemical package of agents for coating and improving the adhesion. The mixing temperature is between 70 – 115°C.

4.7. Cold mix technology

Besides the production of hot mix asphalt the possibility exists for mixing the different ingredients at lower temperatures without heating.. The final properties of this cold mix asphalt are obviously different from those of hot mixes. Usually these mixes are used in the low traffic roads or in a base course.

The basic change which permits mixing at lower temperatures is the use of bitumen emulsion or soft bitumen. Cold emulsion based road mixes can either be mixed on site or on a stationary/mobile mixing plant. Only the latter is within the scope of this document.

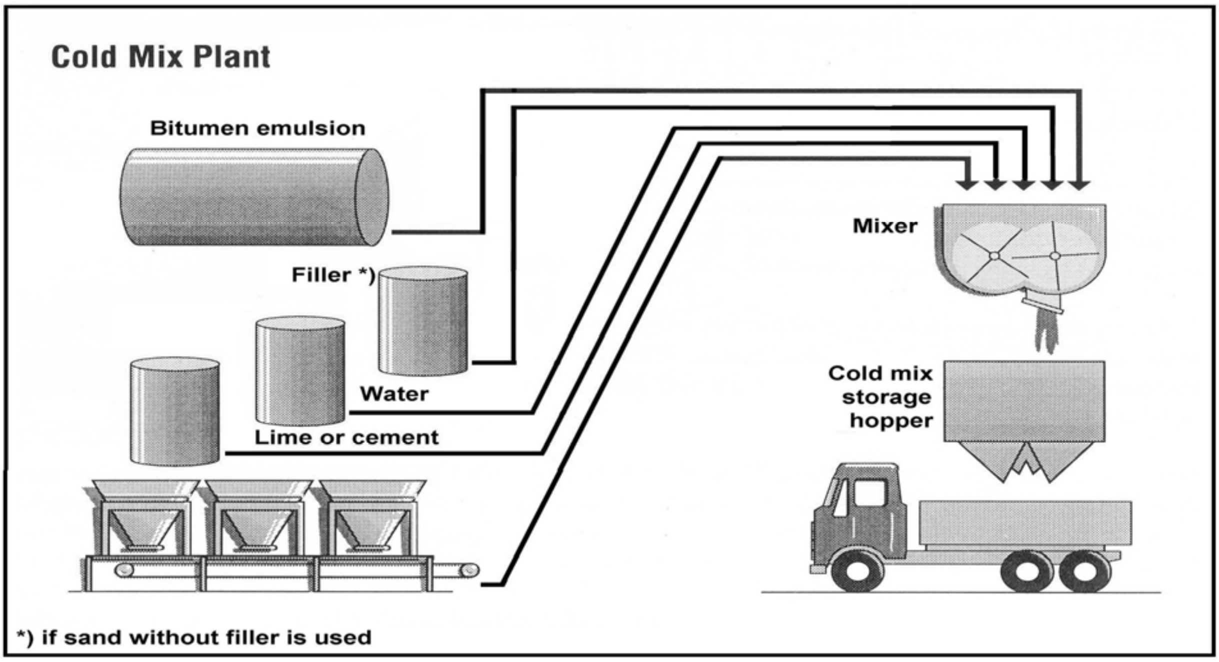


Figure 4.9.

As an example of a cold mix plant, reference is made to figure 4.10. Cold mix is a continuously graded bitumen mix consisting of aggregate, water and a slow setting water based bitumen emulsion. When using soft bitumen, the mix consists only of aggregate and binder.

If necessary, aggregates are first screened into different sizes and are fed onto a collecting conveyor. The combined aggregate is transported by the conveyor to the mixer. The mixer comprises two contra-rotating longitudinal shafts with blades attached. The appropriate amount of water is sprayed onto the aggregate as it enters the mixer and bitumen emulsion is added through a spray bar also at the required rate. The added water serves to disperse the emulsion uniformly in the mixture and lubricate the aggregate to facilitate later compaction. In the soft bitumen application only binder is added through the spray nozzles. The resulting cold mix is then discharged into a receiving hopper which stores the mix until it is discharged into a waiting truck.

5. TYPES OF POSSIBLE ENVIRONMENTAL IMPACT

5.1. Introduction

The listing of potential environmental impacts follows the normal order in existing regulations and directives in many European countries. Furthermore it should be recognised that the consequences of the different types of impact vary considerably. The impacts are listed below in approximate decreasing order of importance. The parallel abatement techniques have been well developed as described in chapter 6.

Impact may be:

- associated with **normal operation** of the plant. These may be continuous (e.g. from the drum) or discontinuous (e.g. from loading the lorries);
- associated with **upsets** resulting from unplanned incidents. These are difficult to quantify since they are by definition unexpected, and may result from various circumstances;
- associated with **changes in operating conditions**, e.g. changes in mix temperature, or
- associated with **start-up and shut-down** which result from planned filling, purging or draining operations performed when bringing a unit or the plant into or out of service.

Technical measures have to be taken to abate normal operational impact. Occasional impact has to be covered by good housekeeping and environmental management.

This document places emphasis on abatement techniques related to specific emissions of asphalt plants (mostly dust and gaseous organic and inorganic emissions) and less emphasis on non-specific emissions (noise, waste etc.).

Figure 5.1. Gives an overview of possible sources of emissions at an asphalt plant. The characters in figure 5.1 are related to the examples mentioned in table 5.1.

