kempeneers milieu en management

Environmental and health related aspects of Granuflex rubber tiles

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SUMMARY

This report provides an overview of environmental and health related aspects related to the use of GRANUFLEX rubber tiles made from recycled car tyres. The conclusions reached in this study may definitely not be applied to other brands of rubber tiles, as the composition of the latter was not evaluated in this study.

This study is based on research studies done inside and outside the Netherlands, supplemented with leaching trials done in the laboratory.

The relevant environmental risks – which were therefore investigated – are:

- evaporation of volatile compounds
- leaching of heavy metals to the soil, groundwater and surface water

The relevant health risks – which were therefore investigated – are:

- inhalation of dust and volatile compounds
- consumption of rubber granulate
- skin contact with rubber granulate

Based on the available literature and the laboratory trials, the following conclusions can be reached:

Environmental risks

1. There is no significant environmental risk resulting from the evaporation of volatile compounds from Granuflex rubber tiles made of recycled car tyres.
2. The leaching of heavy metals from Granuflex rubber tiles made of recycled car tyres remains within the limit values of the Building Materials Decree (in Dutch: 'Bouwstoffenbesluit') and does not result in any relevant environmental risk.

Health risks

1. On the basis of the studies mentioned above, one may conclude that the consumption of a small quantity of rubber granulate does not lead to a significant health risk for children.
2. On the basis of the studies mentioned above, one may conclude that the use of Granuflex rubber tiles does not lead to a relevant health risk for children and/or adults as a result of the release of dust and/or volatile compounds.
3. On the basis of the studies mentioned above, one may conclude that the use of rubber tiles does not lead to a relevant health risk as a result of skin contact with rubber from recycled car tyres.

In summary, on the basis of the available literature data and the leaching trials carried out in the laboratory, one may conclude that no significant environmental and/or health risks are to be expected if GRANUFLEX rubber tiles made of recycled car tyres are used in the manner and for the purpose for which they are intended.

Contents

1 Introduction

In the past year, various negative reports have appeared in the media regarding the potential health effects associated with the use of rubber granulate made from recycled car tyres on sports fields. Even though the rubber tiles carrying the Granuband mark have an environmental inspection certificate, the negative media reports have caused clients who purchase rubber tiles to ask themselves whether the rubber tiles made of recycled car tyres cause any negative environmental and/or health-related effects when being used.

In the past year, at the request of various organizations – including KNVB (Dutch Football Association), NOC*NSF (Dutch Olympic Committee), WG Materials (builders of sports fields), VACO, DSM, RecyBEM and TenCate – INTRON Certificatie carried out an extensive literature study supplemented with experimental trials to determine the environmental and health risks associated with the use of rubber granulate. The supervisory committee included the organizations listed above as well as the Ministry for Housing, Regional Development, and the Environment, the Ministry of Health, Welfare and Sports, and the National Institute for Public Health and Environmental Protection.

On behalf of the VACO (organization representing the tyre industry) and the Association for Tyres and Environment (tyre industry and importers), Kempeneers Milieu en Management BV (firm specializing in the environment and management) was closely involved in the national study into the environmental and health related aspects of rubber granulate, as an expert member of the technical committee and the supervisory committee.

The interim report prepared by INTRON (May 2006) is available to the public and is used in this study as a source. The follow-up study carried out by INTRON has not yet been released to the public, but it is expected to be released no later than February 2007.

In advance of the publication of the final results of the above-mentioned study into the use of rubber granulate on sports fields, Granuband requested Kempeneers Milieu en Management to carry out an investigation, specifically focusing on Granuflex rubber tiles, into the environmental and health related aspects of rubber tiles made of recycled car tyres during the user phase.

Wherever rubber or rubber products are mentioned in this report, the reference is to rubber from recycled car tyres unless specified otherwise.

