BASEL CONVENTION TECHNICAL GUIDELINES ON THE IDENTIFICATION AND MANAGEMENT OF USED TYRES

Basel Convention on the Control of Transboundary Movements on Hazardous Wastes and Their Disposal

No. 10

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ON THE CONTROL OF TRANSBOUNDARY MOVEMENTS OF
HAZARDOUS WASTES AND THEIR DISPOSAL

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SECRETARIAT

TECHNICAL GUIDELINES ON THE IDENTIFICATION AND MANAGEMENT OF USED TYRES

Prepared by the Technical Working Group of the Basel Convention
with support from industry and
adopted by the fifth meeting of the Conference of the Parties
in December 1999, Basel, Switzerland

Basel Convention
Technical Guidelines on the Identification and Management of Used Tyres

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Foreword

These technical guidelines are principally meant to provide guidance to countries who are building their capacity to manage waste in an environmentally sound and efficient way and in their development of detailed procedures or waste management plan or strategy. They should not be used in isolation by the competent authorities for consenting to or rejecting a transboundary movement of hazardous waste, as they are not sufficiently comprehensive for environmentally sound management of hazardous waste and other waste as defined by the Basel Convention. These technical guidelines concern waste generated nationally and disposed of at the national level as well as waste imported as a result of a transboundary movement, or arising from the treatment of imported wastes.

It is necessary to consider this document in conjunction with the Document on Guidance in developing national and/or regional strategies for the environmentally sound management of hazardous wastes (SBC Publication - Basel Convention Highlights No. 96/001 - December 1995) adopted by the second meeting of the Conference of the Parties. In particular, special attention should be given to the national/domestic legal framework and the responsibilities of the competent authorities.

These guidelines are meant to assist countries in their efforts to ensure, as far as practicable, the environmentally sound management of the wastes subject to the Basel Convention within the national territory and are not intended to promote transboundary movements of such wastes.

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Introduction

These technical guidelines have been prepared by the Technical Working Group of the Basel Convention with support from industry. It is a response to the needs of those Parties experiencing difficulties in the identification and disposal of end-of-life tyres.

Lack of capacity to identify and dispose of end-of-life tyres can lead to serious health and environmental problems. These present technical guidelines are meant to assist national authorities to manage and dispose of these waste tyres in an environmentally sound way.

1. The composition of tyres and general properties

A tyre is a rubber article with a complex structure. The tyre transmits to the road the motor forces necessary for propulsion. Together with the suspension the tyre dampens the unevenness of the road surface and thus ensures driving comfort. The tyre serves as a container to keep air under pressure. Passenger car and truck tyres represent about 85% of the total number of tyres manufactured.

Depending on their size and utilization, tyres vary in design, construction and total weight. As an example, the weight of a used passenger tyre in Europe is about 6.5 kg and that of a truck tyre is about 53kg.

Table 1: Examples of the range of weights for passenger car and truck tyres.

Type of vehicle	Kilos	per ton
Passenger car	6.5 - 9	+100 - 154 per ton
Light utility vehicles	11	91 per ton
Heavy goods vehicles	50	20 per ton
Long-haul trucks	55-80	12-18 per ton
Agricultural tyres	100	10 per ton

Chemical composition

Approximately 80% of the weight of car tyres and 75% of truck tyres is rubber compound. The composition of the tyres produced by different manufacturers are very similar. Table 2 shows the material composition of passenger car and truck tyres.

Table 2: Comparison of material composition of passenger car and truck tyres in the EU

Material	Passenger Car	Truck
Rubber /Elastomers	47%	45%
Carbon black*	21.5%	22%
Metal	16.5%	25%
Textile	5.5%	--
Zinc oxide	1%	2%
Sulphur	1%	1%
Additives	7.5%	5%

* Part of the carbon black may be replaced by silica in certain types of tyres

Tyres contain about 1.5% by weight of elements or compounds listed in Annex 1 of the Basel Convention. These are encased in the rubber compound or present as an alloying element.

Table 3: Basel Convention hazardous waste constituents

Constituent	Chemical Name	Remarks	Content (% weight)
Y22	Copper Compounds	Alloying constituent of the metallic reinforcing material (Steelcord)	Approx. 0.02 %
Y23	Zinc Compounds	Zinc Oxide, retained in the rubber matrix	Approx. 1 %
Y26	Cadmium	On trace levels, as Cadmium compounds attendant substance of the Zinc Oxide	Max. 0.001 %
Y31	Lead Lead Compounds	On trace levels, as attendant substance of the Zinc Oxide	Max. 0.005 %
Y34	Acidic solutions or acids in solid form	Strearic acid, in solid form	Approx. 0.3 %
Y45	Organohalogen compounds other than substances in Annex	Halogen butyl rubber (tendency: decreasing)	Content of halogens max. 0.10 %

Thermal properties

The net calorific value of a tyre is between 32 and 34 MJ/kg (Millions of Joules/Kilogram). A ton of tyres is equivalent to a ton of good quality coal or 0.7 ton of fuel oil. It is therefore, an excellent potential as a fuel, which is not surprising since tyres are mainly composed of oil products.

Table 4: Comparison of the Energy Content Tyre Derived Fuel and Other Fuels

Fuel	Grade	Heat content
Gas	Natural	1.000 BTU/ft^3
TDF	Tyre Derived Fuel	15.500 BTU/lb
Coal	Sub-bituminous	10.500 BTU/lb
Coal	Bituminous	12.700 BTU/lb
Wood	Wet wood >hog fuel	4.375 BTU/lb

The combustion of a tyre, like the combustion of any hydrocarbon, produces principally carbon dioxide, water, plus inert residues. The sulphur content of tyres (approx. 1%), is comparable to a low sulphur content coal or very low sulphur content fuel oil and, therefore, the level of the sulphur dioxide is as low as these other fuels.

A tyre is very difficult to ignite. The temperature at which the ignition induced by the pilot flame may be maintained was 33°-350°. There is no possibility of self ignition for tyres. The tyre burns completely at 650° and only ash and slag remain.

2. Potential risks to the environment

Despite the obvious stability of tyres, due to the fact that the different components of the rubber mixtures are trapped in the three-dimensional grid of the polymer, it is essential to ensure that tyres are not treated in a way that may cause harm to the environment.

Potential risks from tyres

Two types of studies may be carried out to assess the impact: ecotoxicological study and leaching test.

Ecotoxicity

At the request of BLIC the following tests were performed, using ISO standard test methods on powdered rubber from tyre tread.

- In 1995, studies were carried out at the Pasteur Institute in Lille using rubber powder generated from tyre tread (on Alga: S. Capricornutum and crustacean: Daphnia magnia and Fish Brachydanio rerio) as per norms ISO 8692, 6341 and 7346.

- In 1996, a supplemental study was done: "Determination of Acute Toxicity as per ISO11268/1 - Observation of effect of tyre powder rubber on a population of earthworm placed in a definite substratum" - at the Pasteur Institute in Lyon. using standardised norms, they showed no toxicity (see Annex 2).

These 4 tests showed no toxicity (see Annex 2a).

Leaching

The Rubber Manufacturers Association (RMA, United States), authorised Radian Corporation to assess what level of chemicals, if any, are leached from tyres and other representative RMA products using EPA's proposed Toxicity Characteristics Leaching Procedure (TCLP). The report, published in September 1989, showed that there was no threat to ground or surface water arising from the contact with granulated or shredded tyres (see Annex 2b).

In 1989, the Minnesota Pollution Control Agency (MPCA) studied the leachate from waste tyre samples to distinguish any which may be detrimental to the environment. In addition soil and groundwater were taken from two existing shredded tyre fill sites and stockpile site were analysed and compared to the laboratory results. The results of the study were revealed in a report entitled "Waste tyre in sub-grade road beds" published by MPCA in February, 1990.

The following points summarise the findings of the study:

1. Tyre samples exposed to acidic solutions leach higher concentrations of metals than those subjected to neutral or basic solutions.

2. In neutral solutions (pH 7.0) tyre samples did not leach any contaminants of concern.

3. Samples subject to a pH of 3.5 produced leachate metal concentrations that exceeded the Minnesota Department of Health Recommended Allowable Limits (RALs) for drinking water standards.

4. Metals detected in the highest concentrations included barium, cadmium, chromium, lead, selenium and zinc.

5. Soil samples taken from shredded tyre field sites displayed constituent concentrations comparable to those found in natural settings.

More recently the Department of Civil and Environmental Engineering of the University of Maine has published a new study where two field trials were constructed to investigate the effect on water quality of tyre chip fills placed above the groundwater table. Control wells were used to distinguish the substances naturally present in groundwater from those that leachate from tyre chips. There was no evidence that tyre chips increased the level of substances that have a primary drinking water standard. In addition, there was no evidence that tyre chips increased the level of aluminium, zinc, chloride or sulfate which have secondary (aesthetic) drinking water standards. Under some conditions iron levels may exceed their secondary standard. It is likely that manganese levels will exceed their secondary standard, however, manganese is naturally present in groundwater in many areas. Two sets of samples were tested for organics. Results obtained were below the method detection limit for all compounds (see Annex 3).

Annex 3 contains additional information on the effects of tyres shreds in civil engineering applications.

