



Department
for Environment
Food & Rural Affairs

www.gov.uk/defra

Process Guidance Note 2/04(13)

Statutory guidance for iron, steel and non-ferrous foundry processes

Revised: July 2013



Llywodraeth Cymru
Welsh Government



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Defra would like to acknowledge the work of the Environment Agency's Local Authority Unit in the drafting of this guidance note.



Revision of the guidance

The electronic version of this publication is updated from time to time with new or amended guidance. **Table 0.1** is an index to the latest changes (minor amendments are generally not listed).

Table 0.1 - Revision of the guidance		
Date of change	Section/ paragraph where change can be found	Nature of change - what paragraphs have been inserted, deleted or amended - what subject matter is covered by the change
July 2013	Throughout	Addition of colour coding to tables

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1. Introduction

Legal basis

- 1.1 This note applies to the whole of the UK. It is issued by the Secretary of State, the Welsh Government, the Scottish Government and the Department of the Environment in Northern Ireland (DoE NI) to give guidance on the conditions appropriate for the control of emissions into the air from iron, steel and non-ferrous foundry processes. It is published only in electronic form and can be found on the [Defra](#) website. It supersedes PG2/04(06) and NIPG2/04(06).
- 1.2 This guidance document is compliant with the [Code of Practice on Guidance on Regulation](#) page 6 of which contains the "golden rules of good guidance". If you feel this guidance breaches the code or you notice any inaccuracies within the guidance, please [contact us](#).
- 1.3 This is one of a series of statutory notes giving guidance on the Best Available Techniques (BAT). The notes are all aimed at providing a strong framework for consistent and transparent regulation of installations regulated under the statutory Local Air Pollution Prevention and Control (LAPPC) regime in [England and Wales](#), [Scotland](#) and [Northern Ireland](#). The note will be treated as one of the material considerations when determining any appeals against a decision made under this legislation. Further guidance on the meaning of BAT can be found for [England and Wales](#) (in chapter 12 of the General Guidance Manual), [Scotland](#), and [Northern Ireland](#), (in chapter 9).
- 1.4 In general terms, what are BAT for one installation in a sector are likely to be BAT for a comparable installation. Consistency is important where circumstances are the same. However, in each case it is, in practice, for regulators (subject to appeal) to decide what are BAT for each individual installation, taking into account variable factors such as the configuration, size and other individual characteristics of the installation, as well as the locality (e.g. proximity to particularly sensitive receptors).
- 1.5 The note also, where appropriate, gives details of any mandatory requirements affecting air emissions which are in force at the time of publication, such as those contained in Regulations or in Directions from the Government. In the case of this note, at the time of publication there were no such mandatory requirements.

1.6 In **Section 4** and **Section 5**, arrows are used to indicate the matters which should be considered for inclusion as permit conditions. It is important to note, however, that this should not be taken as a short cut for regulators to a proper determination of BAT or to disregard the explanatory material which accompanies the arrows. In individual cases it may be justified to:

- include additional conditions;
- include different conditions;
- not include conditions relating to some of the matters indicated.

In addition, conditions will need to be derived from other parts of the note, in particular to specify emission limits, compliance deadlines and mandatory requirements arising from directions or other legislation.

Who is the guidance for?

1.7 This guidance is for:

Regulators

- local authorities in England and Wales, who must have regard to this statutory guidance when determining applications for permits and reviewing extant permits;
- the Scottish Environment Protection Agency (SEPA) in Scotland, and district councils or the Northern Ireland Environment Agency (NIEA), in Northern Ireland;

Operators who are best advised also to have regard to it when making applications and in the subsequent operation of their installation;

Members of the public who may be interested to know what the Government considers, in accordance with the legislation, amounts to appropriate conditions for controlling air emissions for the generality of installations in this particular industry sector.

Updating the guidance

1.8 The guidance is based on the state of knowledge and understanding, at the time of writing, of what constitute BAT for this sector. The note may be amended from time to time to keep up with developments in BAT, including improvements in techniques, changes to the economic parameters, and new understanding of environmental impacts and risks. The updated version will replace the previous version on the [Defra](#) website and will include an index to the amendments.

- 1.9 Reasonable steps will be taken to keep the guidance up-to-date to ensure that those who need to know about changes to the guidance are informed of any published revisions. However, because there can be rapid changes to matters referred to in the guidance – for example to legislation – it should not be assumed that the most recent version of this note reflects the very latest legal requirements; these requirements apply.

Consultation

- 1.10 This note has been produced in consultation with relevant trade bodies, representatives of regulators including members of the Industrial Pollution Liaison Committee and other potentially-interested organisations.

Policy and procedures

- 1.11 General guidance explaining LAPPC and setting out the policy and procedures is contained in separate documents for [England and Wales](#), [Scotland](#) and [Northern Ireland](#).

When to use another note rather than PG2/04

- 1.12 This note refers to foundry operations carried out in conjunction with iron and steel and non-ferrous metal processes prescribed for LAPPC. There are separate [Process Guidance notes](#) to cover prescribed ferrous and non-ferrous melting processes, listed below.

The melting notes cover the storage and handling of raw materials used in the melting process and any metal treatments carried out in the furnace or ladle, excluding nodularisation of ferrous metal using magnesium, which has been transferred from PG2/03 and from PG2/05 into this guidance note (see **paragraphs 3.3 - 3.4 and paragraph 5.3**).

- PG2/03 - electrical furnaces
- PG2/05 - cold blast cupolas and rotary furnaces
- PG2/06 - processes for melting and producing aluminium and its alloys
- PG2/07 - zinc and zinc alloy processes
- PG2/08 - copper and copper alloy processes
- PG2/10 (previously PG2/06b) processes for melting and producing magnesium and its alloys

Where an installation is potentially covered by more than one PG note, then the more stringent emission limits and provisions should be applied.

2. Timetable for compliance and reviews

Existing processes or activities

- 2.1 This note contains all the provisions from previous editions which have not been removed. Some have been amended. For installations in operation at the date this note is published, the regulator should have already issued or varied the permit having regard to the previous editions. If they have not done so, this should now be done.
- 2.2 The new provisions of this note and the dates by which compliance with these provisions is expected are listed in **Table 2.1**, together with the paragraph number where the provision is to be found. Compliance with the new provisions should normally be achieved by the dates shown. Permits should be varied as necessary, having regard to the changes and the timetable.

Table 2.1 - Compliance timetable

Guidance	Relevant paragraph/row in this note	Compliance date
There are no new provisions in this note likely of themselves to result in a need to vary existing permit conditions. For a full list of changes made by this note, excluding very minor ones, see Table 6.1 .		

- 2.3 Replacement plant should normally be designed to meet the appropriate standards specified for new installations/activities.
- 2.4 Where provisions in the preceding guidance note have been deleted or relaxed, permits should be varied as necessary as soon as reasonably practicable.
- 2.5 For new activities, the permit should have regard to the full standards of this guidance from the first day of operation.
- 2.6 For substantially changed activities, the permit should normally have regard to the full standards of this guidance with respect to the parts of the activity that have been substantially changed and any part of the activity affected by the change, from the first day of operation.

Permit reviews

- 2.7 Under LAPPC, the legislation requires permits to be reviewed periodically but does not specify a frequency. It is considered for this sector that a frequency of once every eight years ought normally to be sufficient for the purposes of the appropriate Regulations. Further guidance on permit reviews is contained in the appropriate Guidance Manual for [England and Wales](#), [Scotland, Practical guide](#) section 10 and Northern Ireland [Part B Guidance](#) page 9, Northern Ireland [Part C Guidance](#) chapter 17. Regulators should use any opportunities to determine the variations to permits necessitated by **paragraph 2.2** above in conjunction with these reviews.
- 2.8 Conditions should also be reviewed where complaint is attributable to the operation of the process and is, in the opinion of the regulator, justified.

3. Activity description

Regulations

- 3.1 This note applies to LAPPC installations for the iron, steel and non-ferrous foundry processes. The activities are listed for regulation as follows.

Table 3.1 - Regulations listing activities			
LAPPC	England and Wales	Scotland	Northern Ireland
	EPR Schedule 1 reference	PPC Schedule 1 reference	PPC Schedule 1 reference
Part B	Section 2.1 & 2.2 Part B	Section 2.1 & 2.2 Part B	n/a
Part C	n/a	n/a	Section 2.1 & 2.2 Part C

The links are to the original version of the Regulations. A consolidated version is not available on www.legislation.gov.uk.

- 3.2 This note refers to foundry operations carried out in conjunction with iron and steel and non-ferrous metal processes which are prescribed for local air pollution control. It includes nodularisation of ferrous metal using magnesium (previously included in PG2/03 and PG2/05), mould and core making, casting and cooling processes (including die casting), knock out, quenching, shot blasting, metal removal (for example, grinding, fettling, and arc air), degreasing, polishing and finishing (including oxy-cutting). In addition the note relates to foundry sand reclamation operations.

Nodularisation

- 3.3 Nodularisation is the addition to the melt of an alloy containing magnesium. It produces a ductile iron by promoting the formation of graphite in the nodular or spheroidal form. White magnesium oxide fume is produced. There are a choice of techniques which should meet the emission requirements depending upon the process specific circumstances; they include:

- a Tundish cover for the ladle;
- use of totally enclosed flow through treatment boxes ;
- magnesium addition in the mould;
- use of magnesium-containing wire feed process;
- collection of the emission followed by arrestment in a bag filtration system.