2 Environmental aspects

2.1 Assessment framework

For environmental risk assessment, attention is focused on possible emissions into:

- air
- water
- soil

Environmental aspects which may be relevant during the user phase of Granuflex rubber tiles are:

1. Spread of volatile compounds into the air via evaporation
2. Leaching of compounds into the soil, groundwater and surface water

For stony materials and building materials, the Building Materials Decree is applicable in the Netherlands. Formally speaking, rubber products are not covered by this decree. Nevertheless, the Building Materials Decree (which was replaced at the beginning of 2007 by the Decree and Regulations governing Soil Quality (Dutch acronym: BRB)) provides a well documented assessment and standards framework for the protection of the soil and surface water. The Building Materials Decree also sets limit values for the concentrations of volatile compounds in building materials. Application of the Building Materials Decree as the assessment framework for rubber tiles for the assessment of possible environmental risks therefore offers the following advantages:

- sampling protocols are described in the implementation scheme of the Building Materials Decree[1].
- the required analyses with regard to composition and leaching are set out in NEN (-EN) and ISO standards, which means that certified laboratories can carry out these standard analyses.
- the interpretation of analytical results is described in the implementation scheme of the Building Materials Decree.
- the standards used are up-to-date and based on internationally accepted toxicological limit values.

In summary, if we make use of the standards framework in the Building Materials Decree, it has the advantage that we can apply standards that are scientifically well established. Another significant advantage is that certified laboratories can then carry out the necessary product tests.

Rubber tiles made from car tyres differ from loosely aggregated car tyre granulate in terms of composition (particle size, glue and density), layer thickness, and water permeability. In this study, Granuband rubber tiles were therefore investigated in accordance with the guidelines of the Building Materials Decree for dimensionally stable products (NEN 7345). Where necessary, the results of the investigation were supplemented with results from other studies into the environmental aspects of rubber.

[1] The Clean Soil and Building Materials 'user's protocol' can be downloaded at www.overheid.nl

2.2 Spread of compounds into the air

Rubber contains a number of volatile components which can be released via evaporation. The Building Materials Decree sets limit values to the quantity of volatile compounds in rubber.
At the beginning of 2006, the composition of representative samples of Granuband rubber granulate was investigated by INTRON in accordance with the Building Materials Decree. This granulate is also used for the production of rubber tiles, the only difference being that the granulate particles used in rubber tiles are coarser. This does not affect the determination of the actual composition of rubber granulate.

The following components were investigated:

- heavy metals (standard package used in Dutch soil investigations)
- volatile components (standard package used in environmental investigations)
- EOX
- PAC

Table 1 presents the analytical results together with the relevant limit values for building materials from the Building Materials Decree (Dutch acronym: BSB) and the draft Soil Quality Decree (Dutch acronym: BB). With regard to heavy metals in building materials, the Building Materials Decree sets limits to the leachability and not to the absolute concentration in a building material. As a result, no limit values are included in Table 1 for heavy metals.

Table 1. Composition of crumb rubber for use in sports fields

Component	**Rubber granulate Granuband (mg/kg dw)**	**BSB limit value (mg/kg dw)**	**BB draft limit value (mg/kg dw)**
Arsenic	< 3.0	not available	not available
Cadmium	1.5	not available	not available
Chromium	< 4.0	not available	not available
Copper	120	not available	not available
Mercury	< 0.05	not available	not available
Lead	21	not available	not available
Nickel	2.1	not available	not available
Zinc	8800	not available	not available
Benzene	< 0.05	1.25	1
Toluene	0.10	1.25	1.25
Ethyl benzene	< 0.05	1.25	1.25
m+p-Xylene	0.18	1.25	1.25
Styrene	0.15	1.25	
o-Xylene	0.05	1.25	1.25
Total Xylenes	0.23	1.25	1.25
EOX	18	0.8[1]	0.8[1]
Naphthalene	**0.39**	5	5
Acenaphthalene	0.72		
Acenaphtene	0.13		
Fluorene	0.31		
Phenanthrene	**4.18**	20	20
Anthracene	**4.03**	10	10
Fluoranthene	**9.42**	35	35
Pyrene	27.2		
Benzo(a)anthracene	**0.93**	50	40
Chrysene	**3.50**	10	10
Benzo(b)fluoranthene	0.65		
Benzo(k)fluoranthene	**0.64**	50	40
Benzo(a)pyrene	**0.35**	10	10
Dibenz(ah)anthracene	0.16		
Benzo(ghi)perylene	**0.85**	50	40
Indeno(1,2,3-cd)pyrene	**0.85**	50	40
Total PAC 10 VROM (Dutch Ministry for Housing Regional Development and the Environment)	**25.1**	75	40
Total PAC 16 EPA	54.4		

Source: **crumb rubber from shredded car tyres for use in synthetic surfaces for sports fields Study of environmental and health risks,** A831410/R20060129/UHo/eal, INTRON, 23 May 2006

With the exception of zinc, the concentrations of heavy metals in the production samples were low. Under normal conditions of use, heavy metals do not evaporate and are therefore not relevant for the assessment of environmental risks as a result of emissions into the air.