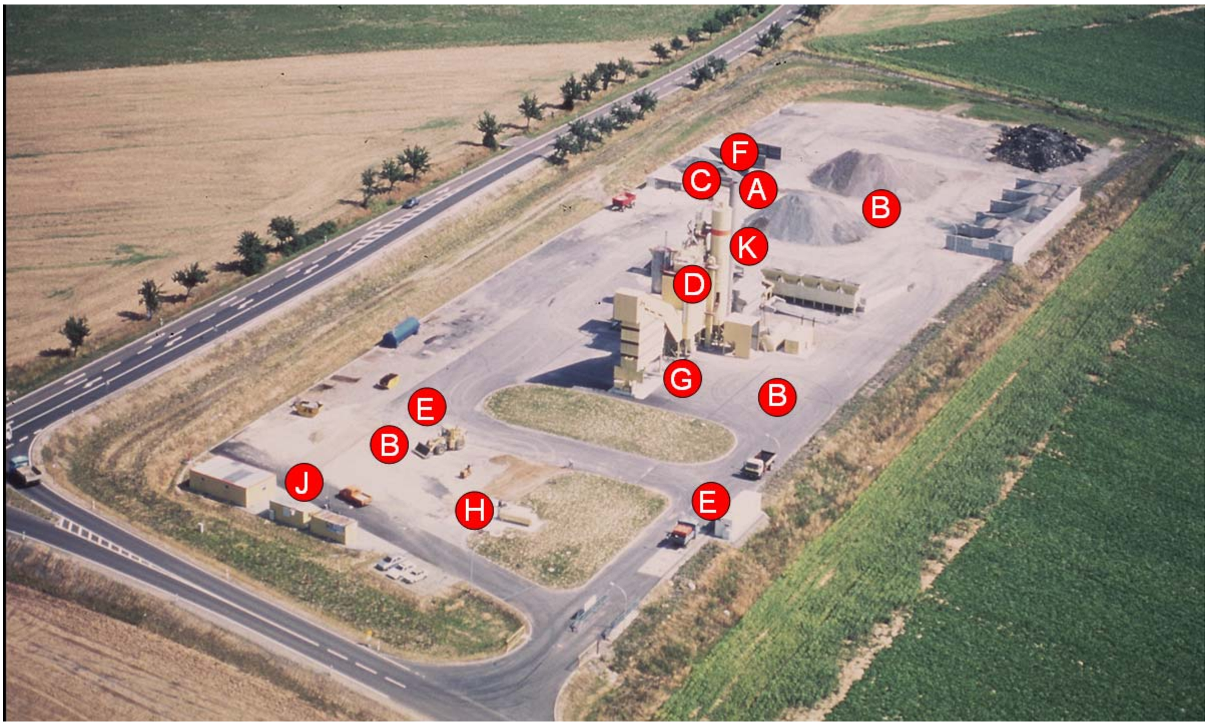


Figure 5.1. View of an asphalt plant, indicating possible sources of emissions.
"This picture was intentionally chosen to be able to show all sources of emission. It is not intended to show the most perfect plant with regard to minimizing environmental and visual impact."

Possible environmental impact	Source	Source reference number in figure 5.1	Impact description in chapter 5	Abatement techniques in chapter 6	Emission measure-ments: in chapter 7
Particulates			5.2	6.2	7.4
- Stack dust	Stack dust	A	5.2.1	6.2.1	7.4.1
- Other sources and fugitive dust	Fugitive dust	B	5.2.2	6.2.2	7.4.1
Gaseous emissions	Stack	C	5.3	6.3	7.4
Noise	Plant Traffic	D E	5.4	6.4	7.5
Odour	Stack (fuel) Loading trucks	F G	5.5	6.5	7.6
Water effluent, ground water preservation	Fuel tank	H	5.6	6.6	
Waste	Laboratory waste	J	5.7	6.7	7.7
Visual aspects	The plant itself	K	5.8	6.8	7.8

Table 5.1: Possible sources of emissions and the related chapters describing the impact, abatement techniques and measurement of these emissions.

5.2. Particulates

5.2.1. Stack dust

Basically the stack emission is related to the drying and heating process. (In reality the stack is connected to other parts of the system via the filter system). The amount of dust is determined by operating conditions.

The main source of stack dust are the raw materials that are used for the production of the asphalt and which are dried in the drum (sand and stone). These materials contain a certain percentage of inherent fines and fines may be produced during the heating process, by mechanical and/or temperature effects. The fines are separated by the hot gas flow in the drum.

The dust concentration in the crude gas depends on:

- the nature and the moisture content of the used mineral materials
- the treatment of the mineral materials in the drum
- the amount and temperature of the waste gas
- the waste gas velocity in the drum
- the shape of the extraction hood
- the output of the plant

The dust contents of the crude gas can be up to 500 g/m^3. However, dust contents in the crude gas are found to be from 40 to 200 g/m^3 in most cases.
The volume of gas extracted from the dryer drum, meaning flue gas and water vapour, is from about 250 to 300 m^3 per metric ton of dry material.

Often waste gas is extracted from the mixer unit (hot bucket elevator, screen, hot mineral storage hopper, scales and expansion from the mixer). The waste air has dust contents of from 20 to 50 g/m^3; the volume flow is, depending on the size of the plant, about 50.000 m^3/h.

The waste gases from the dryer drum and the mixer unit are dedusted together, see chapter 7.

In the case of recycling reclaimed asphalt dust is originated if a parallel drum is used. These particulates may contain binder particles in addition to mineral aggregate particles.

5.2.2. Other sources of particles and fugitive dust

Dust may be, in theory, also emitted from the whole filler system, starting from the loading of the silos from the lorries, transport hoses or screws (pneumatic or mechanical transport), scale and the addition of the filler into the mixer.

In practice the processing of the filler takes place in a closed system including bunker filter attachments, so under normal conditions no emission of filler dust will take place.

Figure 5.2. View of an asphalt plant, indicating possible sources of fugitive dust
"This picture was intentionally chosen to be able to show the possible sources of fugitive dust. It is not intended to show the most perfect plant with regard to minimizing environmental and visual impact."

Depending on the climatologically conditions (dry weather in combination with wind) and the quality (grading) of the mineral aggregates dust may be emitted from the storage of the (fine) sand. This may also occur during loading of the materials from a ship, tipping by lorries and during feeding of the hoppers. Furthermore, dust on the plant area may be whirled up by traffic and become airborne.

Basically dust may be emitted from all parts of the system where fine dry mineral aggregates are processed: transport system (conveyor belts etc.), screens, scales, addition into the mixer, dry (without bitumen) mixing.

Special attention has to be paid to the possibility of dust production during maintenance activities.

5.2.3. Type of dust

Most of the dust consists of mineral aggregates and are of the inert type. This is also the case with particulates arising from additives such as fibres in some mixes.

In the case of the application of reclaimed asphalt the dust may also contain binder particles.

Hydrocarbons in dust may also result from the combustion depending on the type of fuel. Moreover dust may contain small quantities of heavy metals if waste oils are used.
Attention has to be paid to the dust coming from some artificial aggregates used as replacement for natural mineral aggregates. By-products from other industries may also be used (like slag or fly-ashes), which may require special consideration.
When using certain mineral aggregates, silica dust may occur.

5.3. Gaseous emissions

In this section inorganic and organic emissions will be described.

5.3.1. Inorganic emissions

SO_2 (stack)
The burning process in the dryer is the main SO_2 source, influenced by the sulphur content of the fuel (particularly oil or brown coal). SO_2 is absorbed by certain mineral aggregate, e.g. limestone, and the alkaline dust-layer in the dust filter. Other mineral materials, e.g. furnace slag, can increase the SO_2-emission.

NO_X (stack)
Emission of NO_X mainly originates from the burner in the drying drum. The emission depends on the nitrogen content of the fuel, the amount of excess air, flame temperature and burner type.

CO (stack)
Emission is mainly associated with the combustion process in the dryer. The spaces for generation and utilization of the heat have a smooth transition in the dryer and the parallel drums, so the combustion of the fuel is influenced by the direct contact of the burner flame with mineral material. An unfavourable drum geometry where a combustion space is too small also leads to incomplete combustion of the fuel.

Furthermore, the carbon monoxide emission is strongly influenced by the fines content of the mineral, the water vapour content in the drum and the use of RAP, so higher carbon monoxide emissions occur in asphalt plants compared to classical combustion plants. As a consequence, opposite to classical combustion plants CO is not suited to be a leading substance for evaluating the emissions of an asphalt plant.

