Guidance on the use of tyres for leachate drainage blankets on Landfill sites

The Landfill Regulations do permit the use of used whole and shredded used tyres as an engineering material if they can be shown to be suitable for the required service life of the leachate drainage system.

The generic term for such materials is 'Used Tyre Derived Aggregate Replacements' herein after referred to as UTDAR.

UTDAR is currently used in a number of landfill sites for leachate drainage. The Environment Agency is reviewing the design and performance of UTDAR used for this purpose and will issue further guidance on the completion of this evidence based review.

This interim guidance note is intended to provide regulatory consistency in the design and construction of these engineering structures. It is specifically for the use of whole, shredded or baled whole tyres proposed as UTDAR.

Where the sensitivity of the landfill site is considered to be high in terms of the protection of the underlying groundwater, i.e. sites;

- On major aquifers;
- Within Source Protection Zones I to III;
- below the water table (in any strata where the groundwater provides an important contribution to river flow or other sensitive surface waters)

then UTDAR should not be used unless on the basis of an approved hydrogeological and/or stability and/or landfill gas risk assessment, it has been determined, via sensitivity analysis(es), that the protection of the environment (with regards to groundwater and gas) is insensitive to the control of leachate heads within the waste.

Additionally, where UTDAR is proposed within hazardous landfills consideration should be given to chemical compatibility between tyre rubber and the leachate generated from the waste.

The following requirements should also be considered for both whole or shredded tyre derived UTDAR:

The engineered system – In assessing whether the UTDAR is suitable, consideration should be given to the potential for detrimental interaction with other materials. For example UTDAR emplaced over a geomembrane (or other synthetic liner) are more likely to result in rupture of the synthetic due to shearing forces, metallic fragments from the tyre reinforcement and in extreme circumstances by wastes falling through the tyre mattress. Similarly the lateral forces on leachate and gas extraction and monitoring systems could be greater than those experienced in a mineral drainage blanket. The design of such structures should therefore include detailed consideration of the potential impacts.

Tyre Compressibility – Whole, baled and shredded tyre derived UTDAR compress at different rates depending on the load applied. For assessment of the initial layer thickness to achieve the 500mm equivalence thickness required under load, reference should be made to the work by Beaven (Assessment of the physical and hydraulic properties of tyres for leachate collection and drainage systems in landfills, Report No. CWM/117/94, Department of the Environment, Wastes Technical Division. 1995) and Hudson et al (Hydro-geological properties of tyre segments under compressive load, Report No. CE/APH2003/01, University of Southampton School of Civil Engineering and the Environment 2003). Tyre bale deformation is described in PAS 108 and discussed in more detail by Winter et al. 2006 (Tyre bales in construction: TRL PPR 080, TRL Limited, Wokingham). **Please note that a final equivalent thickness of 500mm and not 300mm will be deemed mandatory for sites where UTDAR's are to be used either as the entire drainage blanket or as a constituent part of it.**

Hydraulic Conductivity - Beaven's work suggests that hydraulic conductivity will be higher than that achievable by natural materials under clean conditions. However, research undertaken by Kerry Rowe would suggest that given certain conditions and within the early life of the landfill clogging rates within shredded tyres may be higher than for granular blankets. It is considered that UTDAR laid in accordance with this guide, [i.e. to achieve a minimum post compression overall drainage blanket thickness of 500mm], should demonstrate a sufficient permeability [defined as equal to that required

from granular materials performing the same function] and that the monitoring methods for assessing the effectiveness of granular blankets are equally applicable for UTDAR blankets.