As the table makes clear, the concentration of volatile compounds in rubber granulate is low and remains well below the limit value for volatile compounds in the Building Materials Decree. Other studies conclude that the concentration of volatile compounds found above sports fields containing shredded rubber from recycled car tyres does not exceed the limit

values relevant for public health standards (see **Fout! Verwijzingsbron niet gevonden.**). The concentration of PACs also remains well below the limit values in the Building Materials Act. It may be noted that as a result of European regulations for the use of PAC-containing extender oils in the rubber industry, the concentration of PACs will be greatly reduced in the coming years (lit. 6 and 7).

Based on the above information, one may conclude that no significant environmental risk exists as a result of the evaporation of volatile compounds from Granuflex rubber tiles made of recycled car tyres.

2.3 Leaching of compounds into the soil, groundwater and surface water

The leaching of compounds from rubber can result in an increase in the background concentrations of compounds in the soil. These compounds can then spread from the soil into groundwater and surface water. The degree to which this occurs depends very much on local conditions such as soil composition, groundwater level and precipitation. The standards set down in the Building Materials Decree include all the leaching activity to soil, groundwater and surface water. The basic point of departure for the standard is that the background concentration in the soil for each compound considered may increase by no more than 1% over a period of 100 years.

The leaching of compounds is evaluated with the help of a so-called leaching trial. In a leaching trial, the product tested is exposed to water for a certain period under predefined conditions. The elutant is then analyzed for the presence of various compounds. Based on the concentrations measured, extrapolation factors are then used to calculate the leaching over a period of 100 years.

To determine the degree of leaching, Kempeneers Milieu en Management commissioned Omegam Laboratories to carry out a diffusion trial on GRANUFLEX rubber tiles in accordance with the NEN 7345 standard. The following GRANUFLEX tiles were subjected to the trial:

- Granuflex, Black safety tile
- Granuflex, Red safety tile
- Granuflex, DHZ tile (cold-pressed)

Table 2 presents the leaching results as well as the limit values from the Building Materials Decree.

Table 2. Results of diffusion trial in accordance with NEN 7345 (in mg/m2)

Inorganic compounds Metals	**Limit value** mg/m2	**Safety tile Black**	**Safety tile Red**	**DHZ tile Black**
antimony (Sb)	117	0.875	0.865	0.762
arsenic (As)	435	2.626	2.596	2.287
barium (Ba)	18900	4.376	20.918	5.977
cadmium (Cd)	12	0.087	0.086	0.762
chromium (Cr)	1500	0.875	0.865	0.762
cobalt (Co)	300	1.760	2.590	1.527
copper (Cu)	540	0.863	2.590	0.762
mercury (Hg)	4,5	0.031	0.031	0.031
lead (Pb)	1275	0.875	0.865	0.762
molybdenum (Mo)	450	0.863	0.865	0.762
nickel (Ni)	525	0.875	0.865	0.762
selenium (Se)	45	0.875	0.865	0.762
tin (Sn)	300	0.875	0.865	0.762
vanadium (V)	7200	0.875	0.865	0.762
zinc (Zn)	2100	1660	2490	1727

Source: Diffusion trials carried out by Omegam Laboratories in accordance with NEN 7345, December 2006, at the request of Kempeneers Milieu en Management. (see appendices). The leaching of mercury was calculated on the basis of the INTRON leaching trials in accordance with NEN 7383 (lit. 10) .

Based on the diffusion trial, one may conclude that leaching for 14 of the 15 heavy metals is negligible and that the 100-year emission limit value in the Building Materials Decree will not be exceeded. Over a period of 100 years, the red safety tile will exceed the emission limit value for zinc by a small margin. The other two tiles remain below the emission limit value in this case. The red pigments are free of heavy metals (see lit. 16 Material Safety Data Sheets). The fact that the zinc emission limit in one case is exceeded by a small margin is therefore the result of fluctuations in the leaching trials. The average amount of leaching over the three tile types is 1959 mg/m^2 and therefore remains below the limit value for zinc, which is 2100 mg/m^2.

