PUBLICLY AVAILABLE SPECIFICATION

PAS 107:2012

Specification for the manufacture and storage of size reduced tyre materials






Working together for a world without waste

British Standards

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Contents

Foreword

This revised Publicly Available Specification, PAS 107:2012, has been sponsored by the Tyre Recovery Association (TRA) in association with WRAP and its development was facilitated by the British Standards Institution (BSI).

The overall aim of this document is to provide a specification that can be adopted by suppliers for producing grades of size reduced tyre rubber such that potential customers will be assured that they are procuring a material of consistent and verifiable quality.

Here it is noted that, under current legislation, all size reduced materials covered by this PAS are classified as waste until incorporated into an end use application. It follows that handling and storage of these materials must comply with all regulations arising out of the *Waste Framework Directive* [1].

The Quality Protocol[1)] developed by WRAP and the Environment Agency in consultation with industry and other regulatory stakeholders is applicable in both England and Wales. The Quality Protocol sets out end of waste criteria for the production and use of tyre derived rubber materials from source aggregated waste tyres. If these criteria are met, tyre derived rubber materials will normally be regarded as having been fully recovered and to have ceased to be waste.

Acknowledgement is given to the following organizations that have been instrumental in the development of this specification.

- Department for Business, Innovations and Skills (BIS);
- Bridgestone;
- British Tyre Manufacturers Association Ltd;
- Charles Lawrence International Ltd;
- Crumb Rubber Ltd;
- Environment Agency;
- Ford Motor Company Ltd;
- Materials Technology Centre;
- Ford Motor Company Limited;
- Murfitts Industries Limited.

Wider comments from other interested parties were invited by BSI. The expert contributions made by the organizations and individuals consulted in the development of this Publicly Available Specification (PAS) are gratefully acknowledged.

1) http://www.environment-agency.gov.uk/business/topics/waste/114455.aspx

Introduction

The use of recycled tyre materials in a wide range of civil engineering applications and industrial products is well established and has grown considerably in the last decade.

The introduction of legislation transposing European Directives, in particular regulations relating to landfill management[2], End of Life Vehicles (ELV) salvage[3] and waste incineration[4], eliminated the disposal option of landfill. Today, the UK is meeting its 100 % recovery target in its entirety through a combination of reuse, recycling and recovery activities.

In order to facilitate the growth of, and to strengthen the end markets for sustainable recovery options for used tyres, WRAP and industry introduced a range of initiatives to encourage expansion of existing processes and investment in new applications.

Information relating to the quality of materials can be an important requirement in the successful functioning of any free market. Such information is often absent for many waste material streams and, in the case of tyre-derived rubber, this Publicly Available Specification (PAS 107) harmonises the various independent specifications across the industry in the UK. It provides a standard, for use by processors and buyers, in defining the quality requirements for the collection and initial storage of used tyres and the processing and final storage of size-reduced, or graded, rubber material.

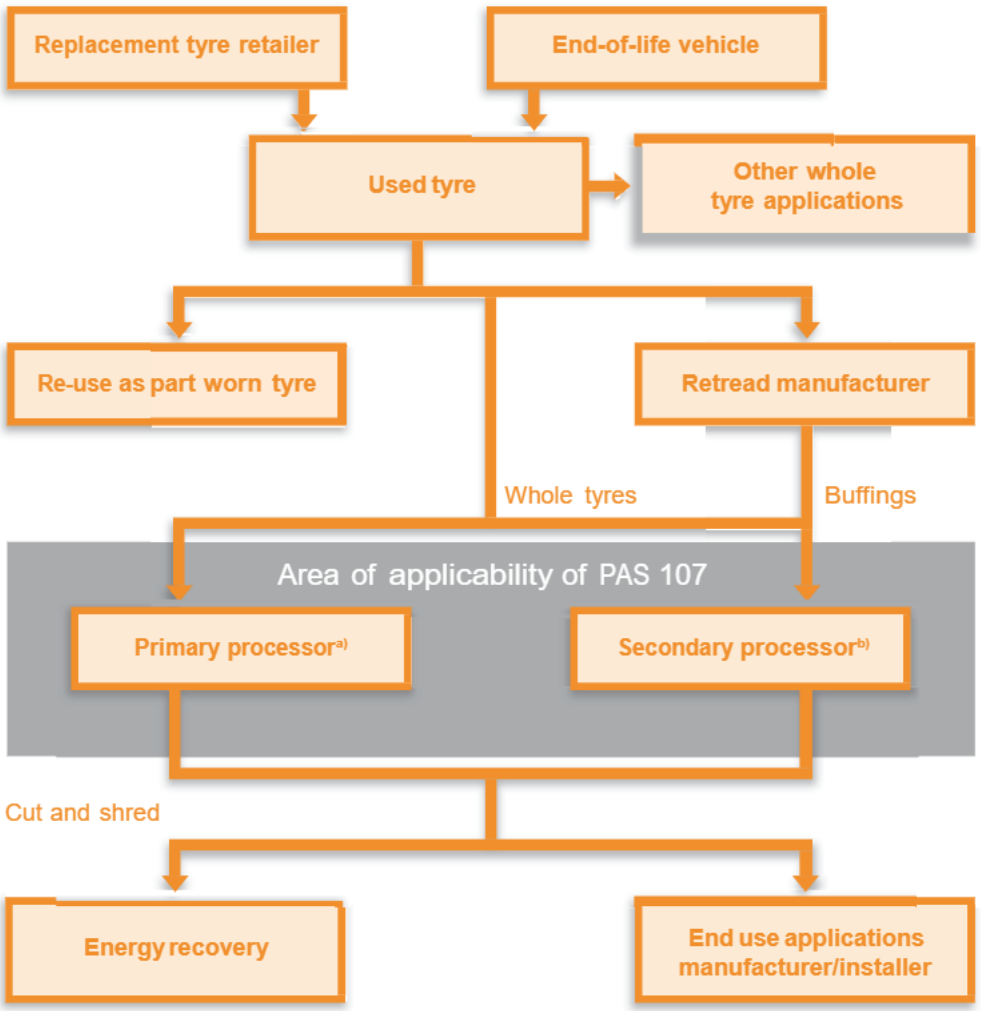
The production of size reduced or graded tyre rubber is currently a process, which is managed under the Environmental Permitting (England and Wales) Regulations 2010 [2].

All of the commercial size reduction of tyres in the UK is currently by means of cutting and grinding, at or above ambient temperature, into increasingly smaller rubber particles for a range of new end use applications. This process, known as ambient size reduction, is the subject of this PAS. Brief reference is made within the body of the PAS to emerging new technologies to produce size reduced rubber, such as cryogenic treatment and water jetting, however these do not currently feature substantially in the UK marketplace. In the future, new technology facilities such as these could provide further capacity for the production of size reduced rubber for end use applications that will be similar to those for ambient ground rubber.

The source material covered by this PAS is end-of-life tyres; specifically tyres that have been removed from road vehicles and off-road vehicles such as agricultural and earthmoving equipment. Used aircraft tyres, due to their unique processing and relatively low level of arisings in the UK, are not included in the PAS. In addition, this PAS excludes the use of whole or baled tyres in end use applications. In conjunction with this document, PAS 108 has been introduced to cover the manufacture and storage of baled tyres.

[2] Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste [3]
[3] Council Directive 2000/53/EC of 18 September 2000 on end-of-life vehicles [4]
[4] Council Directive 2000/76/EC of 4 December 2000 on the incineration of waste [5]

Figure 1 – Applicability of PAS 107 in the used tyre collection and recycling supply chain.



[a)] Carries out primary processing of converting whole tyres to material categories, as listed in Table 1.
[b)] Carries out secondary processing on shred/other tyre rubber size-reduced materials, such as playground surface materials.

Tyre recycling by means of alternative technologies such as pyrolysis or microwave treatment, which reduce the tyre to steel, carbon black and energy products, or devulcanisation, are also excluded as these technologies are yet to be commercially proven across the UK. Consideration will be given to extending the scope of this PAS at the time that the new processing technologies become commercially available in the UK.