Potential risk of waste tyres mismanagement

Risk due to uncontrolled open-air burning

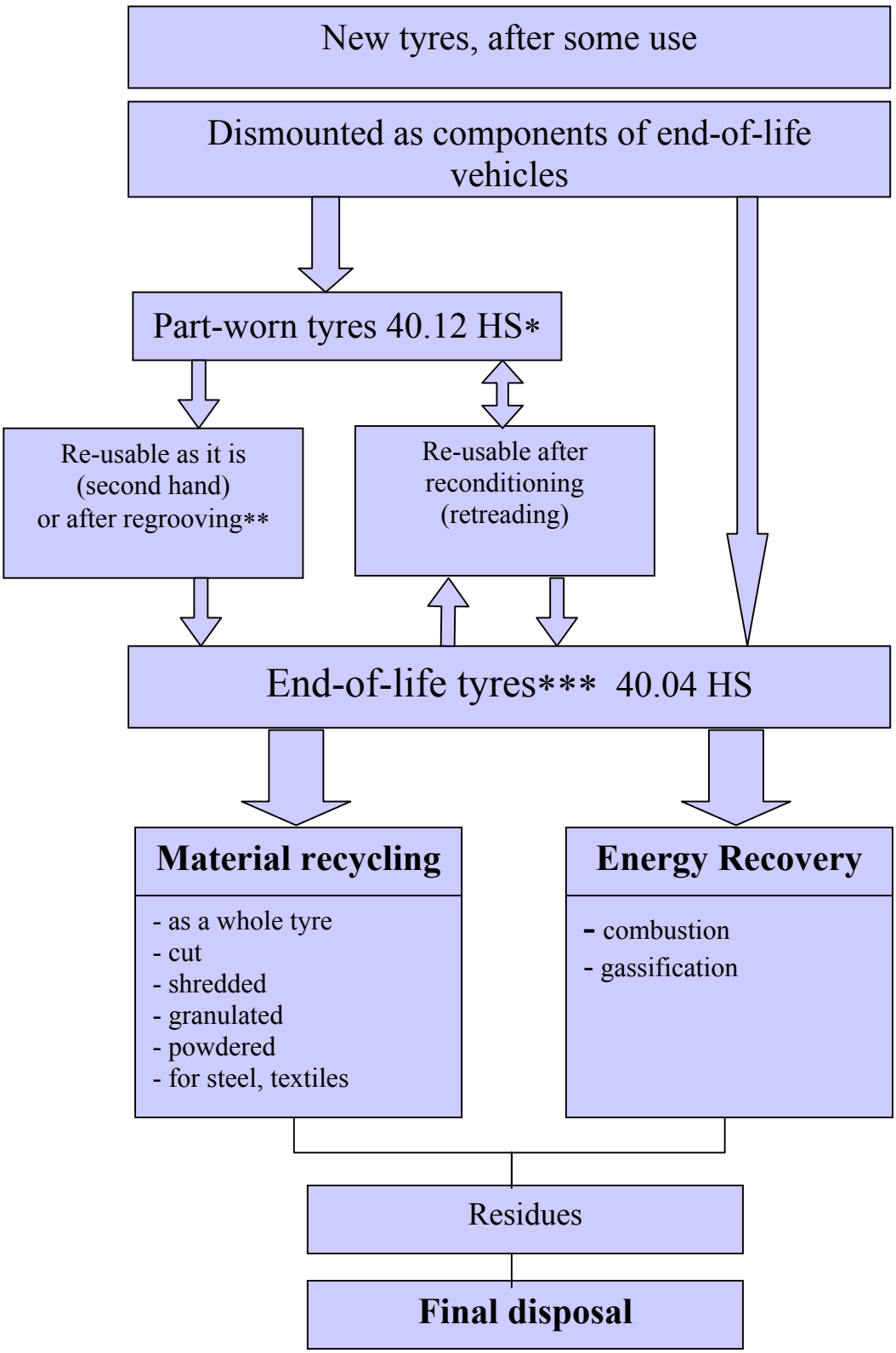
Uncontrolled open-air burning is not an environmentally sound or acceptable management practice. Such practices can release potentially hazardous levels of carbon monoxide and mono – and polyaromatic hydrocarbon in the smoke plume. After open-air burning, organic compounds, like pyrolytic oils, rest in the soil and can cause environmental damages to the flora and fauna.

Risk due to controlled stockpilling or landfilling

Under certain specifically defined climatic conditions waste tyre dumps or stockpiles can become the breeding grounds for insects, such as mosquitoes, which are capable of transmitting diseases to humans. This is of particular concern in tropical or sub-tropical regions.

3.The identification of the different categories of used tyres

The various stages in the life of a tyre can be summarised in the following diagram:



* HS stands for harmonized customs code system

** Regrooving for truck tyres only

*** Scrap tyre is an equivalent term used in the USA

Used tyres are transported all over the world. Many used tyres can be re-used for their originally intended purpose. Most countries accept the import of used tyres for direct re-use or for retrading, but do not accept the import of used tyres that cannot be re-used or retraded. Therefore, in order to allow the importation of used tyres, the identification of the different categories of used tyres is important. In this section a distinction is made between various used tyres in function of their destination.

The following situations may occur:

(a) The used tyre that is legally re-used for its originally intended purpose. Such a tyre is called part worn. This tyre may have further use as a tyre because a minimum of residual tread depth remains and, subject to examining of the structural soundness, the tyre does not show wear affecting its safe and proper functioning. This tyre must meet the road specifications of the country in which it will be used. Some countries have regulations, which set a minimum remaining tread depth of 1,6 mm for a part-worn passenger car tyre to be sold for further use. An example of a regulation in the United Kingdom of Great Britain and Northern Ireland is given in Annex 4, which has been adapted to national standards and requirements.

(b) The used tyre that cannot be re-used for its originally intended purpose but that is suitable for retrading. The used tyre may or may not have residual tread depth sufficient for further use as a part-worn tyre, but subject to an examination of the structural soundness of the casing, it can be reprocessed whereby new tread is vulcanised to the casing and the used tyre becomes a retraded tyre. United Nations Economic Commission for Europe Uniform provision approval for the production of retraded pneumatic tyres R 805 and R 806 give criteria for the selection of the retraded tyres.

(c) The used tyre that cannot be re-used for its originally intended purpose, and that is not suitable for retreading, is worn out. Such a tyre is called end-of-life. This describes used tyres which fail the technical examination to determine their suitability for re-use or retrading. Such tyres may have been rejected due to age or tyre carcass damage or deterioration beyond certain limits. While such tyres are not suitable for re-use or retrading, they may have further use as a raw material for other processes or be destined for final disposal.

This distinction is in accordance with the Harmonised Customs Code System (HS) that uses separate entries for used tyres. The first two situations would be covered by entry 4012: Retraded or used tyres of rubber. The Explanatory Note of this entry reads: This heading includes retraded pneumatic tyres of rubber and used pneumatic tyres of rubber, suitable either for further use or for retrading. The second situation would be covered by 4004: rubber waste, parings, powders and granulates obtained thereof. The Explanatory Note of this entry reads: This category includes worn-out rubber tyres not suitable for retrading and scrap obtained from such worn-out rubber tyres rubber goods rendered unusable because of cutting up, wear or other reasons.

4. The management of part-worn tyres

In this section the following treatments are considered to prolong the life of a used tyre:

- Regrooving (truck tyres only)
- Retreading (all tyres)

Regrooving

Regrooving can prolong the life of truck tyres. This practice is not admissable for car tyres because the tread depth in the grooves is not adequate.

Retreading

Retreading maximises tyre utilisation and is considered desirable to the extent that it is a practical option. Via retreading, 80% of the original material value is available for reuse. Selected undamaged car and truck tyre casings are sold to rethreading companies. Whatever is left of the original tread is removed by a buffing process and a fresh, patterned tread is vulcanised to the casing. Retreaded tyre production, in OECD countries, is a well-developed and mature industry.

5. The management of end-of-life tyres

When tyres have reached the end of their useful life and re-use as a part-worn tyre is not possible, the tyres enter a waste management system. The recovery and eventual final disposal should take place in an environmentally sound manner. This means that an appropriate collection system should take care of these tyres. In most cases the separately collected end-of-life tyres are still valuable for other applications and are not necessarily destined for landfilling.

According to the assessment made by each country, the lawful execution of these applications may vary. In this Technical Guideline many possible environmentally sound applications for used tyres are given. This does not in itself imply an approval of the environmental soundness of the application, but merely a benchmark of existing applications that may be approved by national legislation. Whether or not to allow the use of these techniques is for the national authorities to decide.

The management of end-of-life tyres depends very much on local economic and industrial conditions:

- Product recycling
- Material recycling
- Energy recovery
- Landfill

The direct disposal of end-of-life tyres in landfills is to be used only where economically viable alternatives for the materials or energy recovery are not available. In some countries the landfilling of end-of-life tyres is prohibited.

Product recycling

End-of-life tyres in whole, cut or stamped form can be used in many environmentally sound applications to take advantage of their shape, sound and impact absorption properties and/or material characteristics. Annex 5 contains a list of some of the uses of end-of-life tyres in

whole, cut or stamped form. Machinery used to produce cut or stamped pieces of rubber is readily available.