CO_2 (stack)
Emission is directly related to the type of fuel used and the energy consumption needed for the heating process of the mineral aggregates, reclaimed asphalt and heating system of bitumen tanks. In this context it should be noted that CO_2 emission is not considered relevant for specific limitation. The level of CO_2 emission is determined by process efficiency and depending on the type of fuel used (see table 5.2).

Specific heat requirement per metric ton of asphalt mixed (depending on humidity of mineral material, etc.)	Light Oil	Natural Gas	Butane	Coal	Brown Coal
	kg of CO_2 / metric ton of mixed asphalt				
70 kWh	18,65	11,63	15,27	23,05	23,61
85 kWh	22,65	14,13	18,54	27,99	28,67
100 kWh	26,64	16,62	21,81	32,93	33,73

Table 5.2: CO_2 emissions as a function of the fuel used [14.]

5.3.2. Organic emissions

TOC = Total Organic Compounds
Organic emission consists of a large group of substances generally described as hydrocarbons. Their molecular structure is characterised by the combination of carbon and hydrogen atoms; Additionally these substances can also contain oxygen, nitrogen, sulphur and phosphorus. These are referred to as TOCs. When measured as emissions from asphalt plants the individual carbon elements are added together to give a figure for Total Carbon.

The emission of hydrocarbons finds its origin in the use of organic constituents and organic fuels in the production process. Especially by the heating or combustion emissions of these substances take place in the form of vapour or of reaction products. The most important source of emission of hydrocarbons is the incomplete combustion of fuel. Type of fuel, operating conditions and vapours from bitumen in the mixing process (which may be present in some cases) cause different compositions of the waste gases in respect of their organic constituents.

The hydrocarbons that find their origin in the combustion are mainly emitted by the stack, these emissions can be reduced by regular maintenance of the burner and optimization of the combustion volume.

Another source of organic emission is the bitumen that is heated in the production process. On those places where the bitumen is heated to working temperature fumes are formed.

Possible sources of emission are:

- bitumen tanks, especially out of the vents during loading from the bitumen lorry or continuously by the breathing of the tanks,
- the batch mixer or drum mixer (stack emission),
- the skip,
- the loading station of the asphalt lorries,
- reclaimed asphalt, hydrocarbons may be emitted by heating the reclaimed asphalt in a parallel drum (stack emission),
- in the case that the RAP is added "cold" into the batch mixer (stack emission).

The type of the bitumen (crude, way of production) and the temperature are of influence on the rate and the composition of the emission.

The composition of the RAP (bitumen content and bitumen quality) will also influence the composition of the organic emission.

PAH = Polycyclic Aromatic Hydrocarbons
Depending on their impact on the environment and their effect on health, hydrocarbons are divided in various categories. With respect to their toxicity PAH are of the most importance. Some of these PAH are possibly carcinogenic to humans under prolonged high-level exposure. PAH refers to organic compounds that only contain carbon and hydrogen and consist of two or more benzene rings. Investigations indicate that the hazardous PAH occur in compounds with four or more benzene rings, which usually form only a few percent of the total PAH emission.

The amount of these hazardous PAH in bitumen is very small, less than 10 ppm, while in tar the PAH-content may be approximately a factor 10,000 higher. For this reason the recycling of tar containing materials is done separately only using cold techniques.

At production temperatures of asphalt which seldom exceed 200°C only a small fraction of vaporous PAH exists. From measurement data available [15.] it shows that emissions of hazardous PAH are well below national limit values, if at all traceable. So it is sufficient to set limits for the Total Carbon in the emissions also as an indicator for the emission of hazardous PAH.

5.4. Noise and Traffic

From the plant main sources are:

- the dryer drum;
- burner (especially air intake);
- ventilator behind filter installation (impact high, resonance in stack);
- screeds including by-pass (impact high);
- vertical transport system, hot bucket elevator (impact low when filled);
- pneumatic system (impact low),

With most of these sources being inside the enclosure of the plant.

Other associated noise sources may be:

- traffic noise on the yard by loaders during transport from the aggregate stock to feeder hopper,
- traffic noise from lorries supplying raw materials and collecting asphalt mixes.

The noise impact is especially influenced by the time of the day or night, not just in the amount of activity.

5.5. Odour

Main source of odour is the bitumen. Emission occurs during the loading of the bitumen tanks (by expelling gas from the bitumen tank or by pressure release from the bitumen lorries), and by the emptying of the mixer into the skip or into the asphalt lorries. Moreover the odour is related to the bitumen type and crude source.

The application of reclaimed asphalt may emit odour when heated, especially in the case it contains a high moisture content.

Special additives, such as adhesion improvers or types of polymers may emit perceptible odours, but do not present, as far as known, any environmental or health concern.

5.6. Water effluent, ground water preservation

Possible sources of ground(water) pollution are:

- Artificial aggregate storage (seepage, or mixing with the natural soil).
  Some mineral aggregates or artificial aggregates may contain elements that are allowed up to a maximum concentration in the ground water or soil;
- Fuel oil tanks (if the plant is oil fired);
- Thermal oil for bitumen heating system;
- Gasoil tanks, pipework and fuelling station;
- Solvents (laboratory chemicals);
- Release agents (although nowadays mostly biologically degradable).

5.7. Waste

The production of asphalt itself is not an important source of waste material. Almost all raw materials are supplied in bulk, so no packing remains. Waste material produced during the production process in the form of "failure mixes", are in most cases either recycled through the asphalt plant or are used in the construction of site roads within quarries etc.

Baghouse dust is normally re-used and is therefore not regarded as a waste.

A source of chemical waste may be the laboratory, e.g. solvents used for asphalt analyses, where recycling according to laboratories best practise applies.

5.8. Visual aspects

Dominating are the high silos for filler and/or the hot asphalt storage and the stack, also depending on the colour of painting.

Other visual aspects are:

- steam from damp aggregates emitted from the stack,
- storage of mineral aggregate,
- illumination of the plant area.

6. ABATEMENT TECHNIQUES AND PROCESS CONTROLS

6.1. Introduction

Following the headings of the preceding chapter a number of measures will be discussed and explained that can be incorporated into an asphalt plant to comply with the emission values in chapter 8 where and when appropriate. On overview of the possible sources of emissions is shown in table 5.1. This table also gives an overview of the paragraphs dealing with the related impact description, abatement techniques and emission measurements.

Knowledge of the emissions and concentrations present at the plant are important for adequate preventive measures. In addition, it is necessary to be familiar with the characteristics of processes and ventilation systems. Choice of the specific measures appropriate to any particular situation will depend on location and many other factors.

The general description of plant types and operations and the identified types of environmental impact forms the basis for identification of appropriate abatement techniques conforming to BAT-principles. Implementation of preventative design measures should follow a pre-established action programme that clearly defines an overall long-term strategy for the reduction of environmental impact. A joint strategy ensures maximum benefits from invested capital. Sub-optimisation is imprudent because lack of planning tends to raise costs in the long run.