Size reduced rubber materials are defined primarily by their size. They range from large cuts of greater than 300 mm, which include all of the steel and textile components of the original tyre casings, down to fine rubber powders, which can be virtually free of those components. Size reduced rubber materials are used in an increasingly diverse range of end use applications and markets.

Since this PAS is primarily for use by processors and buyers in defining quality requirements for size reduced rubber materials, it is applicable only to those activities, carried out by the processor, that are appropriate to achieving the required standards. This is shown schematically in Figure 1.

It is noted that PAS 107 would apply where a used tyre collector also carries out primary processing of whole tyres into cuts or shred. In this instance, the collection and processing activities shall be treated as separate entities and the PAS will apply from the receipt of whole tyres at the first stage processing facility to the shipment of material to either the end user or to a second stage processor.

1 Scope

This Publicly Available Specification (PAS) specifies minimum requirements for the manufacture and storage of size-reduced, tyre derived rubber materials intended for a range of applications in existing and emerging secondary end markets. Tyre sources include those from land-based vehicles, i.e. bicycles, motorcycles, cars, light commercial vehicles, trucks, buses, as well as industrial and agricultural vehicles.

This PAS does not cover the processing of aircraft tyres, the use of whole or baled tyres in end use applications or the end use applications. It does not cover the by-products of the process, namely steel and textile fibre, or tyre recycling by means of alternative technologies such as pyrolysis or microwave treatment.

The secondary end markets to which this PAS applies include, but are not limited to, the applications set out in Table 1.

In order to accommodate the widening range of end user requirements for size reduced tyre materials, variations or additions to an end use specification may be required. This is referenced in the PAS as being subject to agreement between the producer and user. However, in all instances, the standard set by this PAS will be the minimum requirement.

Table 1 – Examples of material categories and applications

Material category	Application
Cuts, Shred and Chips	Co-combustion with other fuels in the manufacture of cement and lime products
Cuts, Shred and Chips	Generation of energy by incineration
Shred and Chips	As the leachate drainage layer in the construction of landfill cells
Chips	Clean cut, as the surface for equestrian ménages and pathways
Chips, Granulate and Powder	Resin-bound as a shock absorbing layer for sports tracks and children's playgrounds
Granulate and Powder	Moulded products such as tiles, street furniture and level crossing platforms
Granulate and Powder	In rubber modified bitumen for road surfacing and repair
Granulate and Powder	Carpet underlay and floor tiles
Granulate	Various horticultural applications such as mulching and soil amelioration
Granulate	As a filler, with sand, in artificial turf for sports pitches
Granulate	As aggregate replacement in construction products such as building blocks
Powder	In industrial adhesives and sealants and in new and retreaded tyres

2 Normative references

The following referenced documents are indispensable for the application of this PAS. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE *See Bibliography for other referenced standards which may apply for specific usages if a particular characteristic of the material is required, as decided between producer and user.*

BS ISO 1126, *Rubber compounding ingredients – Carbon black – Determination of loss on heating*

BS 5293-2, *Sampling and testing carbon black for use in the rubber industry – Part 2: Method for determination of pour density (ISO 1306)*

ISO 3310-1, *Test sieves – Technical requirements and testing - Part 1: Test sieves of metal wire cloth*

BS SO 6101-5, *Rubber – Determination of metal content by atomic absorption spectrometry – Part 5: Determination of iron content*

PPG 29: Safe Storage – Combustible materials, prevent and control fire.[5)]

[5)] Available from www.environment-agency.gov.uk

3 Terms and definitions

For the purpose of this PAS the following terms and definitions apply.

3.1 ambient size reduction

processing of used tyres into smaller particles by mechanical means at or above ambient or room temperature

3.2 bead wire

steel strand, or strands, in the form of a hoop, built into the tyre casing to anchor and strengthen the tyre edge where it fits to the wheel rim

3.3 buffings

rubber particles of varying sizes obtained from abrading an end of life tyre to remove the tread or part of the sidewalls prior to retreading or remoulding

3.4 butyl rubber

synthetic rubber, which is virtually impermeable to air, used in the manufacture of tyres and tyre inner tubes

3.5 casing

structural body of a tyre on which the tread and sidewalls are laid and which forms the major part of a used tyre

3.6 chips

fragmented pieces of used tyres, including embedded wire or textile material, whose maximum dimension, of the rubber portion, is between approximately 10 mm and 50 mm in size

3.7 civil engineering applications

use of tyre derived materials in any construction project, either above or below ground

3.8 cord

elements comprising textile or steel plies forming the basic structure of the tyre

3.9 crosslink

chemical bond between polymer chains, such as rubber, which influence the physical properties of the material

3.10 crossply tyre

type of tyre construction in which the cord plies run at angles to the direction of travel and cross each other diagonally

3.11 cryogenic process

process occurring at extremely low temperatures which facilitates the fragmentation of tyres into very small, smooth surfaced particles

3.12 cuts

size reduced pieces of used tyres, including embedded wire or textile material

3.13 devulcanisation

process of breaking the chemical cross links of vulcanized rubber which may enable the material to be re-used as a compounding ingredient and again vulcanized

3.14 duty of care

a provision of the Environmental Protection Act 1990 [6], which applies to anyone who imports, produces, carries, keeps, treats or disposes of waste, requiring that waste can only be carried by registered waste carriers and that all movements of waste are fully auditable

3.15 end of life tyre

tyre which has been permanently discarded following normal use

3.16 energy recovery

use of tyres as a means to generate energy through direct incineration with or without other waste but with the generation of heat and/or electrical power

3.17 feedstock

stock of whole tyres, or tyre derived rubber material, which has been partially size reduced, awaiting further size reduction

3.18 fine powder

particles of rubber below 500 µm in size

3.19 fluff

fine textile materials that are separated from the rubber during the process of cutting and grinding tyres

3.20 granulate

particles of rubber whose maximum dimension is between 0.5 mm and 10 mm in size

3.21 lower defined limit

lower limit of size for the majority of rubber particles in a batch of material

3.22 particle size

<of a batch of granulate or powder is> the range of dimensions between the upper defined limit and the lower defined limit

NOTE The particle size of a batch of cuts, shred or chips is more commonly determined by the average or nominal particle size within the batch.

3.23 powder

particles of rubber below 1 mm in size

3.24 pyrolysis

process by which tyres are heated in the absence of oxygen in order to break down the structure of the tyres into steel, oil, gas and char

3.25 radial tyre

type of tyre construction in which the cord plies run at right angles to the direction of travel

3.26 recovery

any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, in the plant or in the wider economy

NOTE Definition taken from Waste Framework Directive [1].

3.27 recyclate

re-usable material from any recycling process

3.28 recycling

reprocessing, in a production process, of tyres for their original purpose or for other purposes but excluding energy recovery

3.29 retread

re-manufactured tyre where the remaining original tread has been replaced with new (with/without) sidewall

NOTE Retreading is a process to re-use structurally sound worn tyres, known as casings, by removing and replacing the remaining tyre tread, with the new tread being vulcanized to the body (casing). The process is described as "hot" (moulding a new tread pattern usually together with new sidewalls) or "cold" (application of a precured tread only).

