

WASTE TYRES

RELEVANCE OF WASTE STREAM:

- Waste tyres are bulky and cause a risk for the environment as hazardous substances are contained or other environmental pollution is created when set on fire. They shall therefore be separately collected and treated adequately, also to exploit the high utilisation potential.

COMPOSITION/ MAIN MATERIAL COMPONENTS

Tyres are made up from the tyre carcass as the basic body and the tread. The tyre carcass consists of rubberized fabric from twisted fibre or filament of polyester rayon and nylon, the belt and a bead which is made out of wire material and of particular strength on truck tyres. Given the different types of tyres and the fact that producers keep their receipts secret, no specific details are available about the composition of tyres. For coarse orientation the following data can be used:

Table 1: Material composition of waste tyres

Materials		according to BUWAL ¹ in mass-%	according to LfU ² in mass-%			
			Motor car	Light truck	truck	average
Hydrocarbon-polymers	Natural rubber	47,0	21	19	31	24
	Synthetic rubber		24	23	14	21
Soot and active filler substances		21,5	28	26 ¹	21 ¹	26 ¹
Steel		16,5	12	18	24	16
Fabrics		5,5	4	4	1	3
Zinc oxide		1,0	11	10	9	10
Sulphur		1,0				
Miscellaneous		7,5				

Table 2: Chemical composition of waste tyres

Element/substance	BUWAL ¹	Vest ³	Element/ substance	BUWAL ¹	Vest ³
Carbon	Ca. 70 %	70–75 %	Oxygen	4 %	3,5– 5%
Iron	16 %	13–15 %	Nitrogen	0,5 %	
Hydrogen	7 %	6–7 %	Stearic acid	0,3 %	
Zinc oxide	1 %	1,2–2,0%	Halogens	0,1 %	
Sulphur	1 %	1,3–1,7%	Copper compounds	200 mg/kg	
			Cadmium	10 mg/kg	
			Chromium	90 mg/kg	
			Nickel	80 mg/kg	
			Lead	50 mg/kg	

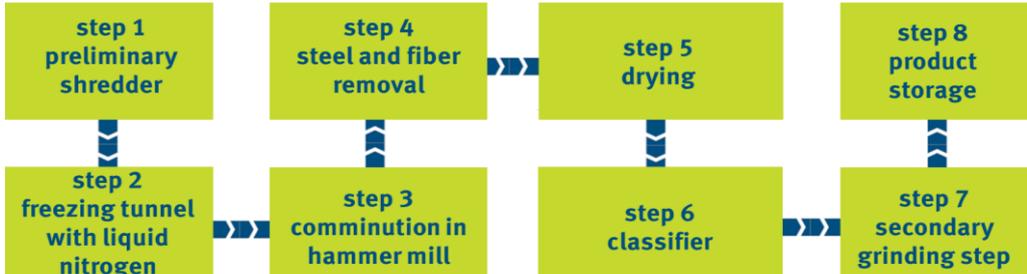
As a rule of thumb, the scrap tyre generation in industrialized countries is approx. one passenger car tyre equivalent (20 lbs.) per person and year.

¹ Bundesamt für Umwelt, Wald und Landschaft: Vollzugshilfe für die Lagerung, Behandlung und Verwertung von Altreifen (Altpneus) – Merkblatt Altreifen, zugänglich über BiCon AG: Altreifen Entsorgung – Was ist ökologisch sinnvoll? http://www.bicon-ag.com/gutachten-uvp/VCS_Altreifen_BiCon_2003.pdf, last access 26.08.2015

² Landesanstalt für Umweltschutz Baden-Württemberg: a.a.O., S. 8. Entsorgung von Altreifen in Baden-Württemberg, 03/2002, http://www.lubw.baden-wuerttemberg.de/servlet/is/11081/entsorgung_altreifen.pdf?command=downloadContent&filename=entsorgung_altreifen.pdf, last access 26.08.2015

³ Vest, H.: Recycling of Used Car Tyres, Technical Information W13e, www.gate-international.org/documents/techbriefs/webdocs/pdfs/w13e_2000.pdf, last access 26.08.2015