As a particular example, whole tyres are used frequently in coastal protection projects. Whole tyres have been used with considerable success to create artificial reefs and erosion barriers, *s*ea-walls and off-coast breakwaters. Artificial reefs have proven to be inexpensive means of protecting sea life by providing shelter while improving water circulation. Cement filled tyres are often used to provide base.

In both sea and fresh water harbours, tyres are used as boat fenders, absorbing the shock from moving boats to protect the hulls and sea walls, particularly during storms. Used tyres are an inexpensive remedy because there is little heavy construction involved and the materials are relatively reasonable in cost. Tyres generally do not require expensive pilings and preparatory work before installation. It is important to note that cut, chunked and shredded tyres also used as a principal material on building riverbank protections, reversing and preventing erosion particularly in swift water areas.

North America Journal of Fisheries Management, 14:616-625, 1994 Evaluation of Tyres Reefs for Enhancing Aquatic Communities in Concrete-lined Canal, by G. Mueller, C.R. Listen.

Material Recycling

Shred

End-of-life tyres can be shredded to facilitate transport, as a first step towards granulation, or for use in several applications. The tyres are fed into a shredder and in most circumstances, the steel and textile are not removed, but may include the additional process of material separation. The shredder can be mobile or fixed. Mobile shredders are used to facilitate the movement of end-of-life tyres from place to place for another treatment. Regions which permit land filling of end-of-life tyres often require that they are shredded in order to minimise the space requirements and to reduce the potential of the tyres rising to the surface once the landfill has been capped. Tyre shred can be used as a secondary fuel for incineration or as a first step in the granulation process, or may be utilised as daily cover for landfills.

Granulate

End-of-life tyres and tyre buffing can be used to produce rubber crumb or granulate. There are two principal methods of granulating end-of-life tyres.

Grinding at ambient temperature: end-of-life tyres are shredded and then fed into a grinding mill. After grinding, the material is separated into rubber granulate, steel and textile; the granulate can be sieved into different particle sizes. Peels and buffings obtained from rethreaded tyre manufacturing processes are currently ground and the rubber obtained can be directly recycled into compounds used to produce new and rethreaded tyres.

Grinding at very low temperature (cryogenic method). In this process the end-of-life tyre and chopped rubber has to be cooled to below the freezing point, after which it is ground in a hammer mill. This process enables rapid separation of fibres, metal and rubber. ASTM Standard

D5603 gives a classification for Recycled Vulcanisate particulate rubber.

Total costs for unit management also takes into account the labour and power costs on the basis of local prices. Ratio between income and cost is calculated considering the current price for selling the ground rubber or other outputs from the unit. Large cost differences, especially for labour, can be expected due to region variations.

Rubber granulate can be used in many product applications. Annex 5 shows the capability of a typical grinding unit and contains a list of products which can be manufactured from rubber granulates.

Reclaim

Rubber reclaim is produced by the chemical processing of a mixture of size reduced end-of-life tyres, oil, water and chemicals. The resulting compound is submitted to a further thermo-mechanical process where additives can be incorporated depending on the final product requirements. The material is extruded into slabs, cut and wrapped for shipment. Reclaim rubber blends in with virgin compounds can be used in a wide range of moulded articles.

Pyrolysis

Pyrolysis is the chemical conversion or breakdown of organic compounds by heating in the total or partial absence of oxygen. Carbon black, oil (which must be refined) and scrap steel can be obtained from the pyrolysis of end-of-life tyres. The 'pyro-oil' may be used as fuel or mixed in equal proportion with diesel oil. After refining, the 'pyro-carbon' may be used as a semi-reinforcing filler or as an active carbon. Even if recent technological advances have improved product quality, it is still unclear whether there is a market demand for this product.

Energy recovery

There are several controlled energy recovery methods which are environmentally sound.

End-of-life tyres represent an alternative supplementary non-fossil fuel. End-of-life tyres provide the same heat energy commonly achieved by coal. Whole or shredded end-of-life tyres can be used as a principal or secondary fuel source in the production of steam, electricity, cement, lime, paper, steel and in the incineration of garbage. The addition of end-of-life tyres is environmentally safe and does not release additional emissions in the atmosphere of sulphur oxides or nitrogen oxides when appropriate emission control devices are properly installed and maintained.

Cement kilns

Whole or shredded end-of-life tyres can be used as an alternative, supplementary fuel in cement kilns, depending on size and method. The high operating temperature in the kiln allows for complete combustion of the tyres and oxidation of the steel beads without adversely affecting kiln operation. Therefore, the steel reinforcement does not need to be removed. The addition of end-of-life tyres is environmentally safe and does not produce additional emissions into the atmosphere of sulphur oxides and nitrogen oxides when appropriate emission control devices are

properly installed and maintained. The Canadian Council of Ministers publishes two guidelines for the energy recovery of tyres in cement kilns (which are available upon request) :

National Guidelines for the Use of Hazardous and Non-hazardous Wastes as Supplementary Fuels in Cement Kilns (containing a brief section on potential for use of scrap tyres in cement kilns) and Harmonized Economic Instruments for Used Tyres.

Lime kilns

End-of-life tyres can be used as fuel, alone or together with other materials (i.e., wood, paper) in kilns for the calcinations of $CaCO_3$. Kiln operations and facilities are simpler than cement kilns but the type of combustible greatly influences the quality of the $CaCO_3$ obtained.

Steam production

Incineration with steam recovery is used mainly in the tyre and retreading industries. The steam that is produced can be used for different industrial applications, for example in the rubber industry, steam is used in the vulcanisation process.

Electric power production

Some electric power plants are designed to burn end-of-life tyres in order to minimise fuel costs. During combustion, tyres are supported on a reciprocating stoker grate. This configuration provides for air to flow above and below the tyres which aids the combustion, keeping the grate cool. The grate also allows slag and ash to filter down to the conveyor system which takes them to hoppers for sale off-site. A metal detection system rejects burned tyres with beads. Each incinerator has its own boiler. The boiler produces steam to drive the steam turbine generator.

Waste incineration

The incineration of end-of-life tyres in small quantities mixed with household refuse can be practised where the design characteristics allowed. The operation of the furnace does not seem to be adversely affected provided the tyres do not account for more than 10% of the total weight. Essentially, tyres serve to fill gaps in heat production when the net calorific value of the household refuse drops. When the calorific value is higher than average, tyres should not be added since the furnace temperature would rise above optimum.

Landfilling and stockpiling

Landfilling and stockpiling are the least desired options. Landfilling should be adopted only when no viable alternatives exist. In order to assess the necessary measures when applying these options, the last part of this section deals with minimising the impact on the environment of storage or landfill of end-of-life tyres.

Landfilling

Disposal of end-of-life tyres by landfilling is suggested only when other solutions for material recycling or energy recovery cannot be applied. In some countries the landfilling of end-of-life tyres is prohibited. Landfills must be carefully controlled (see Annex 6).

Tyres can be efficiently used to prevent damage to the landfill cover, to avoid side-slope erosion, to protect drainage piping and to allow the regular flow of landfill percolating fluid and gases. Advantages of disposing of end-of-life tyres in landfills are low investment and running costs, the ease of management, and the possibility to use the end-of-life tyres for better landfill management.

Stockpiling

Stockpiling facilities require investments in transport, handling and fire prevention. Stockpiling with proper control can be used only for temporary storage before an end-of-life tyres is forwarded to a recovery operation.

6. Minimising the risk to the environment when storing or landfilling end-of-life tyres

Storage

Rules for the proper storage of end-of-life tyres are obligatory in a number of countries, and those drawn up by the International Association of Fire Chiefs and the Scrap Tyre Management Council (USA) are reproduced in Annex 7.

Precautions must be taken against the deliberate or accidental igniting of tyre stock piles. The major risk is that a fire could gather pace without it being possible to prevent it from spreading to all of the tyres being stored. In such an eventuality, several different types of pollution of the air, water and soil can occur. Their scale will depend upon the quantity of the tyres being stored.

Landfill

As in the case of storage, the landfill site must be sealed off and managed to prevent malicious actions. To avoid any risk of fire, the following rules should be followed:

- prevent any dumping of waste which represents a potential source of fire;
- ban smoking or any activity which represents a fire risk.

The shape of the tyres and their elasticity necessitate certain precautions when they are being buried if instability or the creation of areas likely to help a fire spread, or serve as a haven for rodents or other pests (mosquitoes), are to be avoided.

Annex 8 provides a discussion of fire, air, soil and water pollution as it is related to tyre storage which can be used as a model for developing guidelines which comply with applicable local conditions, practices and laws.

7. Further information

In several OECD countries voluntary consortia have been established by tyre manufacturers, importing companies, recycling organisations, among others. The objectives of the consortia are:

- To participate in research into new methods of recycling or into better use of end-of-life tyres;
- To assist in the creation of schemes for the nation-wide recovery of end-of-life tyres;
- To favour agreements between the distribution sector and the individuals or bodies involved in collection or disposal;
- To establish agreements on collaboration, integration or synergy with bodies having similar objectives.