Considerations about appropriate BAT abatement measures must take its origin in the specific plant. Different locations (urban/rural), mobility (stationary/mobile) etc. imply different individual solutions. What is applicable for one plant may not be for another just as not all abatement techniques are relevant for all plants.

Some of the measures listed below may seem too expensive at first glance not complying with BAT principles e.g. enclosure of the cold feed hoppers etc., although these actions can in themselves have significant cost benefits. Knowledge of the process combined with close management of input variables can avoid expensive monitoring of the output variables possibly with additional cost savings e.g. on fuel consumption.

CEN has generated a standard for Factory Production Control of Asphalt Mixes to meet the particular needs of the Construction Products Directive. Some plants may wish to combine the management of factory production control, environmental compliance, health and safety requirements etc. in to one management system.

6.2. Particulates

The emission of dust occurs in the first stages of the production of asphalt (until mixing). The most significant source of process particulate emission is the drying process. Other sources of emission include storage of raw materials, cold feed unit, filler silos, hot side screens and elevators.

The main initiative on dust problems should be to try to prevent its creation in the first place or to ensure that it is bound with something (e.g. bitumen) where it arises.

Another basic objective is to keep the emitting process in a closed system with a negative air pressure. Supplementary actions involve covering, hooding, and ducting. These actions should be complemented by installation of monitors enabling the operator visually to follow the process stages.

6.2.1. Stack dust

The main source of process particulate emission is the rotary dryer in batch plants and the drum mixer in drum mixer plants. In both cases combustion gases and water vapour are sucked out and driven through a ventilation system to a dust collector. The final step involves emission of the cleaned air to the atmosphere through a stack. Generally two main concepts are available for the reduction of emitted particulate from the stack. It is possible either to use effective dust collectors or to incorporate process controls and design measures (see section 6.3.2) diminishing the creation of particulate and thereby reducing particulates entering the ventilation system.

Dust collectors

The principal type of dust collectors in the asphalt industry are baghouses. Some older plants may still only rely on cyclones or even wet scrubbers to force the dust out of the air stream. Using these approaches as the single way of dust collection must however nowadays be considered obsolete.

Typical baghouses have cylindrical bags hanging vertically in the unit. The inlet gas stream passes through large bags made of plastics, artificial fibres or ceramics capable of withholding even very fine particulate. The particles are filtered by the dustcake on the fabric, and cleaned air exits through the fabric of the bag. The bags are cleaned when the dust layer on the bags becomes excessive by blowing air through them in the opposite direction, causing the particulate to fall down into the collection hopper to be returned to the asphalt production process.

It is advisable to install primary dust removal equipment in front of the filter bags to reduce the amount of larger particles that reaches the baghouse. Cyclones or separators re-directing the airflow (knockout boxes) can be used as pre-collectors. Cyclones collect dust particles material through a tangential inlet which forces the heavier dust particles to the outside wall where they slow down and drop to the bottom. In this way the baghouse is protected from the abrasion from heavier particles. Higher degree of separation can be achieved with more impenetrable bags demanding bigger filters and enhanced energy consumption. Baghouse operations should constitute an integral part of the overall start-up and shutdown procedures for the asphalt plant.

Generally the emission of dust will increase when air-to-cloth ratio (the ratio between gas flow and filter area), content of dust in the raw gases and the percentage of fine dust in the raw gases are increased. Other factors such as maintenance, pressure drop and flushing sequences also play an important role. The frequency and scope of maintenance of the filters will clearly have a major impact on longer term dedusting performance. Hence determination of the BAT value depends not only of the capital costs but also on the operating costs. Where bag filters are used, it is advisable to design filters with an air-to-cloth ratio of about 1.5 m/min at maximum gas flow.

6.2.2. Other sources and fugitive dust

The number and kind of fugitive emission sources depend on whether the plant is mobile or stationary. Likewise emissions depend upon whether the plant is located adjacent to a gravel pit or quarry. Quarrying operations like crushing and grinding are outside the scope of this document as emphasised in chapter 4. Fugitive dust emissions are roughly associated with material (aggregate) storage and handling, cold feed unit and conveying of material. Additional emissions results from the drums and the mixing process in batch plants. Traffic inside the plant area (loader) and the incoming and outgoing trucks also gives reason to diffuse emissions.

Raw materials handling and storage
Storage of the different types of raw materials used for the production of asphalt is a significant potential fugitive source. Transport distances within the plant area should be minimised.

Under windy conditions basically two different procedures can be practised to reduce dust emissions from the piles: Covering or moistening.

In locations of high amenity it may be appropriate that all fine material (e.g. under 3 mm) is kept in silos or in covered storage for ordinary day-to-day use. To minimise stock movement the storage capacity must be adequate.

In normal circumstances, walls of sufficient height around three sides of stockpiles will greatly reduce fugitive dust emissions. Where possible and appropriate mounds around the plant periphery will further reduce fugitive dust emission outside the plant.

Water can be used as an alternative method of dust suppression. Increased moisture content lowers dust emission, but increases energy consumption.

An adequate supply of water should always be obtainable and all water suppression systems should have adequate frost protection. A higher moisture content does, however, imply increased energy consumption in the ensuing drying process.

Loading to and from stockpiles, and construction and management of stockpiles should be carried out in such a manner as to minimise wind-borne dust.

Trucks delivering dry raw materials containing fines should have the loads covered to prevent dust nuisance.

Cold feed unit
To reduce the dust emission from hoppers of the cold feed unit it can be covered or enclosed. A closed system might require ventilation to air through an arrestment plant, though this would not be considered normal practice. Linkage to the existing ventilation system is a possibility.

Furthermore cold feed units can be placed in the ground to ease loading and minimise the creation of dust while loading.

Filler silos
Filler storage silos should generally be equipped with a ventilation filter and a vent valve. They should be enclosed and vented through a coupling to the existing dust collection system.

Conveyors
Enclosing conveyors, which transfers material from one step of a process to another, will minimise wind-whipping. Transfer points between such conveyors should be enclosed and fitted with flexible seals on inlet and exits. Ducting installations should be checked to form systems as dustproof as possible.

Drums
Both drums used in the batch and drum mixer process give rise to diffuse emissions due to small leakages in the process. Under-pressure in the drum reduces emission. Furthermore enclosure of drums (for batch plants additionally the mixing operation) reduces the diffuse emissions to the surroundings. Above that requirements for air change can be established.

Batch mixing
In batch plants also the transport of hot aggregates, classifying and mixing equipment make up process fugitive dust. Those emissions should by establishing enclosures be vented into the primary dust collection system (explained above) along with the dryer gas. This ventilation system may have its own separate air mover device installed, depending on the specific facility. Most of the emissions transported and captured in the ventilation system is aggregate dust, but may as well contain residual hydrocarbons from the fuel combustion.