- 3.4 There are a number of methods of introducing the nodularising agent into the metal and these include pour-over, plunging, pressure vessel, tundish cover for the ladle, in-stream and in-mould techniques. Some methods result in the evolution of large volumes of fume whilst others produce less fume or enable it to be contained more effectively.

Casting processes

- 3.5 The requirements for making one-off, large castings are quite different from those for making repetition castings, so companies tend to specialise either as jobbing or repetition foundries. The following describes some features of the main casting processes:

- 3.6 **Cores and core making** - Cores are pieces that are placed into casting moulds to form internal cavities of the casting, or to form extra sections of the mould for castings. Multiple cores may be used in complex castings.

Cores can be made from metal (not relevant to this PG Note) or chemically bonded sand (complex shapes and used in all mould types). Sand cores are made from materials similar to those used for chemically bonded sand moulds. These cores are formed in core boxes - similar to pattern boxes used to make moulds.

- 3.7 **Sand casting** - several methods used including the following:

- green sand moulding - traditional method with clay as the binder; most widely used process in iron foundries; 90-95% of sand can be recycled. (Organic additions to the green sand may be made, such as starch and, in the iron foundry industry, coal dust).
- CO₂/silicate process -- dry sand mixed with a viscous sodium silicate binder is compacted in the mould. Carbon dioxide gas is passed through it and causes it to harden. No heating required. Silicate binders can also be self-set with esters.
- organic cold set processes (widely used in iron foundries) - organic binder systems that can be cured at room temperature, sand, binder and curing agent mixed together. Very many processes developed and continuing to be developed.
- organic gassed processes – sand and binder mixed together and shaped into mould or core before the curing agent is introduced in the form of a gas or a vapour.
- shell moulding process - heat required to cure the mould. Fine sand used for improved casting surface finish. Phenol formaldehyde resins used. Described as a two -stage resin (also known as novalac resin) as a curing agent is required (hexamethylene tetra-amine) - this emits formaldehyde under heat which cross-links the resin. Ammonia is also liberated.

- evaporative pattern casting process (Lost foam process) - used for mass production of castings. An expanded polystyrene pattern coated with a suitable refractory wash is embedded in dry, unbonded sand which is vibrated to produce a rigid mould. On pouring the molten metal displaces the polystyrene to produce the shape of the casting required. Moulding sand is entirely reclaimable. Reduced amount of finishing required.
- vacuum-sealed investment process – an expanded polystyrene pattern is coated with several layers of a suitable refractory ceramic material. The ceramic coating is cured in a firing furnace which also removes the polystyrene pattern by combustion leaving a shell mould. The mould is embedded in dry unbonded sand. A vacuum is applied to the moulding box which causes the sand to become rigid and support the ceramic shell mould during casting.

3.8 **Investment casting** (see **Appendix 1** for the typical process steps involved) also known as the lost wax process - highly specialised process. Expendable pattern is used so no mould joint line. Use of very fine refractory particles ensures an improved casting finish. Foundries using this technique tend to specialise in either steels, aluminium alloys or the superalloys (nickel or cobalt based). Minimal finishing required.

3.9 **Die casting** - permanent mould - high degree of consistency. Techniques include gravity diecasting, pressure diecasting (commonly used for aluminium and zinc alloy castings) and low pressure diecasting.

Finishing processes

3.10 Fettling, dressing or finishing are terms given to the finishing stages after the casting has been separated from the mould or die. These stages typically consist of shot blasting, degating, feeder head removing and grinding.

3.11 Heat treatment may also be required. The following heat treatments are most commonly associated with steel:

- annealing - this fully softens the steel -crystal structure is enhanced on controlled cooling,
- tempering - alters the microstructure and hence the properties of steel,
- case hardening - increases the surface hardness of steel or cast iron,
- quenching - rapid cooling.

Sand reclamation processes

- 3.12 Sand Reclamation Processes may involve screening, crushing, grinding, sieving, heating, drying and cooling of used foundry sand in addition to metal recovery. In the case of iron and steel processes metal recovery is usually achieved by magnetic band separators and in non-ferrous processes by flotation/density separation. The reclamation of foundry sand may involve the destruction by incineration of organic compounds present in the used sand.

Pollutants and Sources

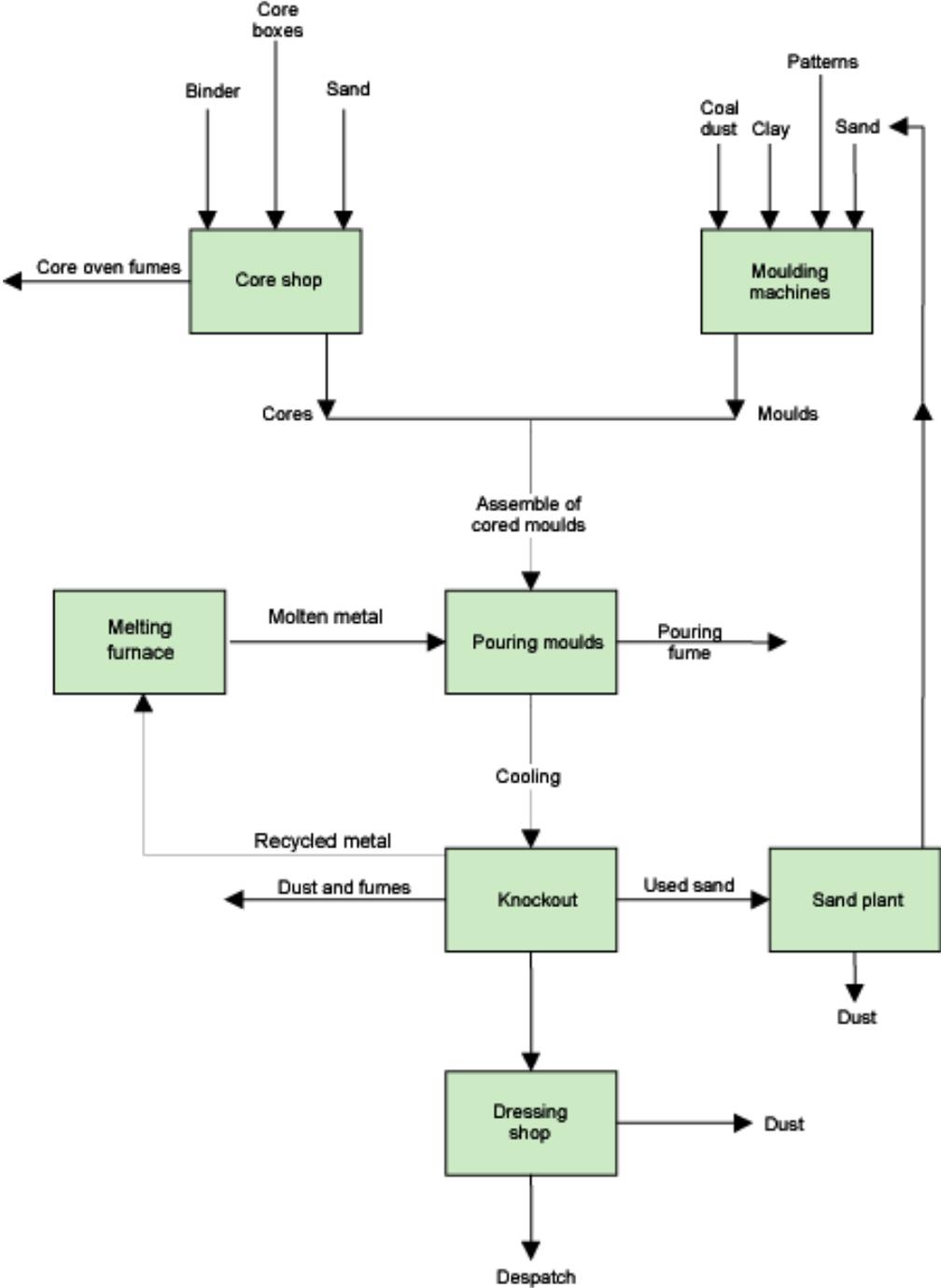
- 3.13 The most significant releases to air are: particulate matter, iron and its oxides, heavy metals, ammonia, VOC including formaldehyde and phenols. Some of these pollutants are malodorous.
- 3.14 Preparation of moulds and cores gives rise to dust from sand handling and gases from any resin, hardener and catalyst used (the binder system) and their reactions during mixing and curing. The different binder systems give rise to different emissions, but the main types emit two or more of the following odorous gases: ammonia, hydrogen sulphide, sulphur dioxide, methyl di-isocyanate, phenol, formaldehyde and a range of other VOCs including amines and esters.
- 3.15 Casting, pouring, moulding and knocking out give rise to emissions relating to the pyrolysis and combustion of the binders. They include all of those mentioned above for the preparation of moulds and cores, as well as carbon monoxide, carbon dioxide and the organic products of thermal degradation of the binders such as cresols (methylphenol) and xylenols (dimethylphenol) that are malodorous.

Appendix 2 describes the main casting and cooling emissions from some commonly used binder systems.

- 3.16 Fettling, dressing or finishing give rise to particulate matter and some fume if techniques involving heat are used.
- 3.17 Sand reclamation gives rise to particulate matter from mechanical reclamation and gaseous emissions from thermal reclamation.
- 3.18 Other fugitive emissions of dust may arise from transfer of potentially dusty materials including discharge into hoppers and onto conveyors, and delivery to storage silos and sheds. Also material collected by bag filters, if it is not securely contained and carefully handled.