Drainage installation – The non tyre elements of the drainage installation should meet the following criteria;

- The minimum gradient of the base of each cell should be between 1% and 2% (1 vertical to 50/100 horizontal) towards the sump
- The drainage layer should be used along the entire base of the cell. The perimeter side slope will require a drainage system that is designed to accommodate transmission of leachate to the base of the site, thus minimising leachate head on the side slope, and provide adequate protection of any side wall lining system. The side slope drainage should be subject to risk based design and may not necessarily be the same design as the basal drainage layer.
- The slotted / perforated pipes should be bedded on suitable pipe bedding material and covered with mineral drainage material to a minimum thickness of twice the external pipe diameter.
- BS EN 1295/Modified Iowa Formula (Koerner 2005 or Rowe et al 2004) should be used to demonstrate the deformation of the specified slotted / perforated pipe is below 5%
- All sections of pipes should be firmly fixed together using butt fusion or electro-fusion welding techniques. Simple push-fit couplings and hand welding techniques should not be used.
- Pipe diameter should be a minimum of 120mm nominal internal diameter for branches and 160mm nominal internal diameter for main runs.
- The pipe spacing should be a maximum of 30 metres or calculated using Rowe Section 2.4 (Rowe et al 2004)
- The as-placed pipework should be surveyed in order to confirm it has been placed to the required gradient.
- Where whole baled tyres are to be used these bales shall be placed such that gaps between bales are minimised. The perimeter of the baled tyre drainage blanket and voids in excess of 600mm in any direction should be backfilled with an alternative drainage medium.

Koerner R M (2005) "Designing with Geosynthetics" Prentice Hall, New Jersey
Rowe RK, Quigley RM, Brachman RWI, and Booker JR (2004) "Barrier Systems for Waste Disposal Facilities", Spon, London

Construction Quality Assurance (CQA) – The installation of the leachate drainage blanket is subject to CQA. The primary objective of CQA is to ensure and document that the leachate drainage blanket is constructed in accordance with an approved specification. In respect of a UTDAR leachate drainage system, the main CQA activities for the installation are detailed below:

- Source approval including assessment of samples and any proposed production facility;
- Initial sampling and testing of materials for laboratory analysis to check that any specified grading is achieved;
- Observation that material stockpiling is in accordance with the specified requirements;
- Visual inspection of materials to check for contamination upon delivery to site and prior to inclusion with in the works;
- Observation of placement of materials to ensure no damage to the underlying elements of the lining system. Including visual checks for projecting bead wire within the initial layer of placed material in direct contact with the geomembrane and protection geo-textile;
- Measurement of the overall placed depth of the drainage blanket to ensure with the required thickness is in place.
- Observation that baled tyres are installed such that gaps between bales are minimised.

UTDAR compliance and conformance criteria

A minimum of three samples of the product shall be submitted for grading analysis and visual inspection for the proposed source of UTDAR material prior to any material being delivered to site.
The chipped/shredded tyre materials shall meet the following manufacturing requirements detailed below:
UTDAR shall be produced using a tyre shredding / or tyre chipping plant incorporating either an internal screen or internal or external classifier. Any 'single pass' machine without those features built in, shall incorporate a trommel screen - such that oversize materials [over and above 200mm maximum size] shall pass back through the cutting chamber via a returns conveyor. The above criteria is relevant to the UTDAR being 'well graded' around the maximum size permitted in the CQA which is proved by research to comply with the required pearmeability standards required elsewhere in this guidance

> Note: There is no specific 'British Standard' for Particle Size Distribution or Gradation of UTDAR products. UTDAR products are man-made with an irregular shape and of a pliable nature.
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> Prior to leaving the processing plant or, after deposition at the site, UTDAR can be tested for particle size distribution. Grading testing is possible using tests to BS1377: Part 2: 1990 (Dry sieving). Sampling should be by representative 10kg samples at reasonable intervals to be agreed in the CQA Plan.
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> Not withstanding any other criteria specified - UTDAR shall have only 0 to 5 % passing the 10mm sieve size and have 100% of the material passing a 200mm sieve.

All the above activities will be recorded and will be required to form part of the validation report produced for the whole of the engineering works.

Manufacturers Quality Control - The selection of chipped, shredded or whole tyres and the manufacture of tyre bales, their subsequent handling, storage and transport shall all be in strict accordance with the requirements of PAS [Publicly Available Specification] quality standards. Further guidance on UTDAR specification derived from the Draft [Publicly Available Specification] PAS 107, which is a standard for the production of shredded and chipped tyres, should be sought if required. It is expected that this standard will be released in 2007. Further guidance on UTDAR specification derived from the Draft [Publicly Available Specification] PAS 108, which is a standard for the production of baled whole tyres, should be sought if required. It is expected that this standard will be released in 2007.