A potential source of fugitive dust from batch plants arises during purging and draining out (when changing from a coarser to a finer recipe of asphalt). Adding of small amounts of bitumen prevents dust emission. The hereby created mix should be handled in the same way as the reclaimed asphalt. Another solution is to use water suppression and partial enclosure of the area. This enables most of the product to be re-used without the costs of setting up reclaiming facilities. An additional measure consists of capturing the emission into the ventilation system.

Housekeeping
Good housekeeping will of course minimise fugitive dust emissions as well as improving plant amenity. This would include for example spraying of dusty roads inside the plant area during dry weather to minimise fugitive dust emissions caused by traffic from the loader and the incoming and outgoing trucks. Good housekeeping also involves promptly cleaning up any spills or debris.

6.3. Gaseous emission

Besides the above-mentioned dust emissions gaseous emissions are also associated with the production of asphalt. Gaseous emissions first of all originate from the mixing process and subsequently from other process steps. Additional emission arises from bitumen and fuel tanks.

An explanation follows of the issues surrounding stack emissions (inorganic and organic), which are especially associated with the drum mix process.

Generally, it should be emphasised that reduction of emissions from the drum can more readily be targeted at optimising the combustion processes. This refers to drum design, flame temperature, type and placing of burner, flame direction in relation to materials, etc. To do this it is prudent and wise to switch from visual monitoring to more secure methods. As suggested later in this section, an automatic monitoring provides a better method for controlling burner and furnace operation.

Using new technologies allowing asphalt to be produced at lower temperatures can also reduce emission and energy consumption. The techniques for producing so-called Warm Asphalt include process engineering, foam bitumen, aerogenous agents, special bitumen and additives, and warm emulsion technique. These different kinds of Warm Asphalt techniques are briefly described in section 4.6.

Tests indicate that the energy consumption in the production process can be reduced by 10 KWh (equivalent to 1 litre oil) per tonnes of asphalt produced if the mixing temperature is lowered by 35°C.

Next to less emissions, less fumes, and less energy consumption, other advantages of Warm Asphalt are less wear of the asphalt plant, less aging of the binder and the possibility of earlier opening of the paved road for traffic. Warm Asphalt is however more expensive than conventional hot asphalt due to the use of extra additives etc. and the technique is still developing.

Besides these overall recommendations some special features influencing the emission level can be associated with each trace item. The following discussion examines the major characteristics for each trace item separately.

Secondly, abatement techniques for gaseous emissions originating from other sources on the plant are outlined.

6.3.1. Inorganic stack emission

SO_X
The SO_2-emissions are primarily influenced by two factors: the sulphur content of the fuel and the rate of absorption in the alkaline dust layer formed on the filter. By using fuel with lower sulphur content or achieving a higher degree of absorption a reduction of SO_2-emissions can be accomplished. Although it should be recognised that also installations, which use brown coal as fuel are operated. The use of basic minerals as e.g. limestone can help to absorb SO_X. There is however no viable technology for absorption of the small quantities of SO_X in an asphalt plant.

NO_X
The formation of NO_X is predominantly determined by burner and flame characteristics (flame temperature, burner type, amount of excess burning air). Also the nitrogen content of the fuel influences NO_X-emission. The emission of gas-fired plants is lower than for oil-fired plants. Improved burner technology is under development to reduce NO_X (e.g. low NO_X burners).

CO
An incomplete combustion results among other things in the formation of CO. Abatement of CO-emissions therefore require improvement of the combustion process. It has been suggested to include a correct air-fuel mixture and a retention time of at least 1-2 seconds at 900°C for the mixture.

CO_2
The complete combustion of fuel results in the creation of CO_2 and water. The CO_2 emission depends on the used fuel type and the required energy consumption for the production process. CO_2 emissions are a little lower if using natural gas as fuel compared to other types of fuel (see table 5.1). Furthermore lower asphalt production temperatures reduces energy consumption and thereby the CO_2 emission.

The excess air level related to the combustion process is calculated on the basis of O_2 or CO_2 measurements. An appropriate level of excess air between app. 2 and 5,5 is a necessary but not a sufficient condition for a clean and energy economic combustion.

6.3.2. Organic emissions

The emission of TOCs finds its most important origin in the incomplete combustion of fuel, oil, gas or brown-coal. The kind of fuel and the burner characteristics as well as the geometry of the drying drum and the parallel drum are influencing the eventual amount and composition of the organic emission. Another source is the heating of bitumen and recycled materials.

The emission can be reduced by several different measures.

Process controls
It is prudent to monitor the combustion process of the burner as it has great effect on the quantity of especially gaseous emissions. The main objective is to secure that the combustion process is as effective as possible and thereby lowering the emissions. In batch plants, where the gas from the recycled asphalt rotary dryer is used as secondary air in the virgin aggregates dryer to burn out the gases, it is advisable to adjust the intake of the recycling gas in such a manner so that the combustion conditions for the burner of the virgin aggregates dryer are not decreased.

Incorporating alarm systems into the different steps of and parts on the asphalt plant both minimise the amount of off-specification asphalt produced and the number of times increased emissions occur due to wrong process conditions. Especially exceedingly high temperatures will produce increased emissions particularly for recycled materials.

Bitumen storage tanks
If required organic emission from bitumen or oil tanks can be minimised by vapour recovery on delivery or water siphoning or active filters under normal operations.

Drum mixer
Several process variations are available to reduce the organic emission if it occurs. These include emplacement of flame shields, changing the arrangement of the flights inside the drum, modification of where the bitumen is injected into the drum, etc.

Transport, handling and storage of the hot asphalt mix
General awareness of the emission problems when transferring the hot asphalt from the mixing process to conveyor, from conveyor to storage silo, and from storage silo to truck is important. These emissions can be prevented or reduced by covering of these process parts or by the installation of a separate cleaning system, in which the process air is collected and cleaned.

After loading the asphalt lorries must be covered as soon as possible.

Generally the most single important item is to avoid the overheating of asphalt. In the temperature range where asphalt production takes place the emission of fumes doubles at every 10°C increase in temperature.

6.4. Noise and traffic

Noise emissions to the surroundings are due to internal and external traffic and processes in the asphalt production. Problems with traffic also have to be viewed in the light of air pollution from exhaust gases from vehicles.

An expedient placing of piles of raw materials in the plant area lowers the dispersion of noise to the encircling area. An additional measure includes landscaping and planting around the plant area. This will both reduce noise and dust dispersion.

Traffic
Internal traffic (loading machines, trucks, etc.) should be minimised by a thorough planning of plant design (piles, hoppers, silos, etc.).

External traffic consisting of trucks departuring from or arriving at the asphalt plant is a major problem if plants are situated in build-up areas. New asphalt plants should be located where traffic to and from does not cause any nuisance to the neighbours. Introducing logistic planning is a means of reducing truck waiting times and thereby the noise and exhaust emissions.

Process noise
Noise occurs at different places in the process. The overall solution to noise problems is to shield the emitting source, reduce the noise from the source or both.