The total contribution by rubber tiles to the total load of zinc in the Netherlands for the soil and surface water is negligible. The total amount of zinc moving into surface water from all sources in the Netherlands is circa 511 ton/year. The most important sources of zinc emissions are the use of manure in agriculture (48%) and galvanized building materials (11%). If we assume that 200 m^2 of rubber safety tiles are used per playground for a total of 100,000 playgrounds, the total contribution to the zinc load would be 40 kg per year, which is less than 0.008% of the total annual zinc load in the Netherlands. The environmental risk resulting from the leaching of zinc from rubber tiles is therefore negligible.

Based on these results, one may conclude that the leaching of heavy metals from Granuflex rubber tiles made of recycled car tyres remains within the limit values in the Building Materials Decree and does not lead to any relevant environmental risk.

3 Health aspects

Studies into the health aspects involved in the sports related use of rubber granulate from recycled car tyres are useful in the assessment of any negative health effects which may be present. Rubber granulates contain a number of chemical compounds which can lead to negative health effects in case of exposures that exceed health related limit values. In addition to the actual amounts of these compounds present in rubber, it is also important to consider the actual exposure levels and the resulting biological availability. The biological availability depends in large part on:

- the exposure route (swallowing, inhaling, or skin contact)
- the properties of the compound
- the matrix in which the compound is bound (rubber)
- the contact duration
- the contact surface

The following section makes use of existing limit values in various regulations and studies that are available.

3.1 Swallowing

In principle, swallowing pieces of rubber tiles or rubber granulate is not a normal use for rubber tiles. However, on playgrounds, it is possible that toddlers will put pieces of rubber in their mouth and swallow them.

When setting standards intended to eliminate health risks involved in swallowing, existing legislation can be used only to a limited degree. Only the assessment framework provided in the Toys Decree (lit 8 and 9) contains standards for the concentrations of heavy metals. This so-called toy standard sets a limit value for the biological availability of 11 heavy metals. However, determining the biological availability in the case of swallowing is rather complex. As a worst-case scenario, we therefore assume here that 100% of the metals contained in rubber granulate also become biologically available if swallowed. In reality, this will certainly not be the case.

Table 3. Comparison of actual concentrations to limit values for biological availability in the Toy Decree

Component	Rubber granulate Granuband concentration (mg/kg dm)	Toy standard biologically available (mg/kg dm)
Antimony	nb	60
Arsenic	< 3.0	25
Barium	Nb	500
Cadmium	1.5	75
Chromium	< 4,0	60
Copper	120	no limit
Mercury	< 0.05	60
Lead	21	90
Nickel	2.1	no limit
Selenium	n/a	500
Zinc	8800	no limit

Source: see table 1. NB Antimony, Barium and Selenium were not determined in the analyses carried out by INTRON.

Based on the analytical results presented in Table 3, the consumption of pieces of rubber tiles made of recycled car tyres would not be expected to cause any health risks in so far as the presence of heavy metals is concerned. However, the organic chemical components can also be relevant in terms of swallowing.

Swallowing rubber granulate is not described as a relevant exposure route in the available literature and has therefore hardly been investigated. There are two studies that have investigated the consumption of rubber granulate and/or material:

1. In 2006, the Norwegian Public Health Institute published a risk assessment on the consumption of rubber granulate by children (lit. 17). In various scenarios, calculations were carried out to determine whether any potential health risks were present. The researchers concluded that there is no increased health risk involved for children who eat small amounts of rubber granulate made of recycled car tyres with some degree of frequency.
2. Researchers from the Canadian Enviro Test Laboratories and the University of Alberta studied the effect of consuming rubber granulate specifically in terms of the organic chemical components (lit.18). The researchers concluded that the consumption of a small amount of rubber granulate (< 200 g) by children does not lead to any significant health risk.

Based on the above information, one may conclude that the consumption of a small quantity of rubber granulate will not lead to a significant health risk for children.

3.2 Inhalation

Inhalation could possibly lead to health risks as a result of dust and/or volatile organic compounds released by the rubber.

Dust and volatile compounds

As a result of the grinding process, rubber granulate contains a small quantity of rubber dust. However, rubber tiles do not actually contain any rubber dust, as the fine rubber particles are bound inside the glue used to make the tile. The risk that any relevant quantities of fine particulate matter will be formed as a result of mechanical wear and tear of the rubber tiles is also considered negligible, in view of the very strict quality requirements that apply to the source product, car tyres, in terms of wear and tear.