3.30 re-use

recovery operation by which tyres that have become waste are used again for their original purpose

3.31 sample (of material)

portion of material intended for testing, selected at random from a batch making, of sufficient quantity to carry out the required test

3.32 secondary raw material

recycled material that is no longer a waste having quantifiable chemical and physical properties, that can be used as a replacement for alternative materials

3.33 shred

fragmented pieces of used tyres, including embedded wire or textile material, whose maximum dimension, the rubber portion, is between 50 mm and 300 mm in size

3.34 sidewall

outer side portion of tyre casing between the bead and the tread

3.35 source material

end-of-life tyres, buffings and tyre inner tubes used as material input to the size reduction process

3.36 transfer point

address of the location of the transfer of a waste material

3.37 tread

portion of the tyre around its circumference, contoured for optimum traction, that is in rolling contact with the ground when in use

3.38 upper defined limit

upper limit of size for the majority of rubber particles in a batch of material

3.39 visual inspection

naked eye examination of a material or product for quality assurance eye

3.40 vulcanization

process that produces crosslinks between rubber polymer strands to improve the physical properties of the rubber for automotive purposes

3.41 whole tyre

complete tyre comprising mainly casing, including cord and wire bead, sidewall and tread

4 Characterization of source materials

4.1 Categories of source materials

The principal material inputs for size reduction under this PAS consist of pneumatic tyres for use on motor cycles, passenger cars, commercial vehicles (ranging from light vans to heavy goods vehicles) and public service vehicles. Pneumatic tyres from these vehicles represent the great majority of the available end-of-life tyres in the UK but small quantities of tyres from bicycles, agricultural, industrial and earthmover vehicles, all inner tubes and solid tyres are also available for size reduction and are therefore covered by this PAS.

The raw material composition of individual tyres varies considerably between different manufacturers and types of tyre. However, this PAS relates to the collection and processing of mixed used tyres from multiple sources, and the average composition of these can be more closely defined. The principal constituents by weight of the tyre are shown in Table 2.[6)]

The major sources of tyres for size reduction are divided into two categories, namely car and truck, due to their different physical and chemical make-ups. These result in some differences in the nature and application of the materials derived from each. A further, minor category, namely "**agricultural** and **earthmover**", is added due to the significantly larger size of these tyres, requiring different storage and handling facilities. The categories are summarized in Table 3.

Table 2 – Indicative composition of a tyre

Ingredient	Passenger car tyre (%)	Lorry tyre (%)	OTR (off-the-road) tyre (%)
Rubber / Elastomers[1)]	47	45	47
Carbon black[2)]	21.5	22	22
Metal	16.5	25	12
Textile	5.5	-	10
Zinc oxide	1	2	2
Sulphur	1	1	1
Additives[3)]	7.5	5	6
Carbon-based materials[4)]	74	67	76

[1)] Lorry and OTR tyres contain higher proportions of natural rubber than passenger car tyres.

[2)] Silica replaces part of the carbon black in certain types of tyres.

[3)] Some of the additives include clays, which may be replaced in part in some tyres with recycled rubber crumb from waste tyres.

[4)] These approximate totals would be slightly higher if clays were replaced by recycled crumb rubber from waste tyres.

[6)] www.etra-eu.org: *The Composition of Tyres in the European Union.*

Table 3 – Material source details

Source	Description	Notes
Car tyre	Motorcycle, two-and four-wheeled drive passenger cars, light commercial vehicles, small agricultural and industrial vehicles	Predominantly radial tyres, containing more synthetic rubber than natural and proportionately more textile than steel
Truck tyre	Medium and heavy commercial vehicles, buses and other public service vehicles	These contain proportionately more natural than synthetic rubber. Tyres can be radial or cross ply. Cross ply tyres contain more textile than steel
Agricultural and Earthmover Tyre	Large agricultural and industrial vehicles	Agricultural tyres tend to be cross ply. Earthmover tyres can be cross ply or radial
Other tyres	Mixed categories, including inner tubes and solid tyres made of rubber	Industrial solid tyres tend to contain natural rubber and textile but no steel

Rubber buffings, produced as a by-product of the tyre retreading process, are also used as a source material in the size reduction process. Some chemical and physical properties of size reduced materials produced from buffings differ slightly from those of whole tyres. To enable the user to differentiate, unique material source codes are used for materials derived from buffings.

Material source codes are shown in Table 4.

Table 4 – Material source codes

Source	Code
Whole car tyre	PW
Whole truck tyre	TW
Car tyre buffings	PB
Truck tyre buffings	TB
Mixed car and truck tyres	MW
Inner tube	BT
Other tyre	OT

Where:
P = Passenger car and light commercial vehicle
T = Truck and bus, tubes or tyres
O = Other vehicle
M = Mixed vehicles
B = Butyl rubber or buffings
W = Whole tyres

The codes used in Table 4 represent the nature of the material source. Other rubber based source materials may be added into the size reduction process. Such additions to the feedstock may not cause the generic chemical and physical properties of the end use application to fall outside of the ranges given in Table 6 and Table 7, unless otherwise agreed in writing between producer and user.

4.2 Condition of source materials

All whole tyres received for size reduction shall have been removed from their wheels.

All whole tyres, inner tubes and other source materials shall be free, wherever practicable, from debris, foreign matter or contaminants that will obstruct or prevent the size reduction process.

NOTE 1 *Examples of such contaminants are wooden fragments from pallets, earth and stones, grease and oils and wheel balancing weights.*

All materials shall show no signs of partial consumption by fire.

NOTE 2 *Source materials are generally separated at the point of collection, into the categories listed in Table 4, and separation should be maintained throughout the transportation, initial storage and size reduction processes unless mixed source materials are agreed in writing between producer and end user.*

5 Overview of process technology

In the majority of ambient size reduction processes, whole tyres are initially cut into shredded rubber portions with protruding steel and textile strands. Alternatively, rubber buffings from the retread manufacturing process are used as feedstock. Depending on the material category being produced, the cuts, shred or buffings may then be progressively reduced in size in a number of stages, by means of cutting and grinding, with extraction of steel and textile materials at each stage. Whilst size reduction is carried out at ambient temperature, heat is generated during the process, and this serves to reduce the moisture content that may be resident in the original feedstock.

After the final size reduction stage, the rubber is passed through screens which separate out particles that are within the size range required for each end use application. These particles are then transferred to the packing stage.

In cryogenic size reduction, whole tyres are shredded as in the ambient process, and are then cooled by liquid nitrogen or natural gas. This process causes the rubber to become hard and brittle and facilitates fragmentation of the rubber by means of mechanical hammers into the various particle sizes.

Ambient processing can produce rubber granulate down to, nominally, 1 mm in size, although considerable quantities of fine powder will also be generated. The granules are irregular in shape and have a rough surface.

6 Characterization of size reduced materials

A summary of the categories of size reduced tyre materials and material category codes are set out in Table 5.

Rough cuts, and rough shred and chips may contain some exposed steel wire and textile fragments depending on the cutting process.

Where exposed material is permitted in clean cuts and in clean shred and chips, the proportion by length of the exposed materials shall be a maximum of 5% of the nominal particle size.

All exposed wire and textiles shall be firmly attached to the body of the rubber fragments.

No exposed wire shall be present in clean chips.

Each category of material output is allocated a material code.

Table 5 – Characteristics of all size reduced tyre materials and material category codes

Material Category	Size range (maximum dimension), mm		Other characteristics	Code
	Minimum	Maximum		
Rough Cuts	300	None	Exposed wire and textiles [1)]	RX
Clean Cuts	300	None	Less than 5% exposed wire and textiles [2)]	CX
Rough Shred	50	300	Exposed wire and textiles	RS
Clean Shred	50	300	Less than 5% exposed wire and textiles	CS
Rough Chips	10	50	Exposed wire and textiles	RC
Clean Chips	10	50	No exposed wire. Less than 5% exposed textiles	CC
Granulate	0.5	10	Free from exposed wire and less than 5% exposed textiles	G
Powder	0	1.0	Free from exposed wire and textiles	P
Fine Powder	0	0.5	Free from exposed wire and textiles	FP

1) All exposed wire and textiles shall be firmly attached to the body of the rubber fragments.
2) Upon visual inspection.

7 The size reduction process

7.1 Background

NOTE 1 Attention is drawn to the requirements of the duty of care provisions of the Environmental Protection Act 1990 [6] for all transportation, storage and handling of end-of-life tyres and tyre derived material.

This clause describes the three key stages of the size reduction process and indicates best practice at each stage. In practice, detailed operational issues will be governed by the waste management licence and planning consent for the processor.