The burner may constitute a major noise source. Replacing older burners with newer ones is beneficial since modern burners tend to be quieter than older ones. The placement of a sound absorber or screen at the intake is also a possible solution. Furthermore, should the high-pressure ventilator to the burner be equipped with a sound absorber or insulation screen. Reducing the noise level can also be done by covering the drying (and mixing) process.

To subdue the ventilator or exhauster noise after the dust collector it is possible to install sound absorbers inside the stack or between ventilator and stack.

Transport of the hot mix asphalt from the mixing process to hot storage silos can create noise problems. The conveyer should be shielded if it makes too much noise. If a skiphoist is used, the employment of rubber wheels will reduce the noise. If noise levels are excessive attenuation screening may become a more economic solution at appropriate areas of the plant.

6.5. Odour

The odour finds its source in the bitumen (closed constructions are therefore very effective) and sulphur-containing fuel (less sulphur means less odour). All measures, which reduce organic emissions, will also of course reduce odour emission. For example a reduction of asphalt production temperatures will lower odour emissions.

Furthermore odour emissions depend upon the use of RAP.

Optimising the aggregate drying process and the combustion of the burner lowers the odour emission. It is advisable to control for a low excess air level (low λ-value).

Generally odour emissions can be reduced by preventing them from leaving the plant area “untreated”. In this respect the following measures can be taken:

- Use closed housing for the essential parts of the plant where odour can be emitted during the process
- Use water siphoning and vapour-recovery on delivery systems for filling the bitumen tanks
- Automated opening of the asphalt storage silos (with short openings)
- Cover lorries as soon as possible after loading
- Use a closed system starting from the mixer unit until and including the storage of the hot mix. The gases can be extracted through the baghouse filter system and led to the stack
- Build the loading area in such a way that the emissions can be extracted and can be led to a high stack.

Furthermore chemical additives can be used in the asphalt mixture to either mask or neutralise the odour, provided that they do not themselves create an unsatisfactory odour.

Raising the stack height lowers odour immission (impact) levels registered in the surroundings. Odour dispersion is often the principle determinant for stack height, while increased height also of course reduces immission levels particularly in the plant area of all other stack emissions both particulate and gaseous. Stack height can be determined by using monograms relating stack height to gas volume, varying typically from 10 m height for a smaller plant, to 20 m or more for a larger plant.

6.6. Water effluent, ground water preservation

Ground water preservation primarily has to do with discharge water, including spraying activities for trucks and general preventative measures at the source.

Spraying of trucks with release agents should be minimised and carried out at a separate place. Nowadays there exist biologically degradable release agents such as rapeseed oil etc.

If detergents are used for spraying, it is imperative that the effluent is led to an individual separator, because the detergents will otherwise cause oil contaminated effluent from e.g. the gas station to emulsify and thereby permitting the oil to pass unhindered through the conventional separator.

Bitumen tanks can be placed in a concrete pit (or similar) to prevent leakage from the fuel that heats the tank. Similar considerations should be made for other heating facilities and for fuel storage at the plant site.

Appropriate preventive measures should be applied in relation to storage of bitumen emulsion, bitumen cut backs, and other oil products.

6.7. Waste (including laboratory chemicals)

Laboratory tasks most commonly encountered on asphalt plants deal with verification of the quality of the produced asphalt. Normally asphalt test samples can be recycled on the plant. Hazardous laboratory chemicals should be recycled. Any waste should be collected through proper channels for incineration.

Waste originating from more everyday life occurrences (workshop, canteen, office, etc.) should be dealt with in accordance to customary channels.

For all waste streams, minimisation represents both best practice and maximum economy. Any off-specification production should be recycled.

6.8. Visual aspects

Improvement of visual aspects of the asphalt plant is particularly advantageous in regard to enhancing relationships with the local community. Moreover it is important to have a positive image for customers visiting the plant.

Good housekeeping and a high level of maintenance are closely related to how outsiders form their own opinion of the plant. Those factors should therefore be emphasised and local guidelines developed.

Entire enclosure of the modules gives the plant a more contemporary appearance, which generally prompts a more positive environmental image where the plant is located in an area of high amenity.

Creative landscaping on and around the plant area also furthers the image and assists in minimising the visibility of plant. Endeavours to integrate the plant into the surroundings as much as possible renders the most returns. Maintenance and painting of buildings has clear benefits.

Locating of new plants should take consideration of longer term housing developments.

7. EMISSION MEASUREMENTS AND LIMIT VALUES

7.1. Introduction

The following section deals with measuring emissions and how to evaluate their magnitude. There is a multitude of different national techniques and circumstances in this field. Especially when comparing different national limits, it is imperative to be aware of the exact conditions under which they are specified and even then, as it is appears in the following, one should be very cautious to compare those values anyway.

First, the measurement parameters and conditions that have to be considered are listed, followed by a list of the available (ISO and EU) standards for the measurements. It should be emphasised that the material in no way is exhaustive.

Bearing this in mind, some (typical) limit values are listed to give the reader an idea in which magnitude the emissions are.

7.2. Measurement Parameters and Conditions

All figures are expressed in mg/m^3 referring to standard conditions 273 K and 1013 hPa, which is indicated by an additional “N”, reading: mg/Nm^3. At this point, however, all similarities stops. To compare the values it is necessary to take a lot of conditions into account as explained below.

Every measurement in the stack must contain a measurement of velocity and flow rate as well as of the O_2 content.

7.2.1 Reference O_2 level

The measurement value of the emission has to be recalculated from the registered O_2 level into the national reference O_2 level by the formula:

$$E_R = [(21-O_R)/(21-O_M)] \times E_M$$

where E_M is measured emission,
E_R is emission with respect to the reference oxygen content,
O_M is measured oxygen content,
O_R is reference oxygen content.

This recalculation must also be done when comparing different national limit values in case different reference O_2 levels are involved. It is evident that comparable emission limits increase when the reference O_2 level is lowered. For example, a limit value of 100 mg/Nm^3 refering to 17 % O_2 is equal to 150 mg/Nm^3 referring to 15 %. (Reason: no dilution wanted)

Most national legislations use a reference level of 17% O_2 because this level is close to operating conditions in many cases. This value is higher than those for combustion plants etc, because it takes into account that most of the air emitted at the stack originates from the baghouse filter, not from the burner. As comparison: most national legislations set a reference O_2 level of 3 % for the thermal oil heater limit values.

7.2.2 Moisture content

Registered emission values are influenced by the moisture content and thereby the humidity of the gas. Most countries specify their limit values based on a dry reference.

Calculations between dry and wet emission values can be done according to the following formula:

$$\text{Emission(dry)} = [\text{Emission(wet)}/(100 - \%\text{humidity})] \times 100$$

For example at a moisture content of 30%, 100 mg/Nm^3 (wet) would be equivalent to 143 mg/Nm^3 (dry).