Figure 3.1 - Flow diagram of a typical greensand foundry process

Note - inputs into the moulding machines may vary in other sand foundries e.g. sand types, resin binders, catalysts etc.



4. Emission limits, monitoring and other provisions

- 4.1 Emissions of the substances listed in **Table 4.1** should be controlled.
- 4.2 The emission limit values and provisions described in this section are achievable using the best available techniques described in **Section 5**. Monitoring of emissions should be carried out according to the method specified in this section or by an equivalent method agreed by the regulator. Where reference is made to a British, European, or International standard (BS, CEN or ISO) in this section, the standards referred to are correct at the date of publication. (Users of this note should bear in mind that the standards are periodically amended, updated or replaced). The latest information regarding the monitoring standards applicable can be found at the [Source Testing Association website](#). Further information on monitoring can be found in Environment Agency publications, [M1 and M2](#).
- 4.3 All activities should comply with the emission limits and provisions with regard to releases in **Table 4.1**.

The reference conditions for limits in **Section 4** are 273.1K, 101.3kPa and the oxygen and water references should be that which corresponds to the normal operating conditions in the process concerned.

Table 4.1 should be considered in conjunction with the monitoring paragraphs found later in this section.

Table 4.1 - Emission limits, monitoring and other provisions

Row	Substance (see Note 1)	Source	Emission limits/provisions	Type of monitoring	Monitoring frequency
1	All emissions to air	All emissions to air, except emissions from: <ul style="list-style-type: none"> condensed water vapour nodularisation 	Free from persistent visible emissions	Visual assessments	At least daily (unless fitted with a continuous indicative monitor and alarm)
2	Total particulate matter	Nodularisation processes	Visible emissions should not cross the site boundary	Visual assessments	At least daily
3	Total particulate matter	Emissions from arrestment equipment with an airflow of less than 150m ³ /minute	Free from persistent visible emissions	Indicative monitoring e.g. pressure drop indicator or burst bag detector	At least daily
4	Total particulate matter	Stack emissions with an air flow greater than 150m ³ /minute where emissions are: <ul style="list-style-type: none"> unabated (see Note 2) from dry filtration plant from new wet arrestment plant. 	20 mg/m ³	Indicative continuous emissions monitoring with alarms (for airflow greater than 300m ³ /minute, see Note 3)	Continuous
				Plus	Manual extractive test
5	Total particulate matter	Where existing wet arrestment plant (i.e. fitted before 1st November 2004) is fitted, or where a green sand shakeout or mixing system is being served by a wet arrester	50 mg/m ³	Indicative monitoring in accordance with paragraph 4.19	Continuous
				Plus	Manual extractive test
6	Total particulate matter	Silo filtration plant	Designed to operate to an emission standard of less than 10mg/m ³	Visual assessments	At least daily and during bulk deliveries
7	VOC	Processes likely to emit VOCs e.g. thermal sand reclamation systems, solvent based investment foundry coating, shelling and setting operations	30 mg/m ³	Manual extractive test	Annual.

8	Hydrogen sulphide	Processes likely to emit hydrogen sulphide (see Appendix 2)	5ppm v/v	Manual extractive test.	Annual.
9	Amines	Processes likely to emit amines* (see also Appendix 2)	5ppm v/v *	Manual extractive test	Annual.
* This limit should be disappplied where it is considered that there is no potential for offensive odour beyond the site boundary. The only likely case is where triethylamine is the only amine used in the activity.					
10	Metals and their salts	Processes likely to emit copper or its compounds (see Note 4)	Copper and its compounds 5 mg/m ³ , except where copper or copper alloy castings are being fettled, in which case the limit remains at 20 mg/m ³ .	Manual extractive test.	Annual.
11	Metals and their salts	Processes likely to emit lead or its compounds (excluded from Note 4)	Lead and its compounds 1 mg/m ³ .	Manual extractive test.	Annual.
12	Sulphur dioxide	All activities using heavy fuel oil	1% wt/wt sulphur in fuel	Sulphur content of fuel is regulated by other arms of government	
		All activities using gas oil	0.1% wt/wt sulphur in fuel		

Note 1 - In some circumstances it may be necessary to set emission standards for other pollutants dependent upon the type of materials used and the nature of the emissions produced by the process.

Note 2 - Where no arrestment plant is required to meet the emission limits, refer to paragraph 4.30.

Note 3 - Where airflow from arrestment equipment is greater than 300m³/minute, indicative continuous emissions monitoring should be in place, capable of recording data.

Note 4 - (applies only to Row 10) [Environment Agency guidance M2](#) gives BS EN 14385 and associated MID 14385 (Method Implementation Document) as the preferred method for the determination of total emissions of metals by isokinetic sampling and impingement. Use of this method gives total metals in both the particulate and vapour phases. Metal emissions in the vapour phase are generally considered to be negligible; therefore, it is not necessary to apply the clauses in EN 14385 that are related to the measurement of metals in the vapour phase.

Monitoring, investigating and reporting

- 4.4 The operator should monitor emissions, make tests and inspections of the activity. The need for and scope of testing (including the frequency and time of sampling) will depend on local circumstances.
- The operator should keep records of inspections, tests and monitoring, including all non-continuous monitoring, inspections and visual assessments. Records should be:
 - kept on the site of the permitted activity;
 - kept by the operator for at least two years; **and**
 - made available for the regulator to examine.
 - If any records are kept off-site they should be made available for inspection within one working week of any request by the regulator.

Information required by the regulator

- 4.5 The regulator needs to be informed of monitoring to be carried out and the results. The results should include process conditions at the time of monitoring.
- The operator should notify the regulator at least 7 days before any periodic monitoring exercise to determine compliance with emission limit values. The operator should state the provisional time and date of monitoring, pollutants to be tested and the methods to be used.
 - The results of non-continuous emission testing should be forwarded to the regulator within 8 weeks of completion of the sampling.
 - Adverse results from any monitoring activity (both continuous and non-continuous) should be investigated by the operator as soon as the monitoring data has been obtained. The operator should:
 - identify the cause and take corrective action;
 - clearly record as much detail as possible regarding the cause and extent of the problem, and the remedial action taken;
 - re-test to demonstrate compliance as soon as possible; **and** inform the regulator of the steps taken and the re-test results.

Visible emissions

- 4.6 The aim should be to prevent any visible airborne emission from any part of the process. This aim includes all sites regardless of location. Monitoring to identify the origin of a visible emission should be undertaken and a variety of indicative techniques are available.
- where ambient monitoring is carried out it may also be appropriate for the regulator to specify recording of wind direction, strength, weather conditions, location and method of monitoring.
- 4.7 Emissions from combustion processes in normal operation should be free from visible smoke. During start up and shut down the emissions should not exceed the equivalent of Ringelmann Shade 1 as described in British Standard BS 2742.
- All other releases to air, other than condensed water vapour, should be free from persistent visible emissions.
 - All emissions to air should be free from droplets.
 - Where an emissions point is not fitted with a continuous indicative monitor and alarm in accordance with **paragraph 4.18**, visual assessments of emissions should be made frequently and at least once each day whilst the process is in operation. The time, location and result of these assessments should be recorded.
- 4.8 Where there are problems that, in the opinion of the regulator, may be attributable to the installation, such as local complaints of visual emissions or where dust from the installation is being detected beyond the site boundary, the operator should investigate in order to find out which part of their operation(s) is the cause.

If this inspection does not lead to correction of the problem then the operator should inform the regulator who will determine whether ambient air monitoring is necessary. Ambient monitoring may either be by a British Standard method or by a method agreed with the regulator.

Whilst problems are ongoing, a visual check should also be made at least once per day/shift, by the operator, when an installation is being operated. The time, location and result of these checks, along with weather conditions such as indicative wind direction and strength, should be recorded. Once the source of the emission is known, corrective action should be taken without delay and where appropriate the regulator may want to vary the permit in order to add a condition requiring the particular measure(s) to be undertaken.

Emissions of odour

- 4.9 The overall aim should be that all emissions are free from offensive odour outside the site boundary, as perceived by the regulator. However, the location of the installation will influence the assessment of the potential for odour impact as local meteorological conditions may lead to poor dispersion conditions. Where the site has a low odour impact due to its remoteness from sensitive receptors, the escape of offensive odour beyond the installation would be unlikely to cause harm.
- 4.10 Parts of the process have the potential to emit odour. **Appendix 2** identifies emissions expected from a range of mould and core manufacturing processes and highlights those that are potentially odorous¹.
- Emissions from core or mould making processes and casting processes should, where necessary to avoid offensively odorous emissions, be passed through suitable abatement plant such as chemical scrubbers or incinerators, and ducted to a stack capable of being monitored in accordance with the requirements of **Table 4.1** and **Section 4** of this note. (This is essential where DMEA (dimethyl ethyl amine) is used in binder systems but not usually necessary where TEA (triethylamine) is used - see **Appendix 3**).
- 4.11 Where it is installed any odour arrestment equipment should be inspected at least once a day/shift to verify correct operation and to identify any malfunctions. Depending upon the type of any arrestment plant used this inspection should include:
- identification of any leaks in air handling equipment and ductwork;
 - in the case of scrubbing equipment, thermal oxidisers and other combustion equipment, the inspection should include verification of the operation of any continuous monitoring equipment, the presence of any blockages and also identification of any leaks of either odorous air or liquid.
- 4.12 Where there are problems that, in the opinion of the regulator, may be attributable to the installation, such as local complaints of odour or where odour from the installation is being detected beyond the site boundary, the operator should investigate in order to find out which part of their operation(s) is the cause.