*NOTE 2 Clause **7.2**, and **7.3.1** apply to the receipt and initial processing of whole tyres.*

7.2 Receipt and initial storage of end-of-life tyres

NOTE 1 Each vehicle delivering tyres to the processing site should be accompanied with a Waste Transfer Note or Delivery Note. It should be subject to a weight check on arrival and the first, gross weight of the vehicle should be recorded on a pre-numbered Waste Transfer Note (WTN). A sample WTN is shown in Annex A.

During unloading the vehicle a visual check shall be carried out to ensure, as far as is practicable, that the delivery is of the appropriate tyres , demounted and free from rubbish, such as pallets and contamination, and that they are free from signs of partial consumption by fire.

Any unsuitable tyres or contaminants shall be separated from the batch and either returned to the delivery vehicle or otherwise disposed of in compliance with current waste legislation after weighing and recording this weight on the WTN.

All tyres shall be unloaded from the vehicle and either fed directly into the first stage of the size reduction plant or removed to a suitable storage area. Separate storage areas shall be maintained for each source category of tyres (see **4.2**).

NOTE 2 Annex B sets out suitable storage facilities and procedures.

NOTE 3 The delivery vehicle should be subject to a further weight check on leaving the site and the second gross weight of the vehicle should be recorded on the WTN.

The WTN shall include all details of the processing company, including the waste operator's licence number and a unique identification number. Other information to be recorded on the WTN shall include, but not be limited to, the following:

a) Description of waste (to include the List of Waste Regulations 2005 description and code, i.e. *"End-of-life tyres, LOW code 16 01 03"*);
b) Customer/supplier;
c) Registration number of vehicle;
d) Collection or transfer point of the waste;
e) Waste carrier's licence number;
f) Date and time of both weight checks;
g) Net weight of goods received;
h) Order/advice note number;
i) Driver's and receiver's signature.

7.3 Production process

NOTE Processors of used tyres operate different plant and machinery configurations. For the purpose of this PAS consideration is given to a typical layout of an ambient size reduction process for truck tyres.

7.3.1 First stage size reduction

The first stage size reduction of the tyre is known as primary shredding. The machine shall reduce the whole tyre down to the appropriate size for further processing or shipping. The resultant material will be in the form of cuts or shred and will exhibit some exposed steel wire and textile material.

Quality checks at this stage are mainly visual and shall be carried out as detailed in Clause **8**.

*NOTE Where a batch of material is found to fall outside the agreed specification (as defined in Clause **6**) it may be returned to the machine for further processing.*

Following this process, the cuts or shred shall be either shipped in bulk as a material to an end user, stored as feedstock or directly fed into the second stage size reduction process.

Consignment notes for bulk shipping of cuts and shred shall contain the following information:

a) Material specification (to include the *List of Waste Regulations 2005* description and code, where applicable, i.e. *"End-of-life tyres, LOW code 16 01 03")* and material specification code as defined by this PAS (see Clause **9**);
b) Material description;
c) Particle size;
d) Haulier;
e) Transfer point;
f) Net weight of consignment;

g) Unique identifier, e.g. batch number;
h) Reference to this PAS, i.e. 107:2012.

7.3.2 Second stage size reduction and steel removal

The second stage of size reduction involves using a machine to reduce the size of the cuts or shred; at this point magnetic separation removes a high percentage of the steel wire.

NOTE 1 Steel wire is extracted and is stored in bulk or shipped directly to a steel re-processor/dealer.

The machine shall chop the shred into material ranging from 0 – 50 mm in size.

NOTE 2 At this stage the chips may still exhibit some exposed steel wire and textile material.

Quality checks at this stage shall be carried out as detailed in Clause **8**.

*NOTE 3 Where a batch of material is found to fall outside the agreed specification (as defined in Clause **6**) it may be returned to the machine for further processing.*

Following this stage, the chips shall be either shipped in bulk as a material to an end user, stored as feedstock or fed directly into a grinding or granulating line.

Consignment notes for bulk shipping of chips shall contain the following information:

a) Material specification (to include the *List of Waste Regulations 2005* description and code, where applicable, i.e."*End-of-life tyres, LOW code 16 01 03*", and material specification code as defined by Clause **9** of this PAS);
b) Material description;
c) Particle size;
d) Haulier;
e) Transfer point;
f) Net weight of consignment;
g) Unique identifier, e.g. batch number;
h) Reference to this PAS, i.e. 107:2012.

7.3.3 Final granulating and grading

The granulation and grading process shall progressively reduce the feedstock down to smaller particles and at key stages further remove any contaminants such as steel, dust or textile.

NOTE 1 Small amounts of rubber remain in with the extracted steel and textile at this stage.

NOTE 2 Both steel and textile particles should be taken away for storage in separate containers.

NOTE 3 The heat generated by the process dries out any moisture from the first two stages.

After being granulated with all other materials removed, the rubber passes a number of screens which separate the material into the desired grades for bagging.

Quality checks at this stage shall be carried out as detailed in Clause **8**.

The material shall be bagged into bulk bags (1 tonne), or sacks (25kg) or into any bag size as agreed between the producer and user.

Individual bags shall be stretch wrapped to secure the load on a pallet.

The consignment shall be quality checked prior to storage.

NOTE 4 Annex B sets out the fire safety precautions that should be taken to minimize the risk of fire and explosion at this stage of processing.

Each pallet or consignment shall be labelled or documented with the following:

a) Material specification (to include the *List of Waste Regulations 2005* description and code, where applicable, i.e. "*End-of-life tyres, LOW code 16 01 03*", and material specification code as defined by this PAS (see Clause **9**);
b) Material description;
c) Nominal particle size;
d) Net weight;
e) Gross weight;
f) Unique identifier, e.g. batch number;
g) Reference to this PAS, i.e. PAS 107:2012.

7.4 Final storage

7.4.1 Handling and storage of cuts, shred and chips

Cuts, shred and chips shall be stored under cover or externally in bulk form in or on concrete or hard storage bays.

They shall be stored to avoid spillage of the contents of the bay into adjacent bays.

7.4.2 Handling and storage of granulate and powder

Granulate and powder shall be clearly separated by grade.

Packaging for granulate and powder shall be waterproof to prevent water ingress if stored outside.

Bags shall be stacked on a pallet and over-wrapped with stretch film to facilitate storage and prevent slippage of the load.

8 Material quality assurance testing

8.1 Background

Different categories of source materials are used to produce size reduced rubber with differing properties and characteristics. As an example, the same size and consistency of material can be produced from truck tyres, from passenger car tyres, from buffings and from solid tyres, using the same processing technology. However, the resulting materials may have different physical and chemical characteristics depending on the material source category, and will consequently be more suited to differing end use applications. Source materials are generally separated at the point of collection and separation is maintained throughout the transportation, initial storage, and size reduction processes.

Furthermore, a number of properties are generic and cannot be controlled or changed during the size reduction process.

NOTE 1 *Examples are rubber hydrocarbon content, carbon black content and hardness.*

Some properties arise as a result of the processing technology involved. Since this PAS only relates to one processing technology, namely ambient size reduction, properties such as specific surface and uncompacted bulk density, cannot be controlled or changed during processing.

The properties that are controlled during storage, and processing, and that are applicable to all end use applications are:

a) Degree of contamination with steel, fibre, or other impurities;

b) Dryness (degree of moisture content);

c) Cleanliness (absence of other debris);

d) Particle size.

These properties shall be checked visually and/or tested on a regular basis (**see 8.2**) at all stages of the size reduction process.

Particle size and related parameters are the key measurements for size reduced materials. They are the first measure of consistency, form the basis for material grading, and have a significant effect on the performance of the material in the final application. Particle size distribution is particularly important since size reduction will always result in a range of sizes. Its determination is strategic to the definition of powders and smaller sized granulates, although it is less commonly used for cuts, shred and chips. Standardized analysis methods are required to assign particle size designations.