<p>EUROPEAN LEGISLATION AND REFERENCE DOCUMENTS</p>	<p>There is no specific Directive for this type of waste in the European Union. Tyres that are collected separately from end-of-life vehicle are covered by the <u>Waste framework directive</u>. The Directive <u>2000/53/EC</u> on the end-of-life-vehicles does refer to tyres on the account that they are part of collected end-of-life vehicles and as such have to be included into the materials reuse and recycling targets stipulated.</p> <p>Further to this, the Landfill Directive <u>1999/31/EC</u> places restrictions on the disposal of tyres at landfills.</p> <p>If old tyres are subject to a retreading, legal guidelines of the UN/ECE (United Nations/Economic Commission Europe) apply regarding requirements on the retreading process:</p> <ul style="list-style-type: none"> - Tyres of passenger cars: <u>UN/ECE Guideline No. 108</u> - Truck tyres: <u>UN/ECE Guideline No. 109</u>
<p>NEEDS AND PRINCIPAL REQUIREMENTS FOR HANDLING THE WASTE STREAM</p>	<p>Waste tyres are generally considered items which require particular attention as discards. This implies their collection and treatment and other specific requirements indicated for this type of waste by different regulations. The EU Landfill Directive lists tyres as a separate waste stream and specifically bans the landfilling of whole tyres and shredded tyres. Next to recycling and recovery of waste tyres, options for their utilisation exist, e.g. the utilisation as safety barriers.</p> <p>The disposal of waste tyres in landfills or their deposition is no suitable option. Aside from legal provisions, which normally should rule out these methods, there is a very high danger of fires with great environmental damages (air pollution) resulting from it. Moreover, the material recovery and the energy value would remain unused.</p>
<p>APPROPRIATE COLLECTION STRATEGIES AND SCHEMES</p>	<p>Waste tyres should preferably be collected at the source of their generation; usually these are car repair shops, retailer, wholesaler and dealer of tyres and used cars, towing companies, fuel stations and companies with large car fleets. Basis for this should be (voluntary) agreements for the taking back of these products.</p> <p>To a certain extent collection will also be necessary thru special collection schemes for bulky items and public bring sites/recycling stations.</p> <p>The used tyres have then to be taken over from recycling firms and companies certified for their further management from whom they should be sorted into the following three main groups:</p> <ul style="list-style-type: none"> - <u>Grooved tyres</u>: tyres which are still in usable state, i.e. the tread have a minimum depth of 1.6 mm and no other damages have occurred so that the tyre can be reused without further treatment. - <u>Carcass</u>: tyres which are not older than 6 years and whose carcass are yet without damages, especially on the side wall. These tyres can be used for retreading. - <u>Scrap tyres</u>: tyres which have serious damages and cannot be treated for reuse on cars.
<p>APPROPRIATE RECYCLING TECHNOLOGIES</p>	<p><u>Reuse</u></p> <p>Only grooved tyres can be directly reused. Due to their lower optical quality these tyres are often exported to low income areas and thus less frequently used within the region/country where they have been generated.</p> <p>Other possibilities for the utilisation of used tyres are:</p> <ul style="list-style-type: none"> - in agriculture: weights for silage cover sheets - in harbours and docks: dock bumpers and ship fenders - in landscaping: as erosion protection for dam, walls and slopes <p>In all these uses, the long life span and elasticity of tyres are availed of.</p> <p><u>Retreading:</u></p> <p>Retreading is only possible for tyres where the tyre carcass is still intact. Requirements on the retreading process are stipulated in UN/ECE Guidelines <u>108</u> and <u>109</u>. Special test and measuring procedures as described in both guidelines make sure that retreading is done with fully intact tyres only and requirements on the retreading process are met.</p>

	<p>For retreading the old tread is stripped off and a new tread applied on the carcass. The methods to be used for this are</p> <ul style="list-style-type: none"> - hot retreading and - cold retreading
<p>APPROPRIATE RECYCLING TECHNOLOGIES –CONTINUATION–</p>	<p>Retreading of one tyre for passenger cars takes about 2–3 kg rubber material for the new profile, for a truck tyre 16–20 kg are needed respectively. The energy demand is about 30 % that for the production of a virgin tyre.</p> <p>Aside from the options of reuse and retreading there is also the possibility to material recycle waste tyres to generate different rubber granule and powder for further applications. The necessary processing steps are:</p> <p><u>Granulation</u></p> <p>Before the shredding the tyres have to be “debeaded“. This is especially important for truck tyres which have a particularly strong bead (up to 25 mm thick). The debader machine used for this has been specifically designed to remove hydraulically the steel beads and side walls from both sides of a truck tyre. Further destruction of the tyre by shredding is considerably easier having debeaded the tyre.</p> <p><u>Comminution</u></p> <p>In the next step, the tyre carcass is shredded to a grain size of about 50–150 mm. Slow speed two-spool shredders are used for this. To get the desired grain size, the chopped tyre particles are passed thru a screen and the oversized parts returned to the shredder aggregate. The screening is done by means of different screens such as drum screen or shaking screen. For the subsequent milling the following two methods are common:</p> <p>- <i>Ambient milling</i></p> <p>This milling method is called an ambient process because the further comminution is done in an atmosphere of ambient temperature. Only the milling aggregates are cooled in order to reduce the heat generated from the friction. A grain size of the rubber material up to 800 µm can be produced with this method.</p> <p>Figure 1: Example of process arrangement for an ambient scrap tyre recycling</p>  <pre> graph LR S1[step 1 preliminary shredder] --> S2[step 2 granulator] S2 --> S3[step 3 steel and fiber removal] S3 --> S4[step 4 consecutive fine grinding steps] S4 --> S5[step 5 classifying with wind sifter] S5 --> S6[step 6 secondary magnetic] S6 --> S7[step 7 fiber and dust removal] S7 --> S8[step 8 product storage] </pre> <p>- <i>Cryogenic milling</i></p> <p>In this milling method, the chopped rubber material is cooled down with liquid nitrogen to a temperature of minus 100°C. The finished particles have a smooth surface so that the mechanical connection in mixture with other materials is somewhat lower than that of the particles obtained from ambient milling.</p> <p>Figure 2: Example of process arrangement for a cryogenic scrap tyre recycling</p>  <pre> graph LR S1[step 1 preliminary shredder] --> S2[step 2 freezing tunnel with liquid nitrogen] S2 --> S3[step 3 comminution in hammer mill] S3 --> S4[step 4 steel and fiber removal] S4 --> S5[step 5 drying] S5 --> S6[step 6 classifier] S6 --> S7[step 7 secondary grinding step] S7 --> S8[step 8 product storage] </pre> <p>In both processes mills are being used that have been specially developed for the production of rubber granule. The so obtained granule and powders can among others also be used for</p>