¹ For details see [England and Wales](#) chapter 17, [Scotland](#), [Northern Ireland](#) chapter 12

4.13 Whilst problems are ongoing, a boundary check should also be made at least once per day/shift, by the operator, when an installation is being operated. The time, location and result of these checks, along with weather conditions such as indicative wind direction and strength, should be recorded. Once the source of the emission is known, corrective action should be taken without delay and where appropriate the regulator may want to vary the permit in order to add a condition requiring the particular measure(s) to be undertaken. Actions that may be considered include an increase in stack height (where a stack has been identified as the cause of the offensive odour), a change in the manufacturing procedure to reduce odour and/or abatement.

Abnormal events

4.14 The operator should respond to problems which may have an adverse effect on emissions to air.

- In the case of abnormal emissions, malfunction or breakdown leading to abnormal emissions the operator should:
 - investigate and undertake remedial action immediately;
 - adjust the process or activity to minimise those emissions; **and**
 - promptly record the events and actions taken.
- The regulator should be informed without delay, whether or not there is related monitoring showing an adverse result:
 - if there is an emission that is likely to have an effect on the local community; **or**
 - in the event of the failure of key arrestment plant, for example, bag filtration plant or scrubber units.
- The operator should provide a list of key arrestment plant and should have a written procedure for dealing with its failure, in order to minimise any adverse effects.

Start up and shutdown

- 4.15 Higher emissions may occur during start-up and shut-down of a process. These emissions can be reduced, by minimising, where possible, the number of start-ups and shut-downs and having adequate procedures in place for start-up, shut-down and emergency shut-downs.
- The number of start-ups and shut downs should be kept to the minimum that is reasonably practicable.
 - All appropriate precautions must be taken to minimise emissions during start-up and shutdown.

Continuous monitoring

- 4.16 Continuous monitoring can be either 'quantitative' or 'indicative'. With quantitative monitoring the discharge of the pollutant(s) of concern is measured and recorded numerically. For pollution control this measurement is normally expressed in milligrams per cubic metre of air (mg/m^3). Where discharge of the pollutant concerned is controlled by measuring an alternative parameter (the 'surrogate' measurement), this surrogate is also expressed numerically.
- 4.17 Continuous indicative monitoring is where a permanent device is fitted, for example, to detect leaks in a bag filter, but the output, whether expressed numerically or not, does not show the true value of the discharge. When connected to a continuous recorder it will show that emissions are gradually (or rapidly) increasing, and therefore maintenance is required. Alternatively it can trigger an alarm when there is a sudden increase in emissions, such as when arrestment plant has failed.
- 4.18 Where continuous indicative monitoring has been specified, the information provided should be used as a management tool. Where used, the monitor should be set up to provide a baseline output when the plant is known to be operating under the best possible conditions and emissions are complying with the requirements of the permit.

Where used to trigger alarms, the instrument manufacturer should be able to set an output level which corresponds to around 75% of the emission limit. Thus the alarms are activated in response to this significant increase in pollutant loading above the baseline, so that warning of the changed state is given before an unacceptable emission occurs. The regulator may wish to agree the alarm trigger level.

4.19 Where continuous monitoring is required, it should be carried out as follows:

- All continuous monitoring readings should be on display to appropriately trained operating staff.
- Instruments should be fitted with audible and visual alarms, situated appropriately to warn the operator of arrestment plant failure or malfunction.
- The activation of alarms should be automatically recorded.
- All continuous monitors should be operated, maintained and calibrated (or referenced, in the case of indicative monitors) in accordance with the manufacturers' instructions, which should be made available for inspection by the regulator.
- The relevant maintenance and calibration (or referencing, in the case of indicative monitors) should be recorded.
- Emission concentrations may be reported as zero when the plant is off and there is no flow from the stack. If required a competent person should confirm that zero is more appropriate than the measured stack concentration if there is no flow.
- Any continuous monitor used should provide reliable data >95% of the operating time, (i.e. availability >95%). A manual or automatic procedure should be in place to detect instrument malfunction and to monitor instrument availability.

Calibration and compliance monitoring

4.20 Monitoring should meet the following provisions as appropriate. Note that different types of continuous monitoring are required for emissions from wet arrestment plant compared to emissions that are either unabated or from dry filtration plant.

- Where arrestment plant includes wet scrubbing for amines or hydrogen sulphide the scrubber liquor should be continuously monitored for pH. The monitor should be fitted with audible and visual alarms which activate at a level that indicates that the emission limits for amines and hydrogen sulphide in **Table 4.1** may be being exceeded.

4.21 Where a wet scrubber is used to abate emissions a visual inspection of the equipment should be made at least once a week to ensure correct functioning of the equipment including adequate liquor circulation. The result of each inspection should be recorded. Scrubber liquor flow should be continuously monitored, triggering an alarm and stand-by pump in the event of pump failure.

- 4.22 Compliance monitoring can be carried out either by use of a continuous emissions monitor (CEM), or by a specific extractive test carried out at a frequency agreed with the regulator.
- 4.23 Where a CEM is used for compliance purposes it must be periodically checked, (calibrated), to ensure the readings being reported are correct. This calibration is normally done by carrying out a parallel stand-alone extractive test and comparing the results with those provided by the CEM.
- 4.24 For extractive testing the sampling should meet the following requirements:
- For batch processes, where the production operation is complete within, say, 2 hours, then the extractive sampling should take place over a complete cycle of the activity.
- 4.25 Should the activity either be continuous, or have a batch cycle that is not compatible with the time available for sampling, then the data required should be obtained over a minimum period of 2 hours in total.
- For demonstration of compliance where a CEM is used no daily mean of all 15-minute mean emission concentrations should exceed the specified emission concentration limits during normal operation (excluding start-up and shut-down); **and**
 - No 15-minute mean emission concentration should exceed twice the specified emission concentration limits during normal operation (excluding start-up and shut-down).
 - For extractive testing, no result of monitoring should exceed the emission limit concentrations specified.
- 4.26 Exhaust flow rates should be consistent with efficient capture of emissions, good operating practice and meeting the requirements of the legislation relating to the workplace environment.
- The introduction of dilution air to achieve emission concentration limits should not be permitted.

Dilution air may be added for waste gas cooling or improved dispersion where this is shown to be necessary because of the operational requirements of the plant. Provided that it is clearly shown that pollutant emission limits are already being met then the regulator may agree to dilution air being introduced in order to render an odorous emission harmless.

Varying of monitoring frequency

- 4.27 Where non-continuous quantitative monitoring is required, the frequency may be varied. Where there is consistent compliance with emission limits, regulators may consider reducing the frequency. However, any significant process changes that might have affected the monitored emission should be taken into account in making the decision.
- 4.28 When determining “consistent compliance” the following are cases which might not qualify for a reduction in monitoring:
- variability of results: cases where monitoring results vary widely and include results in the range 30-45mg/m³ (when the emission limit is 50mg/m³)
 - the margin between the results and the emission limit: cases where results over a period are 45mg/m³ or more (when the emission limit is 50mg/m³).

Consistent compliance should be demonstrated using the results from at least;

- three or more consecutive annual monitoring campaigns; **or**
- two or more consecutive annual monitoring campaigns supported by continuous monitoring.

Where a new or substantially changed process is being commissioned, or where emission levels are near to or approach the emission concentration limits, regulators should consider increasing the frequency of testing.

- 4.29 A reduction in monitoring frequency should not be permitted where continuous quantitative or indicative monitoring is required. These types of monitoring are needed to demonstrate at all times when the plant is operating, that either the emission limits are being complied with or that the arrestment equipment is functioning correctly.

Monitoring of unabated releases

- 4.30 Where emission limit values are consistently met without the use of abatement equipment, the monitoring requirement for those pollutants should be dispensed with subject to the “Varying of monitoring frequency” paragraphs above.
- 4.31 Where no arrestment plant is required to meet the emission limits in **Table 4.1**, the operating parameters applying at the time of the stack monitoring exercise should be recorded.

If the operator does not intend to vary these parameters during the course of the year then there is no need for a continuous indicative monitor. If the operator envisages significant variation in the operating parameters then a continuous indicative monitor should be used to demonstrate compliance or stack sampling should be undertaken to cover the range of parameters being used.

If the regulator finds during the course of the year that different parameters are being applied and no continuous indicative monitor has been required, they can then require it or specify additional stack sampling to cover the particular conditions. The relevant parameters should include: feedstock type, maximum melt temperature, flux or other additions and emission flow rates.

Representative sampling

4.32 Whether sampling on a continuous or non-continuous basis, care is needed in the design and location of sampling systems, in order to obtain representative samples for all release points.

- Sampling points on new plant should be designed to comply with the British or equivalent standards (see **paragraph 4.2**).
- The operator should ensure that relevant stacks or ducts are fitted with facilities for sampling which allow compliance with the sampling standards.

Where monitoring is not in accordance with the main procedural requirements of the relevant standard, deviations should be reported.

Emissions from silos

4.33 During silo filling it is most likely that any emissions would be released during the first and last five minutes of the delivery. During the first few minutes emissions due to leaks or split hoses would first be noticed. Excess pressure from the tanker may cause an emission through the pressure relief valve if the driver is not controlling the delivery correctly. This would be noticed during the last few minutes (see also **paragraph 5.6**)

4.34 Isokinetic monitoring of emissions from the arrestment plant is not likely to be possible during silo filling as the delivery period is so short. For this reason there is no numerical emission limit for such plant. It is important however that the plant is designed to cope with the delivery flow rate that is used for the silo. The following measures relating to arrestment plant on silos and other silo management techniques are only applicable where the silo vents to the external environment or where silo emissions may escape from inside a building into the external environment.