7.2.3 Measurement Circumstances

Maximum/average

A differentiation between maximum and average limit values must be made. When the value is an average it means the accumulation of the emissions over a certain time period and then divided by this time. The corresponding time period must be indicated.

Maximum limit values are more stringent than average limits because the latter typically allows for higher emissions than the limit value in shorter time intervals. Some measurement techniques and processes allow only an average value, as they cannot measure “online” but only an accumulation, e.g. of dust on a filter over time.

Random/planned

Usually the measurements are carried out by a notified body. The measuring team may show up at the plant unannounced (random) or with an appointment (planned). Most legislations ask for planned measurements because only then it is sure that the plant is in production and the (expensive) team does not come in vain.

Measurement frequency

The frequency of measurements by the notified bodies varies between one and three years.

7.3 Measurement Techniques and Standards

Different measurement devices, techniques and procedures are described in the following international and / or European standards. This list is in no way exhaustive. Of course, each different emission needs a different technique/procedure - and so a different standard, but also different standards cover the same field leading to different results. In addition to that many countries modify these standards in their national regulations, which makes comparisons even more difficult.

Assisting Measurement Standards

ISO 10780
Stationary source emissions - Measurement of velocity and volume flowrate of gas streams in ducts

ISO 12039
Stationary source emissions - Determination of carbon monoxide, carbon dioxide and oxygen - Performance characteristics and calibration of automated measuring systems

EN 14790
Stationary source emissions - Determination of the water vapour in ducts

Standards for Particulate Emission (Dust)

ISO 9096
Stationary source emissions - Manual determination of mass concentration of particulate matter

EN 13284-1
Stationary source emissions - Determination of low range mass concentration of dust - Part 1: Manual gravimetric method

Standards for SO_x

ISO 11632
Stationary source emissions - Determination of mass concentration of sulfur dioxide - Ion chromatography method

EN 14791
Stationary source emissions - Determination of mass concentration of sulphur dioxide - Reference method

Standards for NO_x

EN 14792
Stationary source emissions - Determination of mass concentration of nitrogen oxides (NOx) - Reference method: Chemiluminescence

US EPA Method 7E

Standards for CO, CO_2

ISO 12039
Stationary source emissions - Determination of carbon monoxide, carbon dioxide and oxygen - Performance characteristics and calibration of automated measuring systems

EN 14626
Ambient air quality - Standard method for the measurement of the concentration of carbon monoxide by nondispersive infrared spectroscopy

US EPA Method 10

Standards for TOC

EN 12619
Stationary source emissions - Determination of the mass concentration of total gaseous organic carbon at low concentrations in flue gases - Continuous flame ionisation detector method

EN 13526
Stationary source emissions - Determination of the mass concentration of total gaseous organic carbon in flue gases from solvent using processes - Continuous flame ionisation detector method

Standards for PAH

ISO 11338
Stationary source emissions - Determination of gas and particle-phase polycyclic aromatic hydrocarbons
- Part 1: Sampling
- Part 2: Sample preparation, clean-up and determination

EN 13649
Stationary source emissions - Determination of the mass concentration of individual gaseous organic compounds - Activated carbon and solvent desorption method

7.4 Typical Emission Limit Values

Despite the above mentioned warnings to compare different (national) values like “apples and oranges”, some typical values should be mentioned in the following to give the reader an idea about the magnitude of the emissions. These values are by no means suitable as benchmark figures or whatsoever.

7.4.1 Particulates Emission (Dust)

Stack dust

The limits are normally in the range of 20 – 50 mg/Nm³ when referring to 17 % O_2, dry measurement on a planned schedule and applying EN 13284-1. Otherwise, values differ, though, between 10 and 50 mg/Nm³.

As a rule, stack emissions below about 100 mg/Nm³ are not generally visible.

Fugitive dust / other sources

It is impossible to give typical values for this item.

7.4.2 Gaseous stack Emissions

SO_x and NO_x

Typical limit values are between 350 and 500 mg/Nm³, depending on parameters and measuring standards used.

CO, CO_2

Typical limit values for CO are between 350 and 1000 mg/Nm³, in many cases depending on the fuel used and / or the use of RAP.

There are no limits for CO_2 emissions in the European countries, but in some countries the asphalt plants are part of the national allocation plans in the trade of CO_2 emission certificates. The CO_2 emission depends on the fuel used, ranging from about 14 kg CO_2 per ton asphalt produced up to about 28 kg CO_2 per ton asphalt produced.

TOC

Typical limit values are between 50 and 150 mg/Nm³, depending on parameters and measuring standards used. Variations may occur if using RAP.

7.5 Noise and traffic

Some countries have limit values for daytime, night-time and weekend operation of asphalt plants. Some countries have limit values for industrial areas and residential areas, others have several classes. However, there is no standard approach across Europe, so no guidance on limitations can be given in this document..

7.6 Odour

The perception of odour can be quantified according to several approaches.

The hinder or nuisance of odour can be quantified using the so called “Hedonic scale” [10.]. Hedonic scales give a level for the pleasant or unpleasant sensation of an odour. The level varies from -4 (very unpleasant) to + 4 (very pleasant).

The odour concentration itself can be expressed in European Odour Units per m³ (air): [*ou_E/m^3*]. The definition of an European Odour Unit is: *The amount of odorant(s) that, when evaporated into one cubic metre of neutral gas at standard conditions, elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM), evaporated in one cubic meter of neutral gas at standard conditions.* [11.]

The odour of bitumen is differently appreciated than stack odour. Experience shows that 2 ou_E/m^3 of bitumen odour is experienced as unpleasant as 5 ou_E/m^3 of stack odour [13.].

Anyway, it is impossible to give typical –limit - values for this item.

7.7 Waste

Wastes have to be streamed into categories and recycled and disposed of according to the national or local legislation.

It has to be emphasised that the production of asphalt does not produce any waste in particular.

7.8 Visual aspects

There is no standard (European) approach to this item and therefore it is not possible to give typical values.

8. RECOMMENDATIONS

8.1 Introduction

In recognition of rapidly developing EU environmental legislation the European Asphalt Pavement Association (EAPA) decided to proactively address the incoming environmental requirements of the industry in order to further enhance its reputation and record in this key area.

This document describes the technologies and emission limits that are currently considered to be reasonable, economic and proven in practice. This document is therefore called "Best Available Techniques' abbreviated as BAT.

It is presented in the form of guidelines for voluntary adoption by the asphalt industry across Europe. It should be stated that BAT will have different interpretations in different countries, depending on the level of economic development. Interpretation will also vary according to plant location. Decisions on specific limits for each particular plant will, as previously mentioned, remain a matter for local decision.

In this BAT document, the legislative background is described (Chapter 2) including a brief summary of the evolution of EC environmental legislation. The asphalt industry is not specifically targeted in any of the EC initiatives because it is regarded as a low environmental impact industry.