Leak location survey – Any site that has a geomembrane installed as part of the containment engineering is required to undertake a geophysical leak location survey. There are currently 2 methodologies for this; permanent leak detection systems under the geomembrane or a post drainage blanket emplacement geophysical walk over survey. If tyres are proposed as a leachate drainage media then the design must fully justify which methodology is to be utilised.

Due to the placed depth of a UTDAR drainage blanket, in order to achieve a final thickness of 500mm, it is not considered possible to undertake a walkover survey at the full depth of material. If such surveys are to be undertaken, then consideration should be given to either: Conducting the 'walk over' survey after a 'protection' layer [typically a starter layer of aggregate over a suitable geo-textile protector over the FML] is placed, at which point the whole depth of UTDAR can be suitably placed without a further test. Or the placement of the UTDAR drainage blanket in two lifts, with the 'walk over' leak location survey being undertaken after the first lift.

The following considerations should be considered specifically for **whole** tyre derived UTDAR: -

Upwards migration of tyres – In order to prevent this, it is recommended that a geogrid is laid over the mass of whole tyres to resist uplift forces. The geogrid should be overlapped and tied to ensure it remains in place during waste placement.

Installation – There is much discussion as to the optimal method of whole tyre placement. Random placement has the advantage of producing a more homogenous hydraulic performance but may

suffer from tyre displacement. Regular placement, for example in a herringbone 'laced' pattern, tends to produce a uniform thickness of drainage blanket thus allowing less than the required maximum thickness to be placed as the initial lift. The later is the preferred method of placement.

The following issues should be considered specifically for **shredded** tyre derived UTDAR: -

Installation - UTDAR should be installed in accordance with the design and CQA Plan and with all the same precautions as a traditional stone blanket.

Blocking of drainage media – Blocking of the voids between the tyres by waste materials and biochemical growths could be a potential problem. It is recommended that any shredded tyre drainage blanket is overlain with a filter geotextile. A typical geotextile specification is given in the table below;

Property	*Test*	*Acceptance*	*Reasoning*
Polymer		Polypropylene	To avoid provide long life
Geotextile Construction		Non-woven - mechanically bonded	To eliminate wovens and provide a 3-D structure for filtration
Marked		CE	Ensure compliance with EU rules
As required by CE marking:			
Tensile strength	EN ISO 10319	Within publ'd parameters	To ensure no production errors
Elongation at max load	EN ISO 10319	Within publ'd parameters	Higher is better
Static puncture (CBR)	EN ISO 12236	3300 N min.	Robustness and puncture resistance
Dynamic perforation resistance (Cone Drop)	EN ISO 918	Within published parameters	Robustness and puncture resistance
Characteristic opening size O_{90}	EN ISO 12956	50 to 90 µm	For filtration of silt and larger particles
Water permeability normal to plane	EN ISO 11058	>40 l/m^2s	Basic function
Thickness	EN 964-1	>1.5 mm	Robustness in Service
Mass per unit area	EN 965	>300 g/m^2	Robustness in Service
ability	See Annex B of EN13252 OR German robustness class (GRK) 5	Finish in right hand box	Robustness in service
Resistance to weathering (UV)	EN 12224	> 1 month	Robustness in service
Resistance to chemical ageing	EN ISO 12960, EV ISO 3438 or ENV 12447	Within published parameters	Robustness in service
Resistance to microbiological degradation	EN 12225	Within published parameters	Robustness in service

NOTES:

1. A method statement shall be provided which shall include as a minimum:
   - The method of joining adjacent roles of geotextile (e.g. heat bonding or sewing).
   - The direction of rolls with respect to eventual placement of waste (e.g. waste dozed in direction of the overlap in heat bonded geotextiles).
   - Where a geotextile is to be placed well in advance of waste, test results should be provided demonstrating adequate performance before waste covers geotextile (i.e. test results showing, say, six months before onset of uv degradation allows geotextile to be left exposed for that period and if still uncovered samples require retesting to demonstrate compliance before covering with waste.