Consultancy analysis, identification of appropriate methods and operative plans can be provided to local government by existing consortia of tyre manufactures and recycling organisations. The following is not an exhaustive list:

APURE (Association Pneus Usages Environment) SNCP
60, rue Auber
94408 Vitry-sur-Seine, France
Phone: 331.49.60.57.57 Fax: 331.45.21.03.50

Association for Tyres and Environment
Postbus 418
2260 AK Leidschendam, The Netherlands
Phone: 31.70.317.72.43 Fax: 31.70.317.74.12

BIR (Bureau of International Recycling)
24, avenue Franklin Roosevelt
1050 Brussels, Belgium
Phone: 32.2.627.57.70 Fax: 32.2.627.57.73

BLIC (Bureau de Liaison des Industries du Caoutchouc de l'UE
Avenue des Arts, 2 Bte. 12
1210 Bruxelles, Belgium
Phone: 32.2.218.49.40 Fax: 32.2.218.61.62 E-mail: blic@skynet.be

Eco. Pne.US (Consorzio per il Riutilizzo e lo Smaltimento dei Pneumatici Usati)
ASSOGOMMA
Via San Vittore, 36
20123 Milano, Italia
Phone: 39.2.481.72.04 Fax: 39.2.435.432

ETRA (European Tyre Recycling Association)
7, rue Leroux
75116 Paris, France
Phone: 33.1.45.00.37.77 Fax:33.1.45.00.83.47

STMC (Scrap Tyre Management Council)
RMA-USA (Rubber Manufacturers= Association)
1400 K Street, NW
Washington, D.C. 20005, USA
Phone: 1.202.682.4800 Fax: 1. 202.4854

Technology Centre for the Tyre and Wheel Industry
POB 33
2300 AA Leiden, The Netherlands
Phone: 31.71.568.69.70 Fax: 31.71.568.69.71

ANNEX 1

GLOSSARY FOR THE IDENTIFICATION AND MANAGEMENT OF USED TYRES

Ambient grinding: the mechanical grinding of rubber products at or above ordinary room temperature, in most instances separating out textiles and other debris and magnetically removing metals.

Bead: the part of the tyre that is made of high tensile steel wires wrapped in woven textile which are held by the plies, anchoring the part of the tyre which is shaped to fit the rim.

Belt: in a radial tyre, it is a layer or layers of material beneath the tread, laid substantially in the direction of the centre line of the tread to restrict the casing in a circumferential direction.

Bias belted tyre: a bias ply casing with relatively rigid reinforcing belts generally placed at approximately 250 angles from shoulder to shoulder.

Buffings: vulcanised rubber generally obtained from a worn/used tyre in the process of removing the old tread in preparation for retreading. (ASTM)

Carbon black: a product used in compounding processes in the manufacture of new tyres, and in other rubber products, pigments, printers ink, etc. which is produced by pyrolysing oils. Experiments have been made by pyrolysing end-of-life tyres.

Casing: the structural part of a tyre which includes the tread and outermost rubber of the sidewalls to which additional tread may be vulcanised for the purpose of retreading.

Civil engineering applications: the use of whole, shredded, or granulated tyres in construction projects including the manufacture of noise absorbers for tram or rail lines, underlayments for roads, drainage areas, porous asphalt mix, among others.

Cord: the twisted fibre or filament of polyester, nylon, rayon or steel which gives the tyre casing and belts stability and strength.

Cryogenics: a technology for reducing materials in size at very low temperatures using liquid nitrogen, or commercial refrigeration to embrittle the rubber which is then processed in a hammermill or granulator to a desired size.

Devulcanisation: the treatment of rubber granulate with heat and/or softening agents to return its elastic qualities to enable the rubber to be reused.

End-of-life: the point at which a tyre is consigned to waste management for recycling or recovery.

Energy recovery: incineration to extract the fuel or heat value from whole or processed tyres.

Environmental impact: any change to the environment, whether adverse or beneficial, wholly or partially resulting from the activities, products or services of an organisation.

Environmental management: that part of the overall management system which includes the organisational structure, planning activities, responsibilities, practices, procedures, processes and resources to develop, implement, achieve, review and maintain an environmental policy.

Granulating: the mechanical shearing of rubber to reduce it in size into finely dispersed particles of under approximately 10mm, from which metals and textiles and extraneous debris are removed.

Landfill: a disposal site for the deposit of waste onto or into land, including internal waste disposal (i.e. landfill where a producer of waste carries out its own waste disposal at the place of production) and excluding facilities where waste is unloaded in order to permit its preparation for further transport for recovery, treatment or disposal elsewhere, and temporary (i.e. less than one year) deposit of waste prior to recovery, treatment or disposal.

Part-worn tyre: a used tyre which retains a minimum of 1.6mm of visible tread depth in its most worn groove and which when subjected to inspection of the structural soundness of the casing and/or proper repair can be safely returned to its originally intended purpose.

Pyrolysis: the thermal decomposition of rubber in the absence of oxygen which chemically breaks the tyre into its original components of oil, gas, and char.

Retradable casing: the structural part of a used tyre which may/may not have residual tread depth sufficient for further road use but which, when subjected to inspection of the structural soundness of the casing, can be reprocessed by vulcanising new tread to the body and it can be safely returned to its originally intended purpose.

Retraded tyre: a post-consumer tyre casing which has been subjected to inspection for its structural soundness and which has been reprocessed whereby new tread has been vulcanised to the body and it can be safely returned to its originally intended purpose as a retreaded tyre.

Retrading: the generic term for reconditioning a used tyre by replacing the worn tread with newly vulcanised material.

Re-use: any way in which a tyre is used for the same purpose for which it was originally intended.

Rough shred: shredded rubber that is larger than 50mmx50mmx50mm but smaller than 762mmx 50mm x 100mm.

Rubber granulate: rubber comprised of finely dispersed particles from which metals and textiles have been removed and which are characterised as light, dry, and having very high surface areas.

Rubber reclaim: the result of treating ground vulcanized tyres, tubes and miscellaneous rubber wastes with heat and chemical agents, followed by intense mechanical working to produce a "devulcanisation" of the rubber to return it to its original state, in order to compound, process, and revulcanise it.

Shredding: any mechanical process by which tyres are fragmented, ripped or torn into irregular pieces more than 2.5mm.

Steel belt: rubber coated steel cords which run diagonally under the tread of steel radial tyres and extend across the tyre approximately the width of the tread which provides improved handling, tread wear and penetration resistance (ASTM).

Tread: the portion of the tyre which is designed to come in contact with the ground, protects the casing against mechanical damage and contributes to ground adhesion.

Tyre-derived fuel (TDF): a fuel derived from whole or processed tyres of all kinds.

Tyre recycling: any process by which post-consumer tyres or materials derived from post-consumer tyres are converted into products or raw materials.

Vulcanisation: a process which involves reaction with sulphur and other chemicals at temperatures generally around 1500C to produce crosslinks between the rubber molecules which cures it to make the rubber stronger and more durable.

Whole tyre applications: taking used tyres which would otherwise have been sent to final disposal, and using them without physical and/or chemical transformation as a substitute for virgin materials, examples include the creation of artificial reefs, irrigation systems, barriers, among others.

ANNEX 2 A

ECOTOXICOLOGY

Material tested: finest tyre tread dust obtained from several European tyre companies

Extraction method: test procedure for the leaching of solid and plastic wastes NFX 31 210 (according to specified conditions a concentration of 100g of material in one litre of water is sha*ke*n for 24h and then filtered)

Ecotoxicological test results: results are expressed as averages.

Test feature	Specie	Organism	EC50 (exposure time)	LC50 (exposure time)	Test method
Growth	Algae	S.Capricornutum	> 13 000 mg/l (72h)		NF EN 28692/ ISO 8692
Mobility	Small shellfish	Daphnia magnia	> 69 000 mg/l (24h)		NF T 90 301/ ISO 6341
Mortality	Fish	Brachydano Rerio		> 58 000 mg/l (24h)	NF T 90 303/ ISO 7346-1

EC50 is the corresponding raw material concentration in water at which the growth (algae) or the mobility (small shellfish) is reduced by 50% after exposure time.

LC50 is the corresponding raw material concentration in water at which 50% of the population die after exposure time.

CONCLUSION:

Comparing with the ecotoxicological scale used in the European Union for the labelling of new chemical substances through the effects on aquatic organisms eg:

Very toxic to aquatic organisms if EC50 or LC50 <1mg/1
Toxic to aquatic organisms: 1mg/1 <EC50 or LC50 <10 mg/1
Harmful to aquatic organisms: 10 mg/1 <EC50 or LC50 < 100 mg/1

It can be seen that the first ecotoxicological response (on algae) shows an order of magnitude of 130 times greater than the maximum concentrations at which it is acknowledged one substance is considered harmful to aquatic organisms.

ANNEX 2 B

TYRES WITHIN REGULATORY LEVELS FOR LEACHING CHARACTERISTICS

Tyres and tyre products are within the proposed regulatory levels of the Environmental Protection Agency's (EPA) Toxicity Characterization Leaching Procedure (TCLP), according to test reports released by the Rubber Manufacturers Association (RMA). The tests, performed by Radian Corporation for RMA, included comparative results of EP toxicity procedures.
Most compounds detected were found at trace levels (near method detection limits) from ten to one hundred times less than proposed TCL P regulatory limits using both methods.

Radian also analysed the effects of a modification to the TCLP recently proposed by EPA which would eliminate grinding prior to leaching. In effect making TCLP tests of rubber products more representative of disposal practices. The results for ground and unground samples were comparable.

Why two tests?