A general description of asphalt mixtures and the most commonly produced hot, warm and cold mixes are described in Chapter 3. The next chapter explains the basic processes that are involved in the production of hot mix, warm and cold asphalt mixtures. Here the recycling techniques are also mentioned because recycling is regarded by the industry as being essential for a sustainable development. In many European countries recycling and re-use of reclaimed asphalt is common practice.
In Chapter 5 the potential environmental impacts are described. In Chapter 6 the abatement techniques and the process controls for these potential environmental impacts *emissions) are described and in Chapter 7 deals with measuring emissions and how to evaluate their magnitude.

8.2 General recommendations

It is recommended that **new** stationary asphalt plants should be designed, equipped and operated to the guideline values set out below (all values ideally being referred to the commonly used 17% O_2 level in exhaust gases measured on a dry basis). As mentioned previously the interpretation of what is "Best Available Technique" will vary from country to country.

It is recommended that **existing** stationary asphalt plants should be considered for phased upgrading where economically achievable to the levels appropriate for new plants over a time period. Based on the current rate of development of technology a period of several years seems appropriate.

For new and existing transportable and mobile mixing plants, some exemptions will apply; the limits imposed being usually delegated to local decision. For cold mix (that is emulsion based) plants, the relevant emission parameters need to be addressed.

8.3 Emission specific recommendations

8.3.1 Particulates

Plant design and operation should ensure that fugitive dust emissions are minimised. It is suggested that further reduction of fugitive dust emissions could be more beneficial than any further reduction in stack emission limits. In locations of high amenity it is recommended to keep all fine material (e.g. under 3 mm) with a high fines content in silos or in covered storage for ordinary day-to-day use.

It is recommended that stack particulate emissions should be in the range 20 – 50 mg/Nm^3.
When deciding on the choice of a limit, it should depend on locational requirements and also associated costs and benefits (both capital and operational). Measurement every 1 to 3 years of particulate emission usually suffices combined with daily visual inspection and good plant management.

8.3.2 Gaseous emissions

In typical situations, SO_x emissions will be significantly less than the guideline value of 500 mg/Nm^3, and hence will not require to be measured. Only in cases where high sulphur fuels (for example over 3% sulphur), or where some sulphur containing aggregates are used, will this figure be exceeded. In such cases a higher limit will be appropriate, possibly with associated measurement.

Similarly, under virtually all operation conditions, NO_x emissions will be significantly less than the value of 500 mg/Nm^3, likewise not requiring measurement.

It is not possible to give specific requirements for CO and CO_2 emissions as these vary widely according to the type of fuel used and the construction of burner installation. However both can be optimised by good plant operation.

It is desirable to standardise the basis and methods of emission measurements. Future standards should recognise that good process controls will not only optimise plant performance, but also reduce the frequency of measurements.

Stack height should provide sufficient dispersion of the emissions mentioned above to keep immission levels within acceptable limits. The height of a stack is carefully calculated for the specific site taking account of a number of factors. In general the outcome of these calculations varies between 10 m for smaller plants and 20 m or more for larger plants.

8.3.3 Noise and traffic

Operating noise levels should not cause nuisance at the nearest dwellings, particularly outside normal working hours.

8.3.4 Odour

All practical steps should be taken in plant operation to ensure that there is no offensive odour outside the plant boundary or at the nearest dwellings.
There are several ways to reduce odour, like using products and fuels that create less odour, not giving the odour the opportunity to leave the plant untreated, reducing (production) temperatures of the hot mix, by using (chemical) additives, by masking the odour and/or releasing the odour at a place where it does not create a problem (high stacks).

8.3.5 Energy

In the asphalt industry lowering the production temperature of asphalt mixtures is nowadays under strong development because of environmental reasons and high energy prices.

To achieve this, different methodologies are being used and developed, like low temperature asphalt (also called warm mixes) and cold mix technology. Warm mixes could be more expensive due to the additives, etc. and the technique is still developing.

Lowering the manufacturing temperature reduces the energy need. Using dry aggregate, properly working equipment and appropriate work methods can also reduce energy consumption. It is advantageous to store the raw material at a location where bulk moisture content can be kept at a minimum.

8.3.6 Water effluent, ground water preservation

In plants the usual preventative measures (particularly spill containment for fuel tanks) will be required to prevent ground and ground water containment.

8.3.7 Waste

All incidental wastes should be recycled, or minimised where unavoidable, stored and then disposed of according to good practice.

8.3.8 Visual aspects

Visual amenity should be maximised by appropriate landscaping, screening or enclosure of plant. Good housekeeping will also pay handsome dividends. Communications with neighbours should be encouraged.

Operation within these guidelines will further demonstrate the low environmental impact of asphalt plants, and will further enhance the image and reputation of the asphalt industry.

9. RELEVANT LITERATURE

1. EAPA – Asphalt in Figures 2005, EAPA, Brussels, 2006.

2. EN 13108-1, Bituminous mixtures - Material specifications - Part 1: Asphalt Concrete.

3. EN 13108-2, Bituminous mixtures - Material specifications - Part 2: Asphalt Concrete for very thin layers.

4. EN 13108-3, Bituminous mixtures - Material specifications - Part 3: Soft Asphalt.

5. EN 13108-4, Bituminous mixtures - Material specifications - Part 4: Hot Rolled Asphalt.

6. EN 13108-5, Bituminous mixtures - Material specifications - Part 5: Stone Mastic Asphalt.

7. EN 13108-6, Bituminous mixtures - Material specifications - Part 6: Mastic Asphalt.

8. EN 13108-7, Bituminous mixtures - Material specifications - Part 7: Porous Asphalt.

9. Industry Statement on the recycling of asphalt mixes and use of waste of asphalt pavements – EAPA Position Paper, EAPA, Brussels, July 2005.

10. ASTM, 1968. Manual on Sensory Testing Methods, no. 434. American Society for Testing and Materials, Philadelphia, Pa. http://food.oregonstate.edu/sensory/dena.html).

11. EN 13725, Air quality – Determination of odour concentration by dynamic olfactometry

12. Developments in Low Temperature Asphalt - EAPA Position Paper, EAPA, Brussels, June 2005.

13. Nederlandse Emissie Richtlijnen, (Dutch emission Guidelines), 2006

14. VDI/DIN Handbuch Reinhaltung der Luft, Band 3, Teil: VDI-Richtlinie 2283: Emissionsminderung, Aufbereitungsanlagen für Asphaltmischgut (Asphalt-Mischanlagen), Gründruck 2006
    ((Remark: Will be fully published probably in early 2007))
    (VDI Guideline No. 2283 for reducing emissions, part Asphaltplants, draft 2006)

15. Emissionen luftverunreinigender Stoffe aus Asphaltmischanlagen beim Einsatz von Ausbauasphalt – am Beispiel ausgewählter hessischer Anlagen. Schriftenreihe Umweltplanung, Arbeits- und Umweltschutz der Hessischen Landesanstalt für Umwelt, Heft 190, 1995
    (Emission of air polluting substances from asphaltplants using RAP – measurements of selected plants in Hessia, Hessia State Agency for Environmental Protection, 1995)

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