Inspection of silo system

4.35 Silo systems require appropriate inspections and assessments to minimise potential for emissions during the filling process.

- Operators should have a procedure in place to ensure that visual assessment of emissions from silo inlet connections and the silo arrestment plant are undertaken throughout the duration of all bulk deliveries. The start and finish times of all deliveries should be recorded. This paragraph applies to all deliveries which are part of the permitted process.

Inspection of filtration plant

4.36 Silo arrestment plant and arrestment plant serving other process operations require regular inspection as follows:

- Filtration plant should be inspected at the frequency specified in **Table 4.2**.

Table 4.2 - Filter plant inspection frequency

Filter cleaning method	Frequency of visual inspection
Fitted with reverse jets	at least once a month
Fitted with mechanical shakers	at least once a week
Requiring manual shaking	daily inspection or prior to any delivery being made if deliveries are not daily

4.37 The outlet should be checked for signs that emissions have occurred. The equipment should also be checked for defects in the airflow or the cam shakers. If emissions or defects are detected then corrective action should be taken promptly and before another delivery takes place. Any failure of the silo management system (e.g. high level alarms, filter, pressure relief valve) should lead to full investigation of the operation of the plant and equipment.

- Reduced inspection frequency of silo arrestment plant may be appropriate:
 - a) where pressure drop sensors or other continuous monitors are used to monitor the arrestment plant; such monitors should be inspected according to manufacturers' recommendations to ensure their proper operation
 - b) for filters fitted with reverse jets or with mechanical shakers where operating experience has demonstrated satisfactory operation of the arrestment plant
 - c) where the process operation is infrequent.

5. Control techniques

Summary of best available techniques

5.1 **Table 5.1** provides a summary of the best available techniques that can be used to control the process in order to meet the emission limits and provisions in **Section 4**. Provided that it is demonstrated to the satisfaction of the regulator that an equivalent level of control will be achieved, then other techniques may be used.

Table 5.1 - Summary of control techniques		
Release source	Pollutant	Control techniques
Raw material storage	Particulate matter	Store potentially dusty materials in buildings or appropriate containers
External silos	Particulate matter	Process control especially on delivery Dust arrestment: <ul style="list-style-type: none"> • bag filters • cartridge filters
External operations Conveyors Stockpiles Roadways Loading/unloading	Particulate matter	Containment or appropriate siting <ul style="list-style-type: none"> • away from site boundary especially if near residential or other sensitive receptors Wind dynamics management <ul style="list-style-type: none"> • use of fencing, bunding, profiling • reduced drop heights Suppression <ul style="list-style-type: none"> • water and/or suppressants Covering <ul style="list-style-type: none"> • below ground or covered stock bins • dust covers • housing Process controls <ul style="list-style-type: none"> • use of variable height conveyors • use of chutes Dust arrestment (loading area) <ul style="list-style-type: none"> • bag filters • cartridge filters

Mould making and core making Mixing Curing	VOC and odour	Inspect and maintain burners and ovens Binder chemical use and emissions should be minimised to the greatest extent possible without detriment to mould/core quality and casting production. Containment, extraction, monitoring & arrestment and dispersion where necessary to meet the limits.
Casting and cooling	Smoke particles, fume, VOC and odour	Containment, extraction, monitoring and arrestment where necessary to meet the limits. Production line foundries: contain emissions from casting and cooling (to minimise fugitive emissions) Jobbing foundries: wherever possible contain emissions from casting and cooling (to minimise fugitive emissions). Otherwise disperse and dilute as necessary to comply with visual/odour requirements. Management of working area such as control of through drafts and keeping doors closed
Knock out	Particulate matter, VOC and odour	Adequate cooling period before knockout. Containment, extraction, monitoring and abatement where necessary to meet the limits.
Shot blasting and other finishing processes	Particulate matter	Dust arrestment: <ul style="list-style-type: none"> • bag filters • cartridge filters
Solvent usage	VOC	Maintain an inventory with a view to reducing usage where possible.
Foundry sand reclamation	Particulate matter and VOC	Containment, extraction, monitoring & arrestment and dispersion where necessary to meet the limits.

Techniques to control emissions from contained sources

Particulate matter, metals and their compounds

- 5.2 Emissions of particulate matter should be contained, extracted and abated if necessary to meet the visible emission provisions or the limits described in **Table 4.1** for particulate matter and for metals and their compounds.
- All new plant should be contained such that emissions are extracted and ducted to a single emission point that is designed so that monitoring can take place in accordance with **paragraphs 4.18 - 4.19**.
 - Emissions should be abated where necessary to meet the limits and provisions described in **Table 4.1**.
 - Finishing processes (including, for example, grinding, shotblasting, polishing, and arc air-cutting) should be undertaken in booths or areas with extraction of emissions or using equipment incorporating built in extraction equipment. Any extraction venting outside the building should discharge via arrestment plant to meet the emission limits and provisions of **paragraphs 4.6 - 4.7** and **Table 4.1** of this note.
 - All emissions from foundry sand reclamation processes should be contained, captured and where necessary vented to suitable arrestment plant to meet the provisions of **paragraphs 5.5 - 5.6** and **Table 4.1** in this note.
 - Where particulate matter emissions are abated using a wet scrubber, the scrubber should be regularly maintained. Action should be taken to deal with any blockages that occur due to accumulation of solids, for example, adding flocculating agents to the liquor to settle the solids out. Flocculants will cause deposition which may result in blockages.

Nodularisation

- 5.3 Nodularisation gives rise to an emission of thick, white magnesium oxide fume. Techniques which minimise this emission are described within the process description at **paragraphs 3.3 - 3.4**. Where the fume is exceeding the provisions in **Table 4.1** it will be necessary for the operator to use one of these ameliorative measures or another technique capable of meeting the requirements, in agreement with the regulator.

Silos

5.4 The silo management system includes the high level alarms, arrestment plant and pressure relief valve. If best practice is being applied then any failure of the silo management system leads to full investigation of the operation of the plant and equipment. Continuous high level monitoring systems are currently available for use in storage silos. They may be used telemetrically to monitor stock within the silo. They may also be used to automatically stop delivery of material to the silo. It is expected that such systems will become more widely used in the future. The correct operation of the system should be checked in accordance with manufacturers' instructions.

5.5 Careful delivery by trained personnel will avoid materials being blown into silos at a rate which is likely to result in pressurisation of the silo, especially towards the end of the delivery when the quantity of material entering the ducting is reduced.

Tanker drivers should be informed of the correct procedures to be followed. Care should be taken to avoid delivering materials to silos at a rate which is likely to result in pressurisation of the silo. Particular problems may arise during the release of air from tankers at the end of deliveries and care should therefore also be taken to avoid over pressurisation of silos when venting air from tankers at this stage. These can be alleviated by the use of tankers with sufficient valvework to allow a gradual release to occur and by carefully controlled venting. If deliveries are accepted from tankers without on board relief valve and filtration systems, particular care should be taken to avoid pressurisation of silos when venting air through the silo at the end of the delivery.

5.6 The following measures relating to arrestment plant on silos and other silo management techniques are only applicable where the silo vents to the external environment or where silo emissions may escape from inside a building into the external environment. Note: The regulator might accept sight glasses on the silo as an alternative to alarms where it can be established for each delivery that sufficient capacity remains in the silos to contain the volume of sand being delivered, and that the delivery is continually attended.

- When delivery to a silo or bulk storage tank takes place, displaced air should either be vented to suitable arrestment plant (for example cartridge/bag filters) or back-vented to the delivery tanker, in order to minimise emissions. Arrestment plant fitted to silos should be of sufficient size (and kept clean) to avoid pressurisation during delivery.

- The fitting of pressure relief valves will help to minimise damage to arrestment plant if the silo becomes pressurised due to the blinding of filters. Seating of pressure relief valves, where fitted to silos, should be checked at least once a week or before a delivery takes place, whichever is the longer interval. Immediately it appears that the valve may have become unseated, the delivery should cease and no further delivery should take place. The valve should be examined and resealed if necessary. Bulk storage tanks and silos containing dry materials should be equipped with audible and/ or visual high level alarms to warn of overfilling. The correct operation of such alarms should be checked regularly having regard to the frequency of delivery.
- In order that fugitive emissions are minimised during the charging of silos, care should be taken to ensure that the transfer lines are securely connected to the tanker discharge point and the silo delivery inlet point.
- If emissions of particulate matter are visible from ducting, pipework, the pressure relief valve or dust arrestment plant during silo filling, the operation should cease; the cause of the problem should be rectified prior to further deliveries taking place. Tanker drivers should be informed of the correct procedure to be followed.
- All new silos should be fitted with an automatic system to cut off delivery in the event of pressurisation or overfilling. Use of alternative techniques may be acceptable provided that they achieve an equivalent level of control with regard to potential for emissions to air.

VOC and odour control

- 5.7 Volatile organic compound (VOC) emissions arise from the use of solvents and from the use of organic binders in moulds and cores. VOC also arises from knock-out, thermal de-core processes and thermal sand reclamation – anywhere that heat is used and sand binder systems that contain VOCs have been used.