The Toxic Characteristic Leaching Procedure (TCLP) was proposed as an amendment to EPA's hazardous waste identification regulations (40CFR Parts 261, 271, and 302) on June 13, 1986 in the Federal Register/Vol. 51, No. 114 of EPA Intends to replace the current waste characterization method (EP Toxicity) with the TCLP.

Anticipating the change in waste characterization methodologies, RMA authorized to test for what levels (if any) TCLP pollutants may be leached from representative cured and uncured products manufactured by RMA members.

The purpose of TCLP, as well as the EP Toxicity protocol it was meant to replace, is to determine whether a waste has the potential to pose a significant hazard to human health or to the environment due to its propensity to leach toxic compounds into the ground water.

Data important to market development

In the last half of the eighties, as markets for tyre shreds failed to keep pace with the growing number of processors, the need for tyre shred storage capacity, both above and below ground, became apparent. However, storage facilities, processors and potential; end users have been hampered by incomplete, faulty and/or no available data on which rubber products (if any) leach hazardous constituents when placed on or in the ground.

RMA has taken a much needed step in developing, assuring the environmental quality of tyres and tyre products.

ANNEX 3

WATER QUALITY EFFECTS OF TYRE CHIP FILLS PLACED ABOVE THE GROUNDWATER TABLE

ABSTRACT: Two field trials were constructed to investigate the effect on water quality of tyre chip fills placed above the groundwater table. Control wells were used to distinguish the substances naturally present in groundwater from those that leached from tyre chips. There was no evidence that tyre chips increased the level of substances that have a primary drinking water standard. In addition, there was no evidence that tyre chips increased the levels of aluminium, zinc, chloride or sulfate which have secondary (aesthetic) drinking water standards. Under some conditions iron levels may exceed their secondary standard. It is likely that manganese levels will exceed their secondary standard, however, manganese is naturally present in groundwater in many areas. Two sets of samples were tested for organics. Results were below the method detection limit for all compounds.

KEYWORDS: tyres, tyre chips, tyre shreds, waste tyres, water quality, metals, organics, road construction

REFERENCE: Humphrey, D.N., Katz, L.E., and Blumenthal, M., "Water Quality Effects of Tyre Chip Fills Placed Above the Groundwater Table" Testing Soil Mixed with Waste or Recycled Materials. ASTM STP 1275, Wasemiller, Mark A, Hoddinott, Keith B. Eds., American Society for Testing and Materials, 1997.

ANNEX 4

S T A T U T O R Y I N S T R U M E N T S

1994 No. 3117

CONSUMER PROTECTION

The Motor Vehicle Tyres (Safety) Regulations 1994

Made	7th December 1994
Laid before Parliament	8th December 1994
Coming into force	
Regulation 5	1st June 1997
Regulations 7 and 10	1st June 1995
Remainder	1st January 1995

Whereas the Secretary of State for Transport has, in accordance with section 11(5) of the Consumer Protection Act 1987[(a)], consulted such organisations as appear to him to be representative of interests substantially affected by the following Regulations, the Health and Safety Commission in relation to the application of the following Regulations to Great Britain, and such other persons as he considers appropriate:

Now, the Secretary of State for Transport,-

(a) in exercise of the powers conferred by section 11 of the Consumer Protection Act 1987; and

(b) being a Minister designated[(b)] for the purposes of subsection (2) of section 2 of the European Communities Act 1972[(c)] in relation to the regulation of the construction and equipment of vehicles and of components of vehicles, in exercise of the powers conferred by that subsection,

and in exercise of all other powers enabling him in that behalf, hereby makes the following Regulations:-

PART I

INTRODUCTION

Preliminaries

l. (1)These Regulations may be cited as the Motor Vehicle Tyres (Safety) Regulations 1994.
(2)These Regulations, other than regulations 5, 7 and 10, shall come into force on 1st January 1995.
(3) Regulation 5 of these Regulations shall come into force on 1st June 1997.
(4) Regulations 7 and 10 of these Regulations shall come into force on first June 1995.

(a) 1987 c43
(b) S.I. 1972/1811
(c) 1972 c.68 A relevant amendment was made to section 1 by section 1 of the European Economic Area Act 1993 (c.51).

(5) For the purposes of these Regulations the expressions listed in the left- hand column of the Table below shall have the meanings given by the provisions of the Construction and Use Regulations listed in the right-hand column in relation to those expressions.

Expression	*Provision*
"agricultural motor vehicle"	regulations 3
"agricultural trailer"	regulation 3
"agricultural trailed appliance"	regulation 3
"bias-belted tyre"	regulation 26
"breadth of tread"	regulation 27
"diagonal-ply tyre"	regulation 26
"dual-purpose vehicle"	regulation 3
"light trailer"	regulation 3
"original tread pattern"	regulation 27
"passenger vehicle"	regulation 3

(6) A reference in these Regulations to the supply of a tyre includes offering to supply, agreeing to supply, exposing for supply or possessing for supply and cognate expressions shall be construed accordingly.

(7) A reference to a tyre-size designation is a reference to a designation described in paragraph 2.18 of ECE Regulation 30 or 30.01, paragraph 2.17 of ECE Regulation 30.02, paragraph 2.17 of ECE Regulation 54 or paragraph 2.17 of Annex II to EC Directive 92/23.

(8) A reference to an ECE Regulation shall be construed in accordance with schedule 1 to these Regulations.

(9) Unless the context otherwise requires, any reference in the following provisions of these Regulations to-

a) a numbered regulation is a reference to the regulations bearing that number in these Regulations; and

b) a numbered paragraph is a reference to the paragraph bearing that number in the regulation in which the reference appears.

Application to Northern Ireland

3. Schedule 2 to these Regulations (modifications in relation to Northern Ireland) shall have effect.

PART II

REQUIREMENTS RELATING TO THE SUPPLY OF TYRES

Supply of new passenger car and light trailer tyres

4. Subject to Part III of these Regulations, no person shall supply any tyre (not being a retreaded or part-worn tyre) designed so as to be capable of being fitted to a wheel of a passenger car or light trailer unless the tyre is marked with an approval mark in accordance with the

requirements of ECE Regulation 0,30.01, 30.02 or 54 or of EC Directive 92/23.

Supply of new motor cycle tyres

5. Subject to Part III of these Regulations, no person shall supply any tyre (not being a retreaded or part-worn tyre) designed so as to be capable of being fitted to a wheel of a motor cycle unless the tyre is marked with an approval mark in accordance with the requirements of ECE Regulation 30,30.01, 30.02, 54 or 75 or of EC Directive 92/23.

Supply of retreaded tyres

6. (1) Subject to Part III of these Regulations, no person shall supply any retreaded tyre (not being a part-worn tyre) designed so as to be capable of being fitted to a wheel of a passenger car, commercial vehicle or trailer unless the following requirements are met in respect of the tyre.

(2) The tyre must not bear any mark indicating that it complies with the requirements of ECE Regulation 30, 30.01, 30.02 or 54 or of EC Directive 92123.

(3) The tyre must be marked in accordance with paragraph 6 of BS AU 144c.

(4) If the tyre has been repaired during the course of retreading, it must have been properly repaired.

Supply of part-worn tyres

7. (1) Subject to Part III of these Regulations, no person shall supply-

(a) any part-worn tyre (not being a retreaded tyre) designed so as to be capable of being fitted to a wheel of a motor vehicle or trailer; or

(b) any part-worn retreaded tyre designed so as to be capable of being fitted to a wheel of a passenger car, commercial vehicle or trailer, unless the following requirements are met.

(2) The tyre must not have-

(a) any cut in excess of 25 millimetres or 10 per cent of the section width of the tyre, whichever is the greater, measured in any direction on the outside of the tyre and deep enough to reach the ply or cord;

(b) any internal or external lump, bulge or tear caused by the separation or partial failure of its structure; or

(c) any of the ply or cord exposed internally or externally.

(3) When inflated to the highest pressure at which it is designed to operate, the tyre must not exhibit any of the external defects described in paragraph (2).

(4) The base of any groove which showed in the original tread pattern of the tyre must be clearly visible.

(5) The grooves of the original tread pattern of the tyre must be of a depth of at least 2 millimetres across the full breadth of tread and round the entire outer circumference of the tyre.

(6) If the tyre has not been retreaded and is designed so as to be capable of being fitted to a wheel of a passenger car, commercial vehicle or trailer, it must bear-

a) an approval mark, being a mark that was moulded on to or into the tyre at the time that it was manufactured and that is in accordance with the requirements of ECE Regulations 30, 30.01, 30.02: or 54 or of EC Directive 92123; and

b) immediately adjacent to every approval mark borne by the tyre, a mark that meets the requirements of paragraph (12).

(7) If the tyre has not been retreaded and is designed so as to be capable of being fitted to a wheel of a passenger car, commercial vehicle or trailer, it must bear a speed category symbol and load-capacity index, being marks that were moulded on to or into the tyre at the time that it was manufactured and that are in accordance with the requirements of ECE Regulation 30, 30.01, 30.02 or 54 or of EC Directive 92/23.

(8) If the tyre has been retreaded,

a) it must bear the mark "BS AU 144b", "BS AU 144c", ÇBS AU 144d" or "BS AU 144e".

b) the mark must have been permanently and legibly applied to the tyre at the time that it was retreaded; and

c) it must bear, immediately adjacent to every mark of a description specified in sub-paragraph (a) and borne by the tyre, a mark that meets the requirements of paragraph (12).