NOTE 2 *The generic chemical and physical properties that cannot be controlled by the process are:*

a) Rubber hydrocarbon content;

b) Acetone extract;

c) Carbon black content;

d) Ash Content;

e) Sulphur;

f) Hardness;

g) Uncompacted Bulk Density.

The range of values of these properties shall be recorded in the material specification and shall be measured periodically by testing to the appropriate methodology as set out in **8.2.4**.

All relevant chemical and physical properties, together with codes and definitions are shown in Annex C, Table C.1.

8.2 Quality tests applying to all size reduced material

8.2.1 Visual and magnetic checks

Visual quality checks shall be carried out continuously at all stages of the size reduction process to ensure that there are no obvious problems occurring in the process.

Visual checks on cuts, shred and chips shall be carried out to ensure that all remaining steel wire and textiles are embedded in the rubber particles.

For the production of clean cuts, clean shred and clean chips, visual pass/reject aids shall be provided to the operator to establish the maximum amount of exposed metal and textile material that can be tolerated.

Regular visual checks shall be carried out at the final storage or bagging stage of the size reduction process to ensure that the materials are clean essentially dry and free of metal and textiles.

To establish if steel is present in granulate or powder, a magnet or metal detector shall be passed over a sample of the material. If any steel is detected the batch shall be rejected.

*NOTE 1 In addition to visual checks, cleanliness (OD) or moisture content (MC) checks may be carried out if agreed between producer and user. Standard tests for these properties are detailed in **8.2.4**.*

*NOTE 2 Testing to determine the level of metal content (M) or fibre content (F) may be carried out if agreed between producer and user. Standard tests for these properties are detailed in **8.2.4**.*

8.2.2 Confirmation of particle size for cuts, shred and chips

Particle size for cuts, shred and chips shall be established within the initial stages of the size reduction process. Material particles at or below the maximum size required are passed through suitable screens. The sizes of the screen openings are selected in order to achieve the required average particle size within the batch. Oversized material is rejected or is returned automatically for further size reduction. Fine powders generated by the process will also pass through the screen with the correctly sized material. This may be removed by further processing, such as washing, if agreed between producer and user.

No further particle size checks are required for these materials.

8.2.3 Confirmation of particle size for granulate and powder

Particle size of granulate and powder shall be confirmed using the sampling and testing procedure described in Annex D.

Unless otherwise agreed between producer and user, size quality checks shall be carried out once per batch manufacture or once per production shift, whichever is the more frequent.

All material produced in that batch or shift shall be placed in a store until the particle size test has been carried out.

In compliance testing, more than 90% by mass of the material shall be smaller in size than the upper defined limit and less than 15% by mass of the material shall be smaller than the lower defined limit.

Where the sample passes the particle size distribution test, the batch shall be released to final storage.

If the sample does not pass the test the material batch shall be rejected and, if practical, shall be fed back into the appropriate stage of the machinery for further processing.

8.2.4 Determination of cleanliness, moisture, and metal and fibre content

Some end use applications will require formal measurement of the cleanliness (OD), moisture content (MC), metal content (M) or fibre content (F) properties of a material in addition to the visual and magnetic checks carried out as detailed in **8.2.1**. In these instances, the accepted range of specification for the property and the sampling protocol shall be agreed between producer and user.

The suitable standard test methods for these properties are set out in Table 6 together with the range of measurement.

Preference shall be given to the test methods listed in Table 6.

Table 6 – Standard test methods – cleanliness, moisture, and metal and fibre content

Property	Standard reference	Range
Moisture content	BS ISO 1126	As agreed
Cleanliness (absence of debris)		As agreed
Metal content	BS ISO 6101-5	<0.1% or as agreed
Fibre content		<0.1% or as agreed

8.2.5 Determination of other generic chemical and physical properties

A range of other chemical and physical properties may be tested on size reduced material as agreed between the producer and the user.

The range of measurement for these properties is set by the nature of the source material. If the test measurements indicate a shift of these properties, caused by changes in the structure and composition of new tyres, then the producer shall inform all users and the material specification shall be re-issued.

The relevant properties are set out in Table 7 together with suitable standard test methods and the accepted range of measurement.

NOTE Preference should be given to the test methods listed in Table 7.

Table 7 – Standard test methods – other properties – all size reduced material

Property	Standard reference	Range
Rubber hydrocarbon content	BS 7164	>56%
Acetone extract	BS ISO 1407	5% - 20%
Carbon black content	BS 7164-14	25% - 30%
Ash content at 550°C	BS ISO 247 and BS 529-7	15% maximum
Sulphur	BS ISO 1138 and BS 7164-23.1	1% - 3%
Indentation Hardness	BS ISO 48 and BS ISO 7619	60- 79 IRHD
Uncompacted bulk density	BS 5293-2	300 kg/m³ to 460 kg/m³

8.3 Other quality tests

Chemical and physical properties, other than those measured on all size reduced materials as listed in **8.2**, are set out in Table 8 together with suitable standard test methods.

NOTE 1 *These may require determination for a particular application or end use application.*

The need for the tests, and the accepted range of measurement recorded shall be agreed between producer and user.

NOTE 2 *Preference should be given to the test methods listed in Table 8.*

Table 8 – Optional standard test methods

Property	Standard reference
Calorific value	BS ISO 1928
Chlorine	BS 7164-22.2
Compact density	BS EN ISO 787-11
Hydraulic conductivity	(Site test field trial)
Indentation hardness	BS ISO 48 and BS ISO 7619
pH Value	BS 6057 and BS EN12457
Pour density	BS 5293-2
Specific gravity	BS ISO 2781
Specific surface	(Microscopy)
Thermal conductivity	
Volatiles	BS ISO 248
Water absorption	BS EN 1097-6
Zinc	ISO 2454 and BS 7164-29.1

9 Material specification

9.1 Specification system

*NOTE 1 A standardized material can be identified by the user for each application or end use application. The system comprises four elements required for all size reduced materials, and any number of chemical and physical properties, other than the generic properties listed in **8.2.4**. Table 7 that characterize the specific material for its intended application or end use application. In this way, customized materials may be produced for a specific end use but which comply in other respects with this PAS.*

Elements that shall be specified for all size reduced materials:

a) The category of the material (Clause **6**, Table 5);

b) The material source (**4.1**, Table 4);

c) The processing technology (Clause **5**);

d) The particle size expressed as:

1) Nominal size for cuts shred and chips;

2) Range of upper and lower defined limits for granulate and powder.

Elements that shall be specified only as required by application and end use application:

The chemical and physical properties characterizing the material for the specific end use (Table C.1).

NOTE 2 In addition to listing the characteristics of the material as above, all supplies may be accompanied by a material safety data sheet.

NOTE 3 Size reduced tyre derived rubber material is not classed as hazardous under the (Chemicals Hazard Information and Packaging) for Supply Regulations 2002 [7] and, therefore, the issue of a safety data sheet is optional.

NOTE 4 A sample material safety data sheet is shown in Annex E.

9.2 Examples of specifications

The producer and user shall agree the non-generic chemical and physical properties that are required for the intended application or end use application.

For illustration purpose only, examples of material specifications are shown in Annex F.

NOTE The examples use the codes and designations specified in this PAS.

10 Selection and use of end-of-life tyre materials

10.1 General

The materials described in this PAS have the capacity to be used in one or more end use applications. End use applications fall into three broad categories:

a) civil engineering and construction use;

b) consumer and industrial applications;

c) energy recovery.

Civil engineering and construction use can be divided into three subcategories:

1) Non-road construction and civil engineering;

2) Road construction and civil engineering;

3) Sports and safety surfaces.

Generally, civil engineering and construction applications utilize larger sized materials, i.e. whole tyres, shred and chips. As surfacing treatments have become more prevalent, greater quantities of smaller sized materials are being used, including granulate for sports track and play surfaces and specialized powders for sealants and coatings.