The use of water-borne die lubricants and low- solvent mould and core coatings minimises the emission of organic solvents from the use of die and mould dressing materials. Thermal degradation of the binders occurs when molten metal is poured into the mould, giving rise to a range of organic emissions. It may also be necessary to use a scrubber in conjunction with a very high stack in order to disperse residual odour.

- Emissions from casting processes should be captured and vented to suitable arrestment plant, where necessary to meet the provisions of **Section 4** of this note.
- An inventory of organic solvents usage should be maintained.

- Where organic solvents based cleaning and degreasing is undertaken, the relevant standards in [PG6/45 - surface cleaning](#), should apply.
- The use of odour masking agents and counteractants should not be permitted, except in the case of counteractants where they are used at existing processes and where (in such cases) it can be demonstrated that their use is to secure compliance with the odour provisions of **Section 4**.
- Emissions from local exhaust ventilation from any casting, cooling and knockout areas should be abated if necessary to meet the provisions of **Table 4.1**.
- Where odorous emissions are abated using a wet scrubber, the scrubber should be regularly maintained. Action should be taken to ensure that the liquor is held at a suitable pH, to enhance removal of amine, for example, by dosing with acid.
- Waste liquor from scrubbers should be stored in fully enclosed containers.

5.8 The use of resins, hardeners and catalysts should be minimised, consistent with the correct functioning of the binder system, in order to minimise emissions of volatile organic compounds and odour. Burners in mould and core making equipment require regular inspection and maintenance, to minimise methane leakage.

- Binder chemical additions should be minimised to the greatest extent possible. Records should be kept of the level of necessary binder addition.
- Emissions from mould and core production (including mixing operations) should be discharged via a suitable arrestment plant where necessary to meet the provisions of this note.
- Burners in mould and core making equipment should be regularly inspected and maintained and appropriate records kept.

Techniques to control fugitive emissions

Fugitive emissions

- 5.9 Emissions from the operations covered by this note include very fine particulate matter, in the form of fume and smoke generated over short periods (casting and knocking out), as well as potentially coarser grit and dust (finishing). The control of fugitive emissions of particulate matter is mainly by the carrying out of processes within buildings and use of dilution to achieve the provisions described in **paragraphs 4.6 - 4.7** with regard to visible emissions.

It is recognised that local containment and extraction can sometimes be difficult to design in a manner that does not impede operations, such as overhead crane movements. Where the provisions of **Section 4** are not met then fugitive emissions should be prevented or minimised by the use of containment and extraction and the extracted emissions should be addressed as described in **paragraph 5.2**. An enclosure fitted with extract ventilation to arrestment plant may be a necessary control measure, for example in the finishing process areas.

- All processes likely to emit into the air any particulate matter (for example oxy fuel cutting, burning off of casting residues, casting and knocking out) but excluding the storage and transfer of raw materials, should be undertaken in an enclosed area or building of suitable construction to minimise emissions to air and meet the provisions of **paragraphs 4.6 - 4.7, 4.8** and **Table 4.1**.
- Correctly designed extraction systems should be used where necessary to achieve the limits and provisions of **Table 4.1** and **Section 4**.

Materials handling

- 5.10 Stocks of dusty, or potentially dusty, materials (including waste sand and sand awaiting reclamation) should be stored in such a manner as to minimise wind whipping and loading to and from stockpiles should be carried out so as to minimise emissions to the air. All such materials should be stored in covered containers, purpose built silos or undercover whenever practicable. The transportation and handling of dusty materials and wastes should be carried out by methods which minimise emissions to the air.

- All dusty or potentially dusty materials should be stored in silos, in confined storage areas within buildings, or in fully enclosed containers / packaging. Where the storage is open within a building, then suitable precautions should be taken to prevent wind whipping.
- All new or reclaimed dry sand stored outside should be stored in purpose built silos, sealed bags, or closed containers.

- External above ground conveyors for dusty materials should be fitted with protection against wind whipping. Transfer points should be enclosed and ducted to suitable arrestment equipment where necessary to meet the provisions of **paragraphs 4.6 - 4.7, 4.8** and **Table 4.1** of this note.
- The method of collection of waste from dry arrestment plant should be such that dust emissions are minimised.
- Dusty wastes should be stored in closed containers and handled in a manner that avoids emissions of dust.
- Internal transport of dusty materials should be carried out so as to prevent or minimise airborne dust emissions.
- External surfaces of the process building, ancillary plant and open yards and storage areas should be inspected at least annually and cleaned if necessary to prevent the accumulation of dusty material in circumstances where the dust may become wind entrained. Particular attention should be paid to roofs, guttering, roadways, external storage areas and yards. Cleaning operations should be carried out by methods which minimise emissions of particulate matter to air.
- A high standard of housekeeping should be maintained.

5.11 Adequate provision to contain liquid and solid spillage is needed.

- All spillages should be cleared as soon as possible; solids by vacuum cleaning, wet methods, or other appropriate techniques. Dry sweeping of dusty spillages should not be permitted in circumstances where it may result in the generation of airborne dust outside any building.

Air quality

Dispersion & dilution

5.12 Pollutants that are emitted via a stack require sufficient dispersion and dilution in the atmosphere to ensure that they ground at concentrations that are deemed harmless. This is the basis upon which stack heights are calculated using HMIP Technical Guidance Note (Dispersion) D1. The stack height so obtained is adjusted to take into account local meteorological data, local topography, nearby emissions and the influence of plant structure.

The calculation procedure of D1 is usually used to calculate the required stack height but alternative dispersion models may be used in agreement with the regulator. An operator may choose to meet tighter emission limits in order to reduce the required stack height.

- 5.13 Where an emission consists purely of air and particulate matter, (i.e. no products of combustion or any other gaseous pollutants are emitted) the above provisions relating to stack height calculation for the purpose of dispersion and dilution should not normally be applied. Revised stack height calculations should not be required as a result of publication of this revision of the PG note, unless it is considered necessary because of a breach or serious risk of breach of an EC Directive limit value or because it is clear from the detailed review and assessment work that the permitted process itself is a significant contributor to the problem.
- 5.14 Where offensive odour is likely outside the process site boundary the assessment of stack or vent height should take into account the need to render harmless residual offensive odour.

Ambient air quality management

- 5.15 In areas where air quality standards or objectives are being breached or are in serious risk of breach and it is clear from the detailed review and assessment work under Local Air Quality Management that the permitted process itself is a significant contributor to the problem, it may be necessary to impose tighter emission limits or, in the case of this particular note, additional limits for pollutants not listed in **Table 4.1**, such as NO_x. If the standard that is in danger of being exceeded is not an EC Directive requirement, then industry is not expected to go beyond BAT to meet it. Decisions should be taken in the context of a local authority's Local Air Quality Management action plan. For example, where a permitted process is only responsible to a very small extent for an air quality problem, the authority should not unduly penalise the operator of the process by requiring disproportionate emissions reductions. Paragraph 59 of the [Air Quality Strategy 2007 \[Volume 1\]](#) gives the following advice:

“...In drawing up action plans, local authority environmental health/pollution teams are expected to engage local authority officers across different departments, particularly, land-use and transport planners to ensure the actions are supported by all parts of the authority. In addition, engagement with the wider panorama of relevant stakeholders, including the public, is required to ensure action plans are fit-for-purpose in addressing air quality issues. It is vital that all those organisations, groups and individuals that have an impact upon local air quality, buy-in and work towards objectives of an adopted action plan.”

Stacks, vents and process exhausts

- 5.16 Liquid condensation on internal surfaces of stacks and exhaust ducts might lead to corrosion and ductwork failure or to droplet emission. Adequate insulation will minimise the cooling of waste gases and prevent liquid condensation by keeping the temperature of the exhaust gases above the dewpoint. A leak in a stack/vent and the associated ductwork, or a build up of material on the internal surfaces may affect dispersion:

- Flues and ductwork should be cleaned to prevent accumulation of materials, as part of the routine maintenance programme.

- 5.17 When dispersion of pollutants discharged from the stack (or vent) is necessary, the target exit velocity should be 15m/s under normal operating conditions, however, lower velocities than 15m/s are acceptable provided adequate dispersion and dilution is achieved (see also the paragraph below regarding wet plumes). In order to ensure dispersion is not impaired by either low exit velocity at the point of discharge, or deflection of the discharge, a cap, or other restriction, should not be used at the stack exit. However, a cone may sometimes be useful to increase the exit velocity to achieve greater dispersion.
- 5.18 An exception to the previous paragraph is where wet arrestment is used as the abatement. Unacceptable emissions of droplets could occur from such plant where the linear velocity in the stack exceeds 9m/s.
- 5.19 To reduce the potential of droplet emissions a mist eliminator should be used. Where a linear velocity of 9m/s is exceeded in existing plant consideration should be given to reducing this velocity as far as practicable to ensure such droplet entrainment and fall out does not happen. In these circumstances, the potential for offensive emissions of odour needs to be considered carefully.

Management

Management techniques

- 5.20 Important elements for effective control of emissions include:
- proper management, supervision and training for process operations;
 - proper use of equipment;
 - effective preventative maintenance on all plant and equipment concerned with the control of emissions to the air; **and**
 - ensuring that spares and consumables - in particular, those subject to continual wear – are held on site, or available at short notice from guaranteed local suppliers, so that plant breakdowns can be rectified rapidly. This is important with respect to arrestment plant and other necessary environmental controls. It is useful to have an audited list of essential items.