(9) If the tyre has been retreaded and bears the mark "BS AU 144e", it must bear a speed category symbol and load-capacity index, being marks that were permanently and legibly applied to the tyre at the time that it was manufactured or retreaded and that are in accordance with BS AU 144e: 1988.

(10) If the tyre has been repaired it must have been properly repaired

(11) Without prejudice to paragraph (10), if the tyre has been repaired, it must meet the requirements of paragraph 7 of BS AU 1 159c: l990 (which include marking requirements) and the requirements of paragraphs 4, 5 and 6 of that instrument must have been met in relation to the repair.

(12) In order for a mark to meet the requirements of this paragraph, it must consist of the word "PART-WORN" in uppercase letters at least 4 millimetres high and must have been permanently and legibly applied to the tyre other than by hot branding or otherwise cutting into the tyre.

PART III

EXEMPTIONS

8. (1) For the purposes of this Part of these Regulations, an exempt tyre is a tyre which falls within any of the descriptions set out below-

a) a bias-belted tyre or a diagonal-ply tyre, being a tyre designed for fitting to a wheel of a motor vehicle or trailer manufactured before 1st January 1949;

b) a tyre constructed solely for use off roads and bearing words or letters which indicate that use and which were moulded on to or into the tyre at the time of manufacture;

c) a tyre constructed solely for use on vehicles in competitions and bearing words or letters which indicate that use and which were moulded on to or into the tyre at the time of manufacturer;

d) a tyre bearing one of the following tyre-size designations namely: 185R16, l25R400, 135R400, 145R400, 155R400, 165R400, 175R400 or l85R400, being a mark that was moulded on to or into the tyre at the time of manufacture;

e) a tyre designed primarily for fitting to a wheel of a vehicle manufactured before 1st January 1933

(2) For the purposes of this Part of these Regulations, a tyre is supplied in exempt circumstances if-

a) the tyre is constructed solely for use on a vehicle for the purposes of tests or trials of the tyre, and

b) the supply is other than in the course of a retail trade or business, or if the supply of the tyre is by a person who reasonably believes that the tyre will not be used in the United Kingdom.

Exemptions applicable to the supply of new tyres and retreaded tyres

9. Regulations 4, 5 and 6 do not apply to the supply of an exempt tyre or to the supply of a tyre in exempt circumstances

Exemptions applicable to the supply of part-worn tyres

10. (1) Where a complete vehicle is supplied by any person, regulation 7 does not apply to any tyre on a wheel of the vehicle or on any spare wheel supplied with the vehicle.

(2) Regulation 7(6) to (9) does not apply to the supply of an exempt tyre or to the supply of a tyre in exempt circumstances

(3) Regulation 7(11) does no: apply to-

a) a tyre designed primarily for fitting to a wheel of a vehicle manufactured before 1st January 1933;

b) a tyre of the limited run-flat type, or

c) a tyre designed primarily for fitting to a wheel of an agricultural motor vehicle, agricultural trailer or agricultural trailed appliance.

Transitional exemptions

11. (1) Until 1st January 1997 regulations 4 and 6 shall not apply to the supply of a tyre. constructed so as to be suitable for a vehicle travelling at a speed exceeding 210 km per hour and bearing the appropriate tyre-size designation and (in the vicinity of the tyre-size designation) the letters "VR" or "ZR", both being marks that were moulded on to or into the tyre at the time of manufacture.

(2) Until 1st January 1997 these Regulations shall not apply to the supply of a bias-belted or a diagonal-ply tyre.

(3) Until 1st December 1995 regulation 6(3) shall not apply to the supply of a tyre which is marked in accordance with paragraph 10 of BS AU 144b: 1977, with paragraph 6 of BS AU 144c: 1988 or with paragraph 6 of BS AU 144d: 1988.

PART IV

GENERAL PROVISIONS

Misleading marks

12. (1) No person shall supply a tyre designed so as to be capable of being fitted to a wheel of a motor vehicle or trailer if it bears-

a) an approval mark

b) any mark not falling within sub-paragraph (a) which is of a description specified in any standard (including a British Standard Specification technical specification or code of practice relating (in each case) to retreaded tyres and which indicates compliance with the requirements of that instrument or

c) any mark referred to in regulation 8(1)(d) of these Regulations, and any indication given by that mark taken by itself or that mark as read with any other mark on the tyre is false

2) Where

a) a person supplies a tyre (not being a retreaded tyre) which bears a mark falling within paragraph (1)(a) or supplies a retreaded tyre which bears a mark falling within paragraph (1)(b); and

b) the tyre is not part-worn,
the indications given by the mark shall be deemed for the purposes of this regulation only to include an indication that the tyre complied at the time of manufacture (in the case of a tyre that is not a retreaded tyre), or at the time of retreading (in the case of a retreaded tyre), and (in either case) at the time of supply, with the requirement of the instrument to which the mark relates.

(3) Where

a) a person supplies a tyre (not being a retreaded tyre) which bears a mark falling within paragraph (l)(a) or supplies a retreaded tyre which bears a mark falling within paragraph (1)(b); and

b) the tyre is part-worn and is marked in accordance with regulation 7(6)(b) or (8)(c) as the case may be.
the indications given by the mark referred to in sub-paragraph (a) shall be deemed, for the purposes of this regulation only, to include an indication that the tyre compiled at the time of manufacture (in the case of a tyre that is not a retreaded tyre), or at the time of retreading (in the case of a retreaded tyre), with the requirements of the instrument to which the mark relates, but do" not (in either case) necessarily so comply at the time of supply.

(4) A mark which so nearly resembles a mark falling within paragraph (l)(a), (b) or (c) as to be likely to be taken for such a mark shall be treated for the purposes of this regulation only as if it were a mark of the kind which it so resembles

ANNEX 5

RECYCLING TECHNOLOGIES AND ENERGY RECOVERY

End-of-life tyres can be used for environmentally safe applications in whole, cut or stamped form.

- in civil engineering works: e.g. highway crash barriers, sound absorbing walls, boat fenders on harbour walls; (See : ASTM D 6270-98 B Standard Practice for Use of Scrap Tyres in Civil B Engineering Applications);
- as coastal protection and off-coast break waters;
- as insulation in building foundations and road base material;
- to consolidate steep slopes on roadway sides;
- as cover material in agriculture applications and for landfills;
- as artificial reefs to provide shelter or breeding grounds for sea life;
- as material to be cut up into mats, floor ties, dock fenders, muffler hangers, support pads for back hoes, well chocks, brake pads, light weight and flexible tanks, and after the beads are removed, as clothing accessories such as belts, handbags, shoe soles and buttons;
- as temporary roads for moving heavy construction equipment;
- in irrigation systems as reservoirs or to channel water

Tyre Recycling Technologies and Uses: Granulation

Overview of Granulating Treatments			
Item	**Ambient**	**Reclaim**	**Cryogenic**
Feedstock	tyres production waste	tyres, treads production waste	tyres, shred production waste
Capacity Energy	. 20,000t/y 125kwh/t	. 15,000t/y 120kwh/t	. 2,000t/y 150kwh/t +nitrogen
Product size	<0.5-+25mm	0.425 x .360mm	<0.5 - +5mm
Emisions	dust:. 0.2kg/h SOx= 0 NOx= 0	dust:. 0.2kg/h SOx= 0 NOx= 0	50mg/m^3 AIT SOx= 0 NOx= 0
Manpower per shift	5-6 per team	5 per team	5-6 per team
Operations	3	2	4 (incl. pretreat)
Maintenance, etc.	blades	-	nitrogen
Investment costs*	2	2-4	4-5

* Based on a scale of 1-5, 5 being the most costly in terms if initial investment

1 a simple shredder
2 ambient granulator (single process)
3 ambient granulator with additional separating capacity
4 basic cryogenic or pyrolysis equipment, heat separators/mixers for reclaim
5 multi-process cryogenic or pyrolysis equipment

Percent of Processed Material per Ton		
Product	**% product**	**% loss p/t**
Shred (un-separated)	95%	+5%
Extended shred (metal/fibre removed)	70%	+30%
Granulate (dependent upon mm)	50-60%	+40-50%

Granulating is the basis for many material recuperation projects.

Some of the many products which can be manufactured from different sizes of rubber granulates.