Two studies have investigated the health risks associated with dust and volatile compounds from rubber granulate in synthetic surfaces for sports playing fields:

1. In 2006, the Norwegian Public Health Institute published a risk assessment with regard to the air quality above indoor synthetic playing surfaces enriched with rubber from recycled car tyres (lit. 17). In doing so, they used analyses of air samples previously carried out by the Norwegian Air Research Institute. In two indoor sporting facilities with synthetic playing surfaces containing rubber from recycled car tyres, fine particulate matter (PM 10) was found above the playing surface, which could lead to the absorption of PCBs, PACs, phthalates and alkyl phenols via the lungs. The researchers concluded, on the basis of exposure scenarios for adults, juniors and children, that participating in sports activities in these halls does not lead to an increased health risk.

2. In 2006, the Department of Medical Environmental Science of the Medical Assistance Unit for the region of Gelderland Midden (part of the public health service) carried out a study into exposure via inhalation during sports activities on a synthetic playing surface containing rubber from recycled car tyres (lit. 14). The presence of the following compounds in the air was studied in this context:
   - fine particulate matter and associated Polycyclic Aromatic Hydrocarbons (PAHs) and/or heavy metals
   - volatile nitrosamines, benzene, toluene, ethylbenzene, xylenes and naphthalene.

   Based on the results of analyses of air samples, a risk assessment was carried out to determine whether there are any health risks involved in participating in sporting activities on the synthetic playing surface. The Medical Assistance Unit for the region of Gelderland Midden came to the conclusion that participating in sports on this synthetic playing surface, containing SBR-granulate, does not involve any demonstrable health risks in terms of fine particulate matter, PACs, heavy metals or volatile aromatic hydrocarbons. In addition, the RIVM (Dutch National Institute for Public Health and Environmental Protection) investigated the release of nitrosamines to the air (lit. 15) and concluded that nitrosamines do not present a health risk to the users of such sports playing surfaces.

Based on the above-mentioned studies, one may conclude that the use of Granuflex rubber tiles does not present any relevant health risk for children and/or adults as a result of the release of dust and/or volatile compounds.

3.3 Skin contact

When investigating possible health effects due to skin contact, one should pay particular attention to the exposure to organic components in the rubber, as these components may possibly migrate from the rubber to the skin.

Three studies investigated the issue of skin contact with rubber from car tyres:

1. Danish EPA, Emissions and evaluation of health effects of PAHs and aromatic amines from tyres, (survey of chemical substances in consumer products, no 54, 2005).
2. Norwegian Institute of Public Health and the radium Hospital, Artificial Turf Pitches - an assessment of the health risks for football players (January 2006).
3. EnviroTest laboratories, University of Alberta, Toxicological Evaluation for the Hazard Assessment of Tyre Crumb for Use in Public Playgrounds, Journal of the Air and Waste Management Association 53, 903 (July 2003).

These three studies concluded that no significant health risk exists as a result of prolonged skin contact with rubber. The conclusion in the Canadian study is based on indirect evidence, as the researchers focused their conclusions in particular on the oral consumption of rubber granulate. As their experiments utilized a solvent-based extraction method, in our opinion, their result is also applicable as a model for skin contact in particular for the lipophilic organic chemical compounds.

Based on the above-mentioned studies, one may conclude that, with regard to rubber tiles, no relevant health risk exists as a result of skin contact with rubber from recycled car tyres.

4 Eco-label certification scheme

Granuband has proposed to the Eco-label Association to extend the certification scheme to include a number of additional requirements in the area of health and environment. The aim is to ensure that clients thereby receive an even better and independent guarantee that the rubber tiles at least comply with the health and environmental requirements described in this report. The additional draft requirements proposed to the Eco-label Association are presented below. Around July 2007, these requirements are expected to be integrated in the existing Eco-label certification scheme for rubber tiles made from recycled car tyres.