Appropriate management systems

- 5.21 Effective management is central to environmental performance; it is an important component of BAT and of achieving compliance with permit conditions. It requires a commitment to establishing objectives, setting targets, measuring progress and revising the objectives according to results. This includes managing risks under normal operating conditions and in accidents and emergencies.

It is therefore desirable that installations put in place some form of structured environmental management approach, whether by adopting published standards (ISO 14001 or the EU Eco Management and Audit Scheme [EMAS]) or by setting up an environmental management system (EMS) tailored to the nature and size of the particular process. Operators may also find that an EMS will help identify business savings.

- 5.22 Regulators should use their discretion, in consultation with individual operators, in agreeing the appropriate level of environmental management. Simple systems which ensure that LAPPC considerations are taken account of in the day-to-day running of a process may well suffice, especially for small and medium-sized enterprises. Regulators are urged to encourage operators to have an EMS for all their activities, but it is outside the legal scope of an LAPPC permit to require an EMS for purposes other than LAPPC compliance. For further information/advice on EMS refer to the appropriate chapter of the appropriate Guidance Manual for [England and Wales](#), [Scotland](#) and [Northern Ireland](#).

Training

- 5.23 Staff at all levels need the necessary training and instruction in their duties relating to control of the process and emissions to air. In order to minimise risk of emissions, particular emphasis should be given to control procedures during start-up, shut down and abnormal conditions. Training may often sensibly be addressed in the EMS referred to above.
- All staff whose functions could impact on air emissions from the activity should receive appropriate training on those functions. This should include:
 - awareness of their responsibilities under the permit;
 - steps that are necessary to minimise emissions during start-up and shutdown;
 - actions to take when there are abnormal conditions, or accidents or spillages that could, if not controlled, result in emissions.
 - The operator should maintain a statement of training requirements for each post with the above mentioned functions and keep a record of the training received by each person. These documents should be made available to the regulator on request.

Maintenance

5.24 Effective preventative maintenance plays a key part in achieving compliance with emission limits and other provisions. All aspects of the process including all plant, buildings and the equipment concerned with the control of emissions to air should be properly maintained. In particular:

- The operator should have the following available for inspection by the regulator:
 - a written maintenance programme for all pollution control equipment; **and**
 - a record of maintenance that has been undertaken.

6. Summary of changes

The main changes to this note, with the reasons for the change, are summarised in **Table 6.1**. Minor changes that will not impact on the permit conditions e.g. slight alterations to the Process Description have not been recorded.

Table 6.1 - Summary of changes

Section/ paragraph/ row	Change	Reason
Section 1 - Introduction	Simplification of text	Make note clearer
	Addition of links	Change to electronic format
Section 3 - Activity description, paragraph 3.3 - 3.4	Text added describing nodularisation as a metal treatment process	Transferred from PG2/05 (Cupolas) to allow simplification of PG2/05 and from PG2/03 (Electric furnaces) to avoid duplication.
Section 3 - Activity description, paragraph 3.6	Text added describing cores and core-making	Improves guidance
Section 4 - Emission limits, monitoring and other provisions	Used to be Section 5 in previous note	Section 4 in previous note deleted
Table 4.1 - Emission limits, monitoring and other provisions	Provisions relating to the monitoring requirements depending on rate of airflow from arrestment equipment, are clarified in Table 4.1 and text deleted from main body of note	Improves clarity of the guidance
	Provisions relating to emissions from silos clarified in Table 4.1 and text deleted from main body of note	
	Emissions of copper and its compounds to be measured in particulate phase only	Reduces monitoring costs
	Provisions relating to nodularisation included in Table 4.1	Improves clarity of the guidance
	Existing wet arrestment plant defined as plant fitted before November 1 st 2004.	Improves clarity of the guidance
Para 4.6 - 4.7 (Visible Emissions)	Revised text describing approach to take to visible emissions.	Allows more flexibility in managing visible emissions
Paragraphs 4.8 - 4.12 (Emissions of Odour)	Revised text describing approach to take to odorous emissions.	Allows more flexibility in managing odorous emissions

7. Further information

Sustainable consumption and production (SCP)

Both business and the environment can benefit from adopting sustainable consumption and production practices. Estimates of potential business savings include:

- £6.4 billion a year UK business savings from resource efficiency measures that cost little or nothing;
- 2% of annual profit lost through inefficient management of energy, water and waste;
- 4% of turnover is spent on waste.

When making arrangement to comply with permit conditions, operators are strongly advised to use the opportunity to look into what other steps they may be able to take. Regulators may be willing to provide assistance and ideas, although cannot be expected to act as unpaid consultants.

Health and safety

Operators of installations must protect people at work as well as the environment:

- requirements of a permit should not put at risk the health, safety or welfare of people at work or those who may be harmed by the work activity;
- equally, the permit must not contain conditions whose only purpose is to secure the health of people at work. That is the job of the health and safety enforcing authorities.

Where emission limits quoted in this guidance conflict with health and safety limits, the tighter limit should prevail because:

- emission limits under the relevant environmental legislation relate to the concentration of pollutant released into the air from prescribed activities;
- exposure limits under health and safety legislation relate to the concentration of pollutant in the air breathed by workers;
- these limits may differ since they are set according to different criteria. It will normally be quite appropriate to have different standards for the same pollutant, but in some cases they may be in conflict (for example, where air discharged from a process is breathed by workers). In such cases, the tighter limit should be applied to prevent a relaxation of control.

Further advice on responding to incidents

The UK Environment Agencies have published [guidance](#) on producing an incident response plan to deal with environmental incidents. Only those aspects relating to air emissions can be subject to regulation via a Part B (Part C in NI) permit, but regulators may nonetheless wish to informally draw the attention of all appropriate operators to the guidance.

It is not envisaged that regulators will often want to include conditions, in addition to those advised in this PG note, specifying particular incident response arrangements aimed at minimising air emissions. Regulators should decide this on a case-by-case basis. In accordance with BAT, any such conditions should be proportionate to the risk, including the potential for harm from air emissions if an incident were to occur. Account should therefore be taken of matters such as the amount and type of materials held on site which might be affected by an incident, the likelihood of an incident occurring, the sensitivity of the location of the installation, and the cost of producing any plans and taking any additional measures.

Appendix 1 - Investment casting processes

A. Investment casting processes normally comprise the following process steps²:

a. Wax melting and injection

Special waxes are melted in holding vessels or in tanks as part of the injection moulding machine. They are then injection moulded to the shape of the casting, part of casting or runner and riser required. For product quality reasons the wax must be held at a temperature below which it volatilises. These tanks therefore vent directly into the workplace. Cores are inserted at this stage, though the cores are normally made off-site.

b. Wax assembly

The wax components are assembled into the final casting shape together with the associated gating system of runners and risers. This is normally achieved by melting the interfaces with a hot plate, spatula or direct flame and fusing the components together. There is potential for emission of wax smoke and odour. Local exhaust ventilation is normally provided at these work stations.

c. Coating and shelling

The wax assembly is covered with a refractory in a process known as investing. The wax assembly is dipped into a thin refractory slurry. After draining, fine grains of refractory are deposited onto the still damp surface to provide a primary refractory coating, either by dipping into a fluidised bed or by holding in a cascade of refractory grains in a 'rain machine' or manually. The coats typically contain an alumino silicate and zircon based refractory while the binders used are either hydrolysed ethyl silicate, silica sol or a hybrid of these. These are diluted with propanol, ethanol or water. The ceramic shell is then set in a tunnel or cabinet in the presence of a known concentration of ammonia except in the case of water based silica set binders. These steps of investing, stuccoing and setting are repeated a number of times (up to ten times) until the refractory has sufficient strength to hold the liquid metal during casting and other properties. Robots and conveyors are commonly used for these processes. There is potential for emissions of propanol, ethanol, particulate matter and ammonia, both from process exhausts and workplace air conditioning

² There are a number of similar ceramic shell processes such as Replicast Ceramic Shell and the Shaw Process. These processes are not described further but the provisions of this note apply to them.

d. Dewaxing

Dewaxing is the next process step. This is normally achieved in an autoclave which melts out the wax. The wax is recovered and either re used for runners and risers or returned to the wax producer. The only emissions occur when the autoclave is brought down to atmospheric pressure and when it is opened, when there is likely to be an emission of steam and odour. Local exhaust ventilation may be provided over the autoclave door. Alternatively dewaxing may be undertaken as an integral part of the following process.

e. Mould firing

The mould is fired in a furnace normally at approximately 1000°C. Some processes, especially Aluminium processes, may operate at lower temperatures. This removes any residual wax and induces changes in the refractory which maximise strength whilst minimising potential for reaction with the molten metal. There is a potential for emission of wax smoke.

f. Mould holding

The moulds are held in a furnace at an appropriate temperature until casting. The only emissions are those related to fuel combustion. This process may occur in the same furnace as described in paragraph e.

g. Metal pouring

The metal is poured into the mould. For certain alloys such as some steels, a reducing atmosphere is needed to prevent surface oxidation of the metal. It may be achieved by placing wood, ceramic fibre or a packet of hexamine on top of the poured mould, then placing a box over the top. Alternatively nitrogen may be pumped into the box. For other steel alloys an exothermic compound is placed on the top of the mould. This keeps the metal molten and under pressure, and prevents casting problems.