- compounding material in rubber industry for various applications;
- flooring and surface for indoor and outdoor sports;
- solid tyres;
- roofing materials;
- carpet underlay;
- underlay for artificial sports turf;
- thermoplastic and rubber blends;
- road surfaces (modification of bitumen with rubber);
- component in friction material;
- Sami's, road joints, and roadway filter drains;
- porous drainage pipes;
- children's playgrounds, tennis courts, soccer pitches, etc.;
- train and tram line beds and track guards;
- road furniture including crash barriers, speed bumps, among others;
- outdoor sports and camping equipment;
- as a composting material for heavily trafficked areas; etc.
-

Examples of Granulate Sizes Used in Selected Products	
Product	**m m**
Brake linings	0 -0.6 / 0.8
Carpet backings	0.8 /0.8-1.6
Carpet underlay	0.6 -2.0
Moulded products	0.5-5
Playgrounds	1.6 - 2.5
Road paving materials	0 - 0.8
Running tracks	1.6
Shoe soles	0.4 - 1.6
Sports fields	1.6
Train and tram rails	0.4 - 1.6
TDF	<25 - <50

Example of Whole Tyre Equivalents Used in Civil Engineering Projects		
Treatment	**Tyres Used**	**Product**
Porous bitumen additive	2,500 tyres	per kilometer of road
Sound barriers	20,000 tyres	per kilometer 3 metres high
Playground surface (25mil)	1,400 tyres	per playground (av. 500m2)
Play area safety surface	300 tyres	per play area (av. 50m2)
Sports field (15 mil)	6,000 tyres	per 6000 m2 field
Tennis courts	700 tyres	per 680m2 (incl.surround)
Indoor tracks & surfaces	1300 tyres	per 1000 m2 gymnasium
Tram rail beds	2,000 tyres	per kilometer
Metro rail	2,000 tyres	per kilometer
Cement kilns	2.5 tons	per hour
Electricity generation	150-675 tons	per month

** quantity of tyres used depends upon the producer's formula and job specifications BRRC, BSW, CBR, ETRA, SARCO, YES, CBR

Potential Applications

- There are currently 921,502km of regional road networks in the EU, 702,720 in the United States, 104,049 in Canada, 129,040 in Japan which require periodic repairs and resurfacing.

- Approximately 300,000km of new roads will be constructed in the EU and its Eastern European neighbours during the next 5 years with a equal number anticipated in emerging regions such as China, India, Latin America, etc.

- In addition to surfacing products, many of the new roadbeds will require fill, lining material, expansion joints and drainage systems, each of which can be produced from recycled tyres.

- Recent noise reduction regulations in a number of regions and countries require the installation of noise barriers along major highways: 38,596km in the EU, 85,267km in the US, 15,983km in Canada, 4,869km in Japan.

- The concern for noise reduction has also led to the installation of noise barriers adjacent to inhabited areas along passenger track which in the EU is 136,114 km, US 187,691km; Canada 22,444km; Japan 20,251km.

Energy Recovery Technologies: Incineration and Cement Kilns

Energy reclamation treatments use tyres as a supplementary non-fossil fuel for electricity generation, fuelling of cement kilns and pulp mills, etc. It is used extensively in developed as well as developing regions around the world. In Scandinavia, the United States, Japan, among others, energy reclamation is the first means of valorisation of post-consumer tyres and industrial wastes.

Improved methods of emissions control have made incineration a viable source of energy. Nevertheless, many regions are still concerned about the continued uses of coal as a principal co-fuel. However, research has indicated that the concentration of PCAH is 'below the danger limit for humans'.

The net calorific value of a tyre is between 32 and 34 MJ/kg. A ton of tyres is equivalent to a ton of good quality coal or 0,7 ton of fuel oil. Each tyre represents a significant quantity of energy, not only in terms of the heat that is recoverable through direct combustion (15,000 Btu/lb), but also in terms of the amount of energy consumed in processing petroleum and natural gas into the materials and manufacturing of tyres:

- carbon black 40,000 Btu/lb
- processing oil 18,000 Btu/lb
- elastomers 24,000 Btu/lb

The retreading industry incinerates tyres, buffing, etc., as a secondary fuel to generate electricity and steam which it uses in its operations.

Incineration in Cement Kilns with Energy Recuperation	
Feedstock	Whole, cut or shredded light utility, heavy goods tyres
Annual capacity	+20,000t/y
Energy use	30-50kwh/t
Manpower	Automated: 1 person per shift
Production	Input: 12t Output: 32MJ/kg 800kcal/kg clinker or 120kcal/kg cement
Number of operations	2-3
Processes	Sorting of whole tyres and/or pre-treating into shred Direct, continuous feed by automated conveyors Incineration Continuous cleaning of flues and screens Optional: Heat recuperation and circulating system Optional: Electricity generation and utilisation
Product characteristic	Improved cement hardness from tyre materials, particularly metals and chemicals. Sulphur dioxide and nitrogen oxides from the tyres are neutralised by the lime used in the cement and improve its quality.
Uses	All cement applications for construction, etc. Heat and energy for plant operations
Emissions	SO_x 10kg/h No_x 6kg/h Ash: 250kg/h other: 20kg/h inert fillers
Comments	Tyres improve the heating qualities In many regions cement kilns must comply with new emissions regulations. The number of continuous plants has diminished during the past 3 years due to changing emissions standards. Cement kilns are in both developed and developing countries. Principal concerns are the consistent flow of raw material needed to operate the plant at optimum levels and High maintenance costs for cleaning, replacement of filters, and flue gas scrubbing.

Ambient Grinding	
Feedstock	Whole or cut car, light utility, heavy goods tyres and/or Production waste and stripped treads and/or Inner tubes
Annual capacity	. 20,000t/y
Energy use	125kwh/t
Manpower	Intensive: +5-6 man team per shift
Production	Input: 3.5t Output: crumb - 2.5 t steel - 1.0t
Equipment	Conveyors, mechanical shearing/grinding equipment with magnetic and air separators
Number of operations	3
Processes	Sort, Cut (optional), Feed First pass through shredder - reduction to <30mm Magnetic separation of metals Air separation of textiles Optional: Second pass for further reduction to desired size Packaging (bagging), disposal of metals (possible sale) Disposal of fluff Separation efficiency: 100% for rubber, metals, textiles Purity of rubber granulate: < 0.05% of residual materials
Product characteristics	Irregularly shaped particles due to shearing
Product sizes	Rough 7.mm to 25.mm 2.mm to 7.mm 0.5mm to 2.mm Fine 0.mm to 0.5mm
Uses	7 -15mm: preparation for transporting, fuel for incineration material for sound barriers 2 - 7mm: drainage, light-weight road bed fill, playgrounds, tram and rail beds 0.5-2.mm: asphalt, manufactured products, carpet under lay, moulded products, train and tram rails, running tracks, shoe soles, brake linings, carpet backing 0-0.5mm: tyres, innerliners, belting, cables, friction materials, compound ingredient for tyres, road paving materials, Plus many consumer and industrial products
Emissions	SO_x 0 No_x 0 Dust: 0.2kg/h other:
Comments	High maintenance due to blade sharpening and replacement Odourless High yield of high quality product

Cryogenic Grinding: Companion Phase	
Feedstock	Granulated car, light utility, heavy goods tyres and/or Production waste and stripped treads and/or inner tubes
Annual capacity	2,000t/y
Energy use	150kwh/t + costs of liquidifying the nitrogen liquid nitrogen 0.5kg/kg crumb
Manpower	Limited: 2 man team per shift
Equipment	Conveyors for feed, size reduction equipment, Mill Heat exchanger, Chamber to cool chips to -120°C, Sifting equipment
Production	Input: 1t Output: crumb - 1t from separated granulate
Number of operations	2 for pre-treated material
Processes	Conveyors for feed Nitrogen treatment for fragmentation Further reduction to desired size Separation Milling Packaging (bagging) Separation efficiency: 100% for rubber, metals, textiles Purity of rubber granulate: < 0.05% of residual materials
Product characteristics	Evenly shaped particles due to fracture rather than shearing
Product size	Rough 2.mm to 5.mm 0.5mm to 2.mm Fine 0.mm to 0.5mm
Uses	2- 5mm: drainage, roadbed fill, playgrounds, tram/rail beds 0.5-2.mm: asphalt, manufactured products, carpet under lay, moulded products, train/tram rails, running tracks, shoe soles, brake linings, carpet backs 0-0.5mm: tyres, innerliners, belting, cables, friction materials, compound ingredient for tyres, paving materials Plus many consumer and industrial products
Emissions	SO_x 0 No_x 0 Dust: 0.4kg/h other:
Comments	High cost of liquid nitrogen High product yield. Completely odourless. Lower maintenance due to reduced equipment wear

Pyrolysis	
Feedstock	Shredded car, light utility, heavy goods tyres, other rubber although more dependent on passenger car tyres
Annual capacity	15,000t/y
Energy use	50kwh/t
Manpower	Moderate: 2-3 per shift
Equipment	Pyrolysis furnace heating at 450°-$500^{o}C$ Post-cracking furnace heating at 700°-$800^{o}C$ or, a one step furnace heating at 550°-$600^{o}C$ Heat exchanger and condensing scrubbers Magnetic separator for metals Pyrolytic reactor
Production	Input: 1t/h Output: Carbon black 330kg/h Steel 120kg/h Pyro-oil 350kg/h Gas other - 52kg/h
Number of operations	5
Processes	Optional pretreatment of tyres Semi-continuous or continuous feed Heating to 450°-$500^{o}C$, post-cracking heating to 700°- $800^{o}C$ or, a one step process at 550°-$600^{o}C$ Steam activation for carbon residue Magnetic separation of metals, air removal of fibres Oil filtration Packaging of carbon black, oil, steel
Product characteristics	Commercial grade carbon black after treatment Filtered oil with similar viscosity and calorific value as diesel with a higher aromatic content Steel has the same specification as high quality scrap
Uses	Carbon black: the tyre and automotive industries; paint and printing industries; retreading industry for tread replacement; pretreatment of heavily polluted water; asphalt modifiers and fillers; colouring agents for the plastics industry; recarburiser for the steel industry Gas: for plant heating and drying processes Heavy oils: as a substitute for No. 6 fuel oil Benzene and toluene: as a petrochemical feedstock Steel: independently recycled.
Emissions	SO_x 2kg/h No_x 2kg/h Dust: 1kg/h other:
Comments	Limited maintenance