Consumer and industrial applications generally utilize smaller size granulate and powders. Consumer products, many of which have entered the mainstream and meet existing standards, include a broad array of goods from footwear to the solid wheels found on baggage carts. Industrial products are often components used in other industries, e.g. carpet underlay, floor tiles, insulation, battery housings and pigments.

Energy recovery feedstock comprises larger size materials or whole tyres.

10.2 Examples of end use applications

Annex G presents some examples of current and potential end use applications, illustrating the different material types, sources, technologies and relevant properties for consideration.

Annex A (informative)
Sample Waste Transfer Note (WTN)[7)]

Waste transfer note (WTN)

Waste transfer note number			
Manufacturer			
Telephone no.		Fax no.	
Waste Management Licence number			
Description of waste/goods			
First weigh reference code			
List of waste regulations (LOW) code			
Date		Time	
Customer/supplier			
First weight			
Haulier			
Registration number of vehicle			
Second weigh reference code			
Collection or transfer point of the waste			
Date		Time	
Waste carrier's licence number			
Second weight			
Net weight			
Driver's signature			
Weighbridge operator's signature			
Order/advice note number			

[7)] Changes to the WTN are expected to come into force by the end of 2011; contact the Environment Agency for further information.

Annex B (informative)
Fire safety

Large fires at tyre recycling facilities pose a significant risk to the environment, fire fighters and local communities due to:

a) Toxic smoke plumes;

b) Firewater run-off;

c) Thermal radiation;

d) Production of hazardous waste and residue;

e) Physical risk.

Large fires can also have a significant impact upon operators due to loss of production and raw materials, increased insurance premiums, clean up costs and damage to business reputation.

NOTE 1 *To reduce the risk and impact, TRA members are working with the Environment Agency and the Fire and Rescue Service to produce guidance on how operators can prevent fires at tyre recovery facilities, and if one should break out, how its impact can be minimized.*

The guidance will cover areas such as:

a) Legal backgrounds;

b) Cause of fires;

c) Risk assessments

d) Risk reduction options, i.e. fire prevention,, stack separation distances and/or bunding;

e) Fire responsive planning.

NOTE 2 *This list is not exhaustive.*

Operators should follow this guidance[8)] once published; until then operators should consider fire risk as part of the site management plan, in assistance with the local Fire and rescue Service and the Environment Agency.

[8)] To be published early 2012.

Annex C (informative)
Property codes and definitions

Table C.1 – Chemical and physical property codes and definitions

Property	Code	Definition
Acetone extract	AE	Amount of substances extracted with acetone, refluxed over the material sample during a defined period of time.
Ash content	AC	Amount of ash obtained from a material sample under designated test conditions.
Calorific value	CV	Amount of heat generated per unit mass of material when completely burned.
Carbon black content	CB	Percentage by mass of the carbon black content in the material sample.
Chlorine	CL	Percentage by mass of chlorine in any form in the material sample.
Cleanliness (absence of debris)	OD	Degree of contamination with impurities and/or debris other than metal, fibre and moisture.
Compact density	CD	Density of the individual particle.
Fibre content	F	Amount of fibre retained by the material, expressed as a percentage of total mass.
Hydraulic conductivity	HC	Flow rate of water passing through a specified layer of material under a known hydraulic pressure expressed in metres per second.
Indentation Hardness	H	Hardness measured in International Rubber Hardness Degrees (IRHD) or Shore scale.
Metal content	M	Amount of metal retained by the material, expressed as a percentage of total mass.
Moisture content	MC	Percentage of moisture retained by the material during and/or after processing when compared to dry mass.
Natural/synthetic rubber ratio	S/R	Ratio of natural rubber to synthetic rubber in the material sample.
Particle size	PS	Size of individual particles of material after processing, expressed as a distribution of sizes within the material sample.
pH value	pH	Acidity of an aqueous extract of material.
Pour density	PD	Apparent mass per unit volume of a particulate material.

Property	Code	Definition
Rubber hydrocarbon content	RH	Percentage by mass of the rubber polymer in the material.
Specific gravity	SG	Ratio of the mass of a given volume of material to the mass of an equal volume of water.
Specific surface	SS	Measure of the surface area of the particle.
Sulphur	S	Percentage by mass of sulphur in any form in the material sample.
Thermal conductivity	TC	Measure of the effectiveness of the material as a thermal insulator.
Uncompacted bulk density	BD	Mass per unit volume of a material before compaction, including voids present.
Volatiles	V	Amount of volatile matter emitted by the material sample under designated test conditions.
Water absorption	WA	Increase in mass of dry material due to the penetration of water into the water accessible voids.
Zinc [a)]	Z	Percentage by mass of zinc in the material sample.

[a)] Lead and calcium may also be present but in negligible quantities.

Annex D (normative)
Particle size analysis of granulate and powder

D.1 General

This annex is concerned with the particle size analysis of size reduced materials obtained from end-of-life tyres. It applies to granulate and powder as defined in Clauses **3** and **6** of this PAS and may also be used for chips if agreed between the producer and user.

It covers the measurement of particle size from under 0.5 mm to 50 mm.

D.2 Principle

Divide up and separate, by means of sieves, a test portion of material into several particle size classifications of decreasing sizes. The mass of the material retained on the various sieves is related to the initial mass of the material. Report the cumulative percentage passing each sieve in numerical form and, when required, in graphical form.

D.3 Apparatus

D.3.1 Mechanical sieve shaker, imparting a uniform rotary and tapping motion to a stack of 200 mm diameter sieves.

D.3.2 Test sieves, conforming to ISO 3310-1 and -2.

The nominal sizes of openings shall have the following range of applications:

a) for metal wire cloth: from 20 mm to 50 mm;

b) for perforated metal plate:

i) with square holes: from 4 mm to 50 mm;

ii) with round holes: from 0.5 mm to 50 mm.

NOTE 1 *Methods and equipment given assume the 'rotup' method of sieve analysis. Alternative methods are available for other applications.*

D.3.3 Receiver pan and cover plate, tightly fitting for the sieves.

D.3.4 Balance or scales, accurate to ± 0.1 % of test portion mass.

D.3.5 Brush, for removing material from jar and sieves.

D.3.6 Rubber ball (for powder only, optional), with a diameter from 25 mm to 50 mm.

NOTE *Sufficient balls are needed to have two balls per sieve.*

D.3.7 Talc (for powder only), usually some mixture of magnesium silicate, silica magnesium oxide-aluminium silicate with at least 90% of the particles being less than 40 µm in size.

D.4 Sampling

The sampling of material for particle size analysis shall be agreed between the supplier and the purchaser.

D.5 Test method

The particle size and size distribution of granulate and powder shall be determined by the method specified in **D.6**.

D.6 Determination of the particle size of granulate and powder

D.6.1 General

This test method specifies a general procedure for the particle size analysis of granulate and powder.

For measurements intended to be comparable, the type and sizes of sieves, the test procedure, and calculation and expression of results shall be the same.

NOTE *Similar results may not be obtained if there are differences in the test operation.*

D.6.2 Procedure

D.6.2.1 Take a test portion weighing not less than 100 g for granulate from the sample of material.

D.6.2.2 Weigh to the nearest gram in each case and record as M1.

D.6.2.3 For powder known to be no more than 300 µm in size, weigh 1.5 g of talc.

D.6.2.4 For powder over 300 µm in size weigh 0.5 g of talc.

D.6.2.5 In each case add the talc to the test portion in a 500 cm jar and shake for a minimum of 1 min until all agglomerates are broken and the talc is uniformly mixed.

NOTE *Talc is added to reduce particle agglomeration due to surface tack. It is usually not necessary with granulate but is recommended if problems arise during the test.*

D.6.2.6 Assemble the column of the appropriately sized sieves.

D.6.2.7 The column comprises sieves fitted together and arranged from top to bottom in order of decreasing aperture size.

D.6.2.8 Use at least two sieves to represent the upper and lower defined limits as described in **D.4.5**.