	<p>the production of new tyres. Safety reasons do not allow the use of such material beyond a certain limit in tyre production. Larger amounts can be used for products without special physical and chemical demands, for example floor coverings, basis layer for carpets, sport ground flooring, motorway sleepers.</p> <p><u>Devulcanisation/Depolymerisation</u></p> <p>As a further step after milling, the particles can also be devulcanised. The most advanced method is that of mechanical devulcanisation. In this process, the rubber material undergoes intensive mechanical treatment in order to cut off the sulphur compounds.</p> <p>A technology for depolymerisation is the <u>FORMEX-process</u>. Within this process procedures are applied which prevent the generation of harmful compounds. The end product, called FORMEX CARBON BLACK® can be reused in rubber production. In this process scrap tyres are first shredded and the chips are then feed into a special reactor. The arrangement of the reactor prevents oxygen to be present during the process. The depolymerisation takes place in a bath of liquid tin at a temperature below 500°C. The low temperature guarantees that the rubber particles can stay long enough in the reaction zone. The gases and oil generated in the result of this reaction are stored in tanks. Steel particles are taken out by magnetic separation. Fibres get caught in a tumbling screen. The mix of carbon black is forwarded into a mill which reduces the particle grain size below 40 µm. 99 % of the products generated in this process can be utilized.</p> <p><u>Use of the granule</u></p> <p>Rubber granule aside from being returned for tyre production can also be used in gardening, landscaping and for road construction. The use of rubber granule in mixture with asphalt in roadside construction (rubber modified asphalt – RMA) delivers a road surface which is noise absorbing, more resistant to wear and has a better grip.</p>
<p>APPROPRIATE TREATMENT AND RECOVERY SCHEMES</p>	<p><u>Thermal utilisation</u></p> <p>Waste tyres have a heating value of 26 to 32 MJ per Mg. This makes them especially suitable as substitute fuel. As such they can be used in cement kilns, power plants and paper mills (see also fact sheet on "<u>Industrial co-combustion</u>"). As of now the thermal utilisation is the most used option for the disposal of waste tyres in Europe as well as in the rest of the world. It is principally possible to use waste tyre for all three types of firing in a cement kiln (calcinator, secondary and primary heating). Large scale applications have only been successful for the secondary heating, however. That's why waste tyres are so far used for this process. Here they don't have to be shredded and supply a raw material aside from their thermal value. The steel from the tyre complement to the concentration of iron from the limestone and oxidizes zinc and sulphur which gets then fixed in the cement matrix. Waste tyres can also be used in coal-fed power plants but the need to have them shredded first makes the process too costly.</p>
<p>REFERENCES AND PROVIDER FIRMS</p> <p><i>(Important note: The list of firms does not constitute a complete compilation of companies active in the specified fields.)</i></p>	<p>In Germany, numerous facilities for the processing, recycling and <u>retreading</u> of tyres are in operation. Many of the described applications as well as the use of rubber granule and powders in various production sectors are commonplace.</p> <p><u>Plant manufacturer:</u></p> <ul style="list-style-type: none"> - ANDRITZ MeWa Gechingen: www.andritz.com/index/locations <p><u>Production of rubber granules and retreading materials:</u></p> <ul style="list-style-type: none"> - Genan GmbH, Oranienburg www.genan.de / www.genan.eu - Kraiburg Holding GmbH & Co. KG www.kraiburg.de <p>Providers of required equipment and technologies, among others, are:</p> <p><u>Shredding equipment:</u></p> <ul style="list-style-type: none"> - HERBOLD, Meckesheim www.herbold.com - EuRec Technology GmbH, Merkers www.eurec-technology.com <p><u>FORMEX-process:</u></p> <ul style="list-style-type: none"> - Berliner-Oberspree Sondermaschinenbau BOS GmbH, Berlin www.bos-berlin.de