2. The geotextile is an important part of the drainage system and requires full CQA, whether at the time of cell construction or in phases as waste is placed and should be adequately addressed in the CQA Plan.

Annex A - Material Specification for UTDAR.

Introduction

This Annex is largely derived from PAS 107 which is to provide a protocol that can be adopted by suppliers for producing grades of tyre shred and crumb (size-reduced rubber) such that potential customers will be assured that they are procuring a product of consistent and verifiable quality. Elements of the draft standard are included here to provide guidance with respect to the specification of UTDAR in landfill engineering.

Specification system

Elements that shall be specified for all size reduced materials:

a) The category of the material product.

b) The material source

c) The processing technology

d) The particle size range expressed as the upper and lower defined limits

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

The chemical and physical properties characterizing the material for the specific end use

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

Terms and definitions

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

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

At this point in time 300mm Rough Shred is not considered suitable for use as UTDAR as there is no current evidence base to characterise its performance in situ.

- **Whole**
  Whole pneumatic used tyres having been removed from the mounting rim, free from contamination and from evidence of fire.

Condition of source materials for UTDAR

All whole tyres received for use as UTDAR shall have been removed from their wheels.

All whole tyres, inner tubes and other source materials shall be free from debris, foreign matter or contaminants.

NOTE Examples of such contaminants are pallets, earth and stones, grease and oils and wheel balancing weights.

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

Characterization of size reduced materials

A summary of the categories of recycled tyre materials suitable for use as UTDAR in landfills is set out in the table below:

Characteristics of size reduced materials for UTDAR

Category	Size range (maximum dimension), mm		Other characteristics
	Minimum	Maximum	
Tyre Shred	50	200	Exposed wire and textiles
Cut Chips	10	50	Some exposed wire and textiles

Cuts, shred and chips will contain some exposed metal wire and textile fragments depending on the cleanliness of the cutting process and blade wear on the machine. Any exposed wire and textiles shall be firmly attached to the body of the rubber fragments. For cut chip, and tyre shred suitable for UTDAR the proportion by length of the exposed materials shall be a maximum of 25% of the nominal particle size.

Handling and storage of shred and chips

Shred and chips shall be stored under cover or externally in bulk form in or on concrete or hard storage bays. **Temporary storage on a landfill site prior to placement as UTDAR shall be on a suitable prepared area, not necessarily concrete.**

Material quality assurance testing

Particle size and related parameters (given in the specification system section above) 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 as this may have some impact on the efficacy of UTDAR as a drainage blanket.

Fire Safety

There are two main issues to be considered when using tyres at a site. These concern the storage of large amounts of tyres prior to their use and the potential effect of a landfill fire.

Comprehensive operational plans and risk assessments should be produced before tyres are allowed on site. The storage area should be designed appropriately and have fire breaks to separate stockpiles. Twenty four hour security should be employed if vandalism is a risk. The Fire Brigade should always be consulted prior to operations commencing.

Underground waste fires are an issue for all engineering structures but a leachate drainage blanket may be at a higher risk due to the potential to draw in oxygen although this may be countered to some extent if the blanket can be flooded to reduce temperatures in the lining system. It is recommended that where a tyre blanket is proposed that these issues are paid particular attention in the design.

The Health and Safety Executive (HSE) paper DIN TD5/004 provides guidance on the issue.

On site processing of UTDAR

Where UTDAR is to be made in situ, **i.e. on a landfill site**, extra conditions should be observed with respect to the processing equipment to minimise the risk of [stockpile] fire.

During the size reduction stage of the process, considerable heat is generated and, at final grinding and sieving, fine dust may also be generated which, in an extreme situation, is potentially explosive.

This is the primary safety concern in that the combination of heat, some sparks in the processing, and rubber dust in this stage can cause fires and explosion.

To minimize the risk, the following precautions should be taken:

a) Working practices should preclude the most common sources of ignition which are smoking and smoking materials, hot work such as welding or brazing (if appropriate), and arson.

b) Water dousing and automatic machines stops should be installed at appropriate locations in the final stage of the machine.

The final stage machine should be enclosed in suitable housing to ensure that fine dust does not escape into any surrounding building.