Incineration for Energy Recuperation	
Feedstock	Whole or cut light utility, heavy goods tyres
Annual capacity	20,000t/y
Energy use	50kwh/t
Manpower	Automated: 1 per shift
Equipment	Conveyors Optional pretreatment equipment Preheater/precalcinator kiln Furnace (several designs are available) Incinerators Flue gas cleaners and electrostatic Precipitator filtration systems
Number of operations	2 (optional pre-treatment)
Production	Input: 12-13t/h Steam t/h 38.6 Working pressure bar g 70 Superheat temperature ^{o}C 520 Feed water temperature ^{o}C 109 Pressure in condenser absolute m bar 135 External temperature ^{o}C 12 Turbo-generator MW 9.7
Processes	Automated feed and operation Optional pre-cutting or shredding
Product characteristics	High quality, clean burning energy, Better and cleaner than coal and equivalent to other heating fuels
Uses	Steam: plant heating or sharing with nearby facilities Steel: has the same specification as high quality scrap and is recyclable Zinc oxide: chemical industry Calcium salts: chemical industry
Emissions	SO_x 6kg/h No_x 10kg/h Ash: 250kg/h other: 20kg/h inert fillers
Comments	Low maintenance of filters, gas scrubbing 20% more heat value than fossil fuels. 40% less ash and 20% less emissions than other fuels. Used in Sweden, Germany, Belgium, United States, Japan, South Korea and Wolverhampton, UK As concerns over emissions controls have increased, there has been considerable pressure to have these furnaces comply with new regulations. New installations are hampered by the NIMBY principle.

ANNEX 6

STORAGE SITE DESIGN REQUIREMENTS

1) Tyre piles should be limited to 20 feet in height with a maximum perimeter of 250 feet by 20 feet. The edges of the pile should be at least 50 feet from the perimeter fence, and that area should be clear of debris or vegetation. Since tyres tend to slide down from the sides of the pile and close off the fire breaks, all interior fire breaks should be at least 60 feet wide.

2) An area extending 200 feet from the outside perimeter of the pile(s) should be totally void of trees, plants or vegetation. All exposures, including buildings, vehicles or flammable materials should be at least 200 feet away from the tyre stockpiles. Piles or storage racks should not be located near or below power lines.

3) Scrap tyres should not be stored on wetlands, flood plains, ravines, canyons or on steeply graded surfaces. Ideally, the site should be flat with a concrete or hard packed clay surface (not asphalt or grass) designed to capture and contain water run-off.

4) No open-air burning should be allowed within 1000 feet of the tyre pile and no welding or other heat-generating devices allowed within 200 feet of the pile. Smoking should only be permitted in designated areas well clear of the pile. Lightening rods conforming to local and state codes should be placed on the facility, but away from the tyre piles.

Water Supply Requirements

1) When the volume of tyres in storage exceeds 50,000 cubic feet, a water supply sufficient to supply 1,000 gallons per minute (GPM) for six hours should be made available.

2) If there is a stream, lake or other body of water located in the vicinity of the storage area, fire department drafting connections should be provided in accordance with the fire department's response plan.

3) All water supply systems should be approved by the responsible local authority (fire marshal, fire chief, etc.).

4) Each fuel-fired vehicle operating at the storage yard should be equipped with at least one 2A,lOBC-rated or higher portable fire extinguisher.

By way of example, the following measures have been taken in a dump mainly containing tyres:

- Stacking limited to layers up to 2.5 m high.
- Where there are successive layers, each layer separated by a layer of inert material (earth, hard core) at least 0,3 m thick
- Start with the biggest tyres (civil engineering, agricultural, HGVs) and fill in the remaining gaps with an inert material or waste.
- Pack each layer as much as possible, using compactors if necessary, to prevent subsequent movements.

- Try to reduce to a minimum the quantity of tyres left uncovered, particularly at the end of the day.
- Create an adequate reserve of hard core, which may be used to smother a fire in its early stages.
- Once the dump is full, cover it with a minimum thickness of hard core and then a layer or earth to allow vegetation to be grown on top.

Tyres are inert in landfills. Whole or substantially whole tyres in thin layers can contribute usefully to the permeability of leachate drainage layers within the structure of the landfill. Fragmented tyres can act as useful inert substrate for the biochemical activity which will lead to the stability of the landfill site.

ANNEX 7

GUIDELINES FOR THE PREVENTION AND MANAGEMENT OF SCRAP TYRE FIRES

Guidelines For the Prevention and Management of Scrap Tyre Fires (International Security and Fire Department Access - The Scrap Tyre Management Council). *This is included as a model for developing guidelines which comply with applicable local conditions, practices and laws.*

1) The perimeter of the facility should have a chain-link fence at least 3 meters high with intruder controls on the top (in accordance to applicable local laws). Clearly visible signs with business hours and regulations should be posted near the facility entrance. A qualified security attendant or site manager should be on-site at all times when the facility is open (some sites have developed effective security off-hours by using security dogs).

2) Each tyre storage yard or pile should be provided with emergency vehicle access routes, such that no portion of the pile is more than 150 feet from an access road or fire break. Access routes through the piles should have a clear width of at least 60 feet.

3) There should be gates protecting each access point that can be locked when the facility is closed. All gates should have a 20 foot open width and remain unobstructed at all times. The gates should have rapid entry design compatible with fire department requirements. Electrical gates should have default capabilities to the unlocked position.

4) All roads and accesses should be designed to support the loads imposed by fire fighting equipment. All bridges and structures, including drainage structures on access roads, should be capable of carrying a minimum design load of HS-20 per AASFTO "Standard Specifications for Highway Bridges". Access routes should be surfaced with material designed to permit accessibility under all climatic conditions.

5) All emergency vehicle accesses should have unobstructed vertical clearance of 14 feet or as needed for passage of large fire fighting apparatus. A minimum turning radius of 45 feet should be provided for emergency vehicle access. All dead-end accesses in excess of 150 feet long should be provided with a turn-around area.

6) Accesses should be well-maintained and remain accessible for the fire department at all times.

ANNEX 8

FIRE, AIR, SOIL AND WATER POLLUTION AS IT IS RELATED TO TYRE STORAGE

In terms of fire:

A large number of compounds can then be given off. These decomposition products are extensive and varied depending on a variety of factors such as tyre type, burn rate, pile size, ambient temperature and humidity, among others.

The quantities released and the concentration of these various compounds depend on how the fire has taken hold, but the most largest quantities are those of CO_2, CO_2 and SO_2. It is worth noting that polycyclic aromatic hydrocarbons can be given off, but given the rapid dispersion of the smoke into the atmosphere, their concentration remains very low, and below the danger level for humans.

Many of the decomposition products have been characterised in test burns and include ash (carbon, zinc oxide, titanium dioxide, silicon dioxides, etc.), sulphur compounds (carbon disulphide, sulphur dioxide, hydrogen sulphide), polynuclear aromatic hydrocarbons usually detected in oil runoff (such as benzo(a)pyrene, chrysene, benzo(a)anthracene, etc.), aromatic naphtenic and paraffinic oils, oxides of carbon and nitrogen, particulates and various aromatic hydrocarbons including toluene, xylene, benzene, etc.

As in all fires involving hydrocarbonic products, the presence of carbon monoxide and sulphur oxides represents the greatest immediate threat, but this threat falls rapidly as one moves away from the seat of the fire.

Air pollution

Complete combustion of a tyre produces CO_2, water vapour and inert residues (along with a small quantity of sulphur dioxide), but open air combustion is an incomplete combustion which, apart from intense heat, gives off thick black smoke of varying degrees of noxiousness.

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Water pollution

Incomplete combustion of rubber leads to pyrolitic fragmentation followed by a recombination of the fragments of the various chemical compounds, some of which are liquids (of the aromatic, paraffin or naphtenic oil variety), carried by the water if water is used to put out the fire.

The same is true of certain components of the combustion residues, such as zinc salts which always contain traces of cadmium and lead under these conditions.

These substances can cause harm to flora and fauna. Experience shows that, for the most part, they are sufficiently diluted in the water used to extinguish the fire not to cause harm to the aquatic environment. Otherwise, the water needs to be treated before it is disposed of.

Soil pollution

Residues which remain on the site for a year after a fire can cause two different types of soil pollution.

Instantaneous pollution by products of liquid decomposition which penetrate the soil if the latter is permeable. Gradual pollution by leaching of ash and unburned residues following rainfall or other water entry. The components already referred to in the previous section are then observed again. They should be eliminated if there are possible consequences for the surrounding area.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal was adopted in 1989 and entered into force in 1992. Presently, there are more than 150 Parties to the Basel Convention. Its objective is to protect human health and the environment from the adverse effects caused by the generation, management and transboundary movements of hazardous wastes.

The fundamental aims of the Basel Convention are the reduction of the transboundary movements of hazardous wastes, the prevention and minimization of their generation, the environmentally sound management of such wastes and the active promotion of the transfer and use of cleaner technologies.

In December 1999, the Parties to the Basel Convention adopted the Basel Protocol on Liability and Compensation for Damage resulting from the Transboundary Movements of Hazardous Wastes and Their Disposal.

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