The mould may be poured under vacuum, in which case there are no emissions to air during casting. Chromium and Molybdenum may condense on the internal surfaces of the vacuum melting facility, requiring periodic removal.

h. Shakeout

Pneumatic hammer or vibratory shakeout is normal for alloys other than aluminium. There is potential for particulate emissions. For aluminium castings high pressure water is often used.

i. Shotblasting

Refractory material is further removed by abrasive media in a shotblasting cabinet served by arrestment equipment. There is potential for particulate emission.

j. Core removal

Depending on the cast metal and the intricacy of casting one or more of the following techniques is likely to be used to remove cores

- i. immersion in a high concentration caustic bath. Sodium, potassium or ammonium hydroxides may be used.
- ii. treatment in an autoclave. Potassium hydroxide is used instead of steam, at a temperature of approximately 115°C.
- iii. water blasting, frequently in the presence of core softeners such as low concentration caustic. This technique is followed by a separation of refractory containing solids from the water.
- iv. abrasive methods, such as core drilling.
- v. glass media stripping.
- vi. mechanical methods such as core drilling.

Emissions will depend on the core removal technique used, with particulate matter, steam and caustic vapour being the most likely pollutants.

k. Casting finishing

Castings are finished using physical methods such as cutting, grinding and finishing. There is potential for particulate emissions.

l. Heat treatment

Castings may be heat treated, for instance with indirect gas radiant heaters to develop mechanical properties. Water quenching gives rise to steam emissions only. Oil quenching may also be used, with concomitant potential for oil mist emissions.

m. Chemical treatment

Chemical treatments such as electropolishing in sulphuric /phosphoric acids may be undertaken, but these give rise to no significant air emissions.

If nitric acid is used, for instance in the pickling and passivation of steel castings, [PG4/01 "Processes for the surface treatment of metals"](#) should be consulted. Nitric acid is also used to etch nickel alloys.

- B.** The final emission to air from wax assembly processes should be free from visible smoke and comply with the requirements of **paragraphs 4.6 - 4.7**.
- C.** Water based refractory coatings should be used where this is technically and economically feasible.
- D.** Process exhausts from coating, shelling and setting operations should comply with the requirements of **paragraphs 4.6 - 4.12**. Workplace ventilation or air conditioning should comply with the provisions of **paragraphs 4.6 - 4.12** of this note.
- E.** Dewaxing and mould firing processes should comply with the provisions of **paragraphs 4.6 - 4.12** and be free from visible smoke in normal operation. In any case smoke should not exceed the equivalent of Ringelmann Shade 2 as described in British Standard BS2742.
- F.** Mould firing and holding furnaces should be fuelled by a low sulphur content fuel (less than 1 % of sulphur).
- G.** Metal casting operations should comply with **paragraphs 5.2 and 5.9**.
- H.** Shakeout, shotblasting and finishing operations (and where appropriate, core removal operations) should comply with **paragraph 5.2**.
- I.** Core removal operations should comply with **paragraphs 4.6 - 4.12**.
- J.** Emissions from process exhausts serving mould shelling and setting operations should be tested at least once a year for volatile organic compounds, where alcohol based systems are used.
- K.** Emissions of particulate matter from mould shelling operations, shakeout, shotblasting, core removal and finishing operations should be tested in accordance with **paragraphs 4.15 - 4.29**.
- L.** In addition to the above mentioned paragraphs, the following paragraphs should be applied to investment casting processes:
 - **paragraphs 4.4, 4.5, 4.25, 4.31, 5.7, 5.10- 5.24**
- M.** In cases where only natural draught operates, stacks should be designed to achieve maximum possible efflux velocity consistent with stack height and furnace characteristics. It may be necessary to increase the stack height as calculated, taking into consideration the efflux velocity.

Appendix 2 - Emissions from current foundry processes

Table A - Environmental Impacts from current foundry processes

System name and binder constituents	Setting method and relative energy required	Emissions to air during mixing and setting	Other environmental impacts
GREENSAND Clay Coal dust or substitute Water	Pressure - low	Particulate matter - no significant emission to the environment	Sand spillage around conveyors should be avoided to reduce likelihood of fugitive emission. Abatement from mixing process not essential. (Process is usually contained with displaced air vented to the foundry.)
SHELL SAND Phenol- formaldehyde (Novalak) Resin	Heat - high	Formaldehyde Ammonia* Phenol* Aromatics	Odour can be an issue as the shell machines are normally extracted to air.
ALKALI PHENOLIC Alkaline phenol Formaldehyde resin 1. Self-setting, e.g. "Alphaset", "Novaset" 2. Gas hardened, e.g. "Betaset"	Cold set with esters - low Gas hardened with methyl formate vapour low	Formaldehyde Phenol* Esters Formaldehyde Phenol* Methyl formate	
PHENOLIC URETHANE 1. Gas hardened, e.g. "Coldbox", "Iso cure" 2. Self setting e.g. "Novathane", "Pepset"	Amine vapour low Self set with substituted pyridine low	Solvents* Isocyanate (MDI) Amine* Solvents* Isocyanates (MDI)	Odour is frequently a problem where DMEA is used odours arising are such that abatement is essential. This may be incineration or gas scrubbing (using sulphuric or phosphoric acids) - the latter gives rise to liquors which are a special waste. Where TEA is used scrubbing only required if odour problems arise.

FURANE Combination resins of: Phenol Urea Furfuryl alcohol Formaldehyde	Cold set with acids low	Formaldehyde Phenol* Furfuryl alcohol* Hydrogen sulphide Acid mists	Resins and acids must be kept apart (unless sand is present) as they are vigorously exothermic when in contact and may give rise to an uncontrolled emission.
HOT BOX Combination resins of: Phenol Urea Furfuryl alcohol Formaldehyde	Heat high	Formaldehyde* Acids Furfuryl alcohol* Phenol*	Odour can be an issue as the shell machines are normally extracted to air.
OIL SAND Linseed oil and starch	Heat high	Acrolein* Complex organics	Odour can be an issue as the core ovens are often extracted to air.
CO² PROCESS Sodium silicate	Gas hardened with CO ₂ gas low	None	Reclamation potential is more limited than with other binder systems.
SILICATE ESTER "Self set" Sodium silicate	Cold set with esters low	Esters	Reclamation potential is more limited than with other binder systems.

Note 1: All the above processes give rise to spent sand (including broken cores, spillage and mixer residues) that may go to landfill.

Note 2: Substances marked with * are those most likely to give rise to odour from the process referred to.

Note 3: Any resin binder component would be regarded as special waste for disposal purposes and if spilled could give rise to a risk of contamination of water systems.

Note 4: Amines used for gas hardening are highly flammable and odorous. Avoidance of leaks in storage is essential.

Table B - Environmental Impacts from casting and cooling

System name and binder constituents	Emissions to air during casting and cooling	Comments
GREENSAND Clay Coal dust or substitute Water	Particulate matter Carbon monoxide and carbon dioxide Benzene Toluene Xylene	Potential odour (may be associated with sulphur content of the coal.)
SHELL SAND Phenol Formaldehyde (Novalak) Resin	Particulate matter - soot from the incomplete combustion of the carbon based resins Carbon oxides Phenol*, cresols* and xylenols* Ammonia Aldehydes Benzene PAH	Where the binder system is used for moulds odour problems more prevalent treatment may be necessary although dispersion may suffice. Where the binder systems are used for cores only, the emissions from the cores will largely condense onto the mould material and is unlikely to cause an odour problem.
ALKALI PHENOLIC Alkaline phenol Formaldehyde resin 1. Self-setting e.g. "Alphaset", "Novaset" 2. Gas hardened, e.g. "Beta set"	Particulate matter - soot from the incomplete combustion of the carbon based resins Carbon oxides Formaldehyde Phenol*, cresols* and xylenols* Aromatics	Odour may be a problem
PHENOLIC URETHANE 1. Gas hardened, e.g. "Cold box", "Isocure" 2. Self setting, e.g. "Novathane", Pepset"	Particulate matter - soot from the incomplete combustion of the carbon based resins Carbon oxides Nitrogen oxides Monoisocyanates Formaldehyde Phenol, cresols and xylenols Aromatics (inc polycyclics) Anilines Naphthalenes Ammonia	Where the binder system is used for moulds odour may be a problem treatment may be necessary although dispersion may suffice. Where the binder systems are used for cores only, the emissions from the cores will largely condense onto the mould material and is unlikely to cause an odour problem.

<p>FURANE Combination resins of: Phenol Urea Furfuryl alcohol Formaldehyde</p>	Particulate matter - soot from the incomplete combustion of the carbon based resins Carbon oxides Phenol, cresols and xylenols Formaldehyde Aromatics (inc polycyclics) Sulphur dioxide Ammonia Aniline	Odour occasionally a problem
<p>HOT BOX Combination resins of: Phenol Urea Furfuryl alcohol Formaldehyde</p>	Particulate matter - soot from the incomplete combustion of the carbon based resins Carbon oxides Nitrogen oxides Formaldehyde Phenol, cresols and xylenols Aromatics (inc. polycyclics) Aniline Ammonia	Odour may be a problem, but as only used for cores would usually be contained within the mould.
<p>OIL SAND Linseed oil, starch or core grease</p>	Particulate matter - soot from the incomplete combustion of the carbon based resins Carbon oxides Butadiene Ketones Acrolein	Odour may be a problem, but as only used for cores would usually be contained within the mould.
<p>CO² PROCESS Sodium silicate</p>	Carbon oxides	
<p>SILICATE ESTER "Self set" Sodium silicate</p>	Carbon oxides Alkanes Acetone Acetic acid Acrolein	