D.6.2.9 Use a greater number of sieves to characterize the particle size distribution.

NOTE *Specific requirements may be agreed between the supplier and customer.*

The size range shall include the defined limits as indicated in Figure D.1.

D.6.2.10 Complete the column by putting the receiver pan at the bottom.

D.6.2.11 If required, add two rubber balls to each sieve to assist sieving.

D.6.2.12 Pour the test portion into the top sieve of the column, using a brush to remove traces from the jar if required, and then add the cover plate.

D.6.2.13 A rotary motion shall be applied to the column using the chosen apparatus for a specified time.

D.6.2.14 For powder this shall be 10 min for material designated coarser than 300 µm or 20 min for material finer than 300 µm, unless otherwise specified.

D.6.2.15 Remove the sieves one by one commencing with the largest aperture size, opening and shaking each sieve manually to ensure no material is lost.

D.6.2.16 Brush any material adhering to the bottom of the sieve on to the next finer sieve.

D.6.2.17 Weigh the contents of the sieve with the largest aperture size and record its mass to the nearest 0.1 g as R1.

D.6.2.18 Record any mass less than 0.1 g as a trace.

D.6.2.19 Carry out the same operation for the sieve immediately below and record the mass retained as R2.

D.6.2.20 Continue with the same operation for all the sieves in the column, in order to obtain the masses of the various lots of retained materials and record these masses as R3, R4, …Rn.

D.6.2.21 Also weigh the material which falls into the pan at the bottom of the column and record its mass as P.

D.7 Calculation and expression of results

D.7.1 Record the various masses on a test data sheet alongside the corresponding sieve size.

D.7.2 If the sum of the masses of material, R1... Rn and P differs by more than 1% from the mass of the test portion M1, the test shall be repeated.

D.7.3 Calculate the mass of material retained on each sieve as a percentage of M1.

D.7.4 Calculate the cumulative percentage of M1 passing each sieve, to the nearest decimal point.

D.7.5 Plot the cumulative percentage as a function of particle size using the sieve size, expressed in millimetres for sizes of 1 mm and above and in microns for sizes under 1 mm, unless otherwise specified.

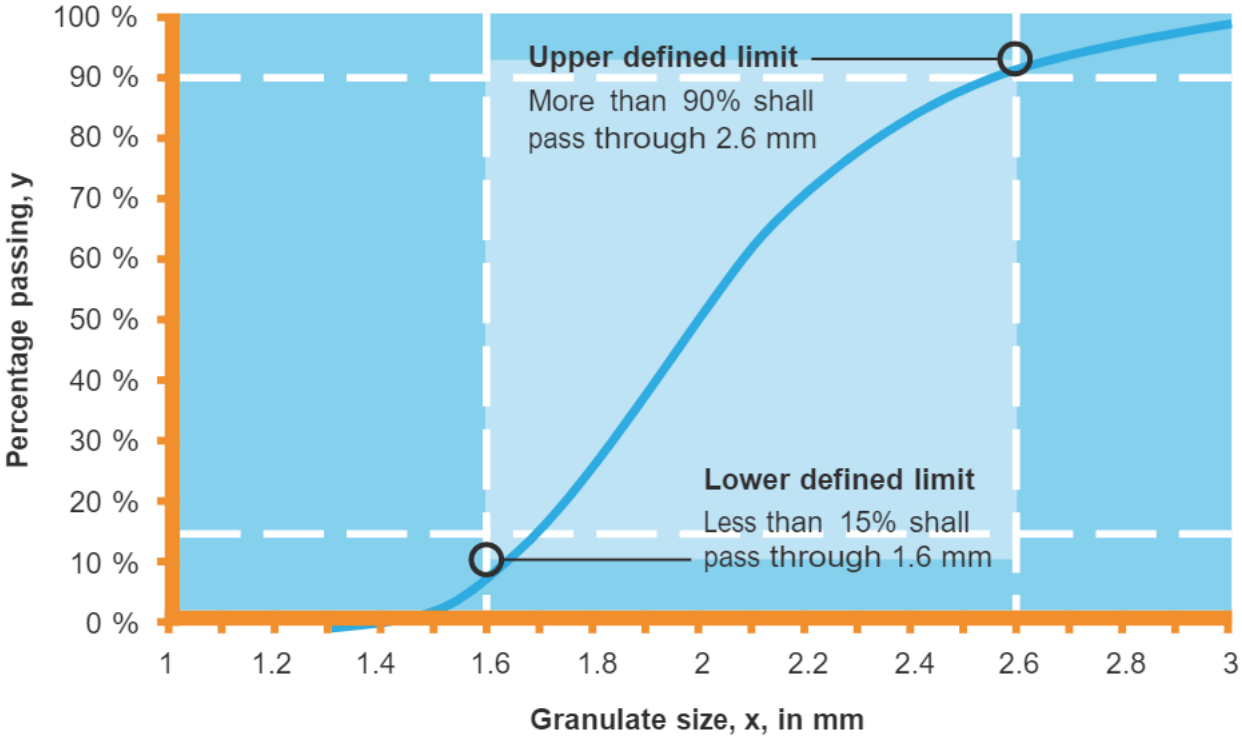
D.7.6 From the plot, determine the particle size at which the passing cumulative percentage is 90% and take this as the upper defined limit. Likewise, determine the particle size at which the passing cumulative percentage is 15% and take this as the lower defined limit. The two limits are a measure of the particle size range of the material.

In compliance testing, more than 90% by mass of the material shall be smaller in size than the upper defined limit and less than 15% by mass of the material shall be smaller than the lower defined limit.

As an example, Figure D.1 depicts the particle parameters of granulate defined as 1.6 mm to 2.6 mm in size.

NOTE *The use of references R1, R2 and so forth are examples only; typical software applications for automated equipment may generate alternative coding.*

Figure D.1 – Example of analysis of granulate



D.8 Test report

D.8.1 Required data

The test report shall include the following information:

a) reference to this PAS, i.e. PAS 107:2012;

b) identification of the test sample, including the code defined in this PAS;

c) identification of the supplier;

d) identification of the test laboratory;

e) sample reception date;

f) method of analysis (including the type of sieve);

g) cumulative percentage of the mass of the test portion passing each of the sieves to the nearest decimal place;

h) details of any deviation from the specified procedure;

i) the date of the test.

D.8.2 Optional data

The test report shall include the following information:

a) name and location of the sample source, including the codes defined in this PAS (Annex G);

b) description of the material and of the sample reduction procedure, including the codes defined in this PAS;

c) graphical representation of results;

d) sampling certificate;

e) mass of test portion.

NOTE *Table D.1 provides an example of a test report.*

Table D.1 – Example test report

Test report No.		Product	
Description		Batch Identification	
Particle range		Producer	
Sample weight		Cat code	
Source code		Technology code	

Method of analysis

Sieve (mm)	Wt (g)	Retained (%)	Cumulative retained (%)	Passing (%)
Totals				

Magnetic test	**Steel detected**	**Yes**		**No**	
Comments					
Visual test	**Fibre content**				
Comments					
Moisture test	**Moisture content**				
Comments					
Pass or fail					
Comments					
Conforms to PAS 107:2012					
Signed			**Date**		

Annex E (informative)
Sample material safety data sheet

Material safety data sheet

Manufacturer		Tel no.	
Fax no.		Email	

Material trade name	
Manufacturer's material code	

1	Identification of substance	
2	Identification of hazards	
3	Composition/information on ingredients	
4	First aid measures	
5	Fire fighting measures	
6	Accidental release measures	
7	Handling and storage	
8	Exposure controls and personal protection	
9	Physical and chemical properties	
10	Stability/reactivity	
11	Toxicological information	
12	Ecological information	
13	Disposal considerations	
14	Transport information	
15	Regulatory information	
16	Other information	

Issue No	
Date of issue	

Annex F (informative)
Material specification examples

Table F.1 – Examples of material specifications

Material description	Category code	Source code	Technology code	Particle size	Other properties
Rough cut ambient shred, car tyres, size range 100 mm to 300 mm	RS	PW	A	200 mm	None
Clean cut ambient chips, car tyres, size range 30 to 50 mm, specified chemical and physical properties	CC	PW	A	40 mm	RH, H, S/R, CB, S, Z
Ambient ground granulate, truck tyres, size range 1 mm to 3 mm, specified chemical and physical properties	G	TW	A	1 mm – 3 mm	RH, AE, CB, AC, BD, H, S,
Ambient ground powder, car tyre buffings, size range 0.5 mm to 1.0 mm, specified chemical and physical properties	P	PB	A	0.5 mm – 1.0 mm	AC, CB, S, V, Z, BD, SG, pH, S/R, PD, SS

Annex G (informative)
Examples of current and potential end use applications for ambient ground size reduced rubber

Application	Material Category Code (Clause **6**, Table 5)	Material Source Code (**4.1**, Table 3)	Key chemical and physical properties (**8.1**, Table 6)
Civil engineering (non-road)			
Bridge abutments	RS, G	PW, TW	BD, CD, HC, TC, SG, SS
Culvert drainage beds	RC, G	PW, TW	CD, HC, SS,WA
Embankments	RS, RC, G	PW,TW	pH, CD, HC,SS,WA
Insulation (e.g. sound)	CS, CC, G	PW, TW	CL, pH, S, Z, others dependent upon design and installation
Landfill drainage layer	RS, RC	PW, TW	CD, HC, S, Z, pH, SS, WA
Other landfill engineering	RS, RC	PW, TW	depends upon specific use
Slope stabilisation	RS, RC	PW, TW	CD, HC, SS, WA
Thermal insulation	CS, CC	PW, TW	BD, HC, SG, TC
Train and tram rail beds	G	PW, TW	OD, dependent on installation
Civil engineering (roads)			
Asphalt rubber	G, P	PW	AE, AC, CB, RH,S/R,AD,CD,CP,SR,OD
Coatings	P	PW	AC,CB, CV, S, V, Z, BD, PD, SG, SS, MC
Collision barriers	CX, CS, CC, G	All	S, HC, MC, TC
Expansion joints	G, P	PW, TW	AE, AC, CB, RH, pH, S, Z, HC, S/R, OD
Lightweight fill	CS, CC	PW, TW	BD, HC, TC, SG
Noise barriers	RX, RS, RC	PW, TW	BD, CD, SG, WA
Road furniture	G, P	All	dependent upon specific application
Sealants	P	PW	AC, CB, S, V, Z, BD, PD, SG, SS, pH, MC
Surfacing	G, P	PW, TW	pH, S, AC, AE, CB,H,/R, CD, OD
Temporary roads	CS, CC	PW, TW	S, V, Z, HC, TC, WA
Wearing course	G, P	PT, PW	AC, CB, RH, S/R, CD, OD

Application	Material Category Code (Clause **6**, Table 5)	Material Source Code (**4.1**, Table 3)	Key chemical and physical properties (**8.1**, Table 6)
Civil engineering (sport and safety surfaces)			
Equestrian tracks and menages	CC	PW, TW	S, Z, CB, RH, H, S/R
Hockey/soccer pitches	G	PW, TW	S, pH, Z, M, OD, AC, HC, MC, S/R, WA
Indoor safety flooring	G, P	PW, TW	CB, RH, H, S/R
Playground surfaces	CC, G, P	PW, TW	C, S, pH, Z, M, OD, AC, HC, MC, S/R, WA
Consumer/Industrial Applications			
Agricultural uses	G	PW	pH, S, Z, HC, WA, plus others dependent upon use
Battery housings	P	All	AC, AE, CB, MC, BD, S
Flooring Materials	G, P, FP	PW, TW, PB, TB	CB, RH, sS/R, H
Floor tiles	G, P, FP	All	S/R, S, M, OD, MC, WA, H
Footwear	G, P, FP	All	AC, AE, BD, S/R, MC, H
Moulded products	G	All	AE, CB, S/R, BD, SG, SS, H, MC
Roofing material	G, P, FP	PW, TW, PB, TB	M, F, OD, S/R, MC, Z, V, pH
Tyre infill materials	G, P, FP	PW, TW, PB, TB	AE, CB, OD, CD, F, S/R, SS, S, Z
Vehicle mats	G, P, FP	All	CB, S/R, S, Z, BD, SG, H
Vibration mats	G, P, FP	PW, TW	S, V, Z, CD, SS, AC, CB, AE, MC, CV, SG
Automotive applications	FP	PW, TW	Dependent upon use
Energy Recovery	RX, RS	All	CV, S, V, Z

Bibliography

Standards publications

PAS 108:2007, *Specification for the production of tyre bales for use in construction*

BS EN 1097-6, *Determination of particle density and water absorption*

BS EN 12457, *Characterisation of waste – Leaching*

BS EN ISO 787-11, *General methods of test for pigments and extenders – Part 11: Determination of tamped volume and apparent density after tamping*

BS ISO 48, *Rubber, vulcanized or thermoplastic – Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

BS ISO 247, *Rubber – Determination of ash*

BS ISO 248, *Rubber, raw – Determination of volatile-matter content*

BS 6057 – 3.9, *Rubber latices – Part 3: Methods of Test – Section 3.9: Determination of pH* (ISO 976)

BS 5293, *Sampling and testing carbon black for use in the rubber industry – Part 3: Method for determination of ash content* (ISO 1125)

BS ISO 1138, *Rubber compounding ingredients – Carbon black – Determination of sulphur content*

BS ISO 1407, *Rubber – Determination of solvent extract*

BS 7164, *Chemical tests for raw and vulcanized rubber – Part 14: Methods for determination of carbon black content* (ISO 1408)

BS ISO 1928, *Solid mineral fuels – Determination of gross calorific value by the bomb calorimetric method, and calculation of net calorific value*

ISO 2454, *Rubber products – Determination of zinc content – EDTA titrimetric method*

BS ISO 2781, *Rubber, vulcanized or thermoplastic – Determination of density*

BS 7164, *Chemical tests for raw and vulcanized rubber – Part 7: Methods for determination of polymer content – Section 7.1: Polyisoprene content* (ISO 5945)

BS 7164-29.1, *Chemical tests for raw and vulcanized rubber — Part 29: Methods for determination of zinc content — Section 29.1: Atomic absorption spectrometry* (ISO 6101-1)

BS 7164-23.1, *Chemical tests for raw and vulcanized rubber — Part 23: Methods for determination of total sulfur content — Section 23.1: Oxygen combustion flask method* (ISO 6528-1)

BS ISO 7619, *Rubber, vulcanized or thermoplastic – Determination of indentation hardness*

BS 7164-22.2, *Chemical tests for raw and vulcanized rubber — Part 22: Methods for determination of bromine and chlorine content — Section 22.2 Oxygen flask combustion technique for determination of bromine and chlorine*

Other publications

[1] Revised Waste Framework Directive: Directive 2008/98/EC on Waste and repealing certain Directives.

[2] GREAT BRITAIN. Environmental Permitting (England and Wales) Regulations 2010 London: The Stationery Office.

[3] Landfill Directive: Directive 1999/31/EC of 26 April 1999 on the landfill of waste.

[4] Council Directive 2000/53/EC of 18 September 2000 on end-of-life vehicles.

[5] Council Directive 2000/76/EC of 4 December 2000 on the incineration of waste.

[6] GREAT BRITAIN. *The Environmental Protection Act* 1990. London: The Stationery Office, Section 34 (as amended) deals specifically with the duty of care etc. as respects waste.

[7] Chemicals Hazard Information and Packaging for Supply Regulations 2002.

Useful reading

DD CEN/TS 14243:2010, *Materials produced from end of life tyres – Specification of categories based on their dimension(s) and impurities and methods for determining their dimension(s) and impurities*

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