Environmental aspect	**Requirement**	**Method**
2.13 Chemical composition	The chemical composition of the product complies with the limit values in the Building Materials Decree	• Implementation scheme of the Building Materials Decree, dimensionally stable products, analysis of composition in accordance with AP04, incl. 15 metals, Article 9 of the Building Materials Decree, composition of building material in accordance with NEN 7300, NEN 7310 and NEN 7330
2.14 Leaching of compounds	The leaching of compounds may not exceed the limit values in the Building Materials Decree based on limit values for the environmental load placed on soil, groundwater and surface water. For zinc, the maximum emission value is 3600 mg/m2 in 20 years. For the other compounds listed in the Building Materials Decree, the actual limit values apply.	• Implementation scheme of the Building Materials Decree, dimensionally stable products, in accordance with NEN 734
2.15 Air quality	The chemical composition of the product complies with the limit values in the Building Materials Decree	• Implementation scheme of the Building Materials Decree, dimensionally stable products, analysis of composition in accordance with AP04, incl. 15 metals, Article 9 of the Building Materials Decree, composition of building material in accordance with NEN 7300, NEN 7310 and NEN 7330
Health aspects	**Requirement**	**Method**
2.16 Inhalation	The chemical composition of the product complies with the limit values in the Building Materials Decree	• Implementation scheme of the Building Materials Decree, dimensionally stable products, analysis of composition in accordance with AP04, incl. 15 metals, Article 9 of the Building Materials Decree, composition of building material in accordance with NEN 7300, NEN 7310 and NEN 7330

2.17 Swallowing	The chemical composition of the product complies with the limit values of the European Toy Standard EN 71	• Implementation scheme of the Building Materials Decree, dimensionally stable products, analysis of composition in accordance with AP04, incl. 15 metals, Article 9 of the Building Materials Decree, composition of building material in accordance with NEN 7300, NEN 7310 and NEN 7330 • Assessment using the European Toy Standard EN 71
2.18 Skin contact	The chemical composition of the product complies with the limit values in the Building Materials Decree	• Building Materials Decree, dimensionally stable products, analysis of composition in accordance with AP04, incl. 15 metals, Article 9 of the Building Materials Decree, composition of building material in accordance with NEN 7300, NEN 7310 and NEN 7330

Conditions:

- Wherever the Building Materials Decree is mentioned in the certification scheme, this refers to the most up-to-date regulations. The relevant regulations can be found at www.overheid.nl and at www.vrom.nl (file on soil).
- As soon as the Decree and Regulations on Soil Quality comes into force, the text ‘Building Materials Decree’ in the certification scheme must be replaced by the text ‘Decree and Regulations on Soil Quality.’
- The analyses listed below must be carried out at a frequency of 1 x each year if the certificate holder has a quality assurance system in place that complies with the requirements of the ISO 9000-2000 standard and if, in accordance with the requirements set out in ISO 9000-2000, it can be shown that only car tyres (from commercial and passenger vehicles) are shredded for the production of rubber tiles. In all other cases, the analyses listed below must be carried out at a frequency of 4 x per year.
- The sampling procedure must be carried out in a demonstrable and traceable fashion by an employee of the certificate holder appointed for that purpose, on condition that the certificate holder has a quality assurance system in place that complies with the requirements of the ISO 9000-2000 standard. Analyses in accordance with NEN (-EN) and ISO standards may be carried out only by institutions accredited to do so.
- If the same analytical methods are specified in various Eco-label requirements, it will be sufficient to carry out the analysis only once on the product concerned.

5 Input quality

The chemical composition of rubber in rubber tiles is influenced in large part by the original intended use of the recycled rubber. GRANUFLEX rubber tiles are made using only tyres from passenger vehicles and commercial vehicles.

The average chemical composition of passenger vehicle and commercial vehicle tyres in Europe is a known and fairly constant quantity. In addition, starting in 2010, European tyre manufacturers will have to greatly reduce the quantity of PACs in rubber. The industry is also working on reducing the zinc concentration in rubber.

Technical rubbers (tubing, conveyor belts etc.) have a very diverse composition and often contain very high concentrations of PACs and volatile compounds. In principle, technical rubbers must therefore be excluded from use as a raw material for rubber tiles, as the use of technical rubber would lead to a highly variable input quality.

Granuband, the producer of GRANUFLEX Rubber tiles, does not use technical rubbers.

Appendix 1 references

Legislation and regulations

4. Environmental Management Act ('Wet Milieubeheer'), update 2005, Stb 317
5. Car Tyre Management Decree ('Besluit beheer autobanden')
6. 27th Amendment to 76/769/EEC, relating to the restrictions on the marketing and use of certain polycyclic aromatic hydrocarbons in extender oils and tyres (February 2004)
7. Decree dd 20 November 2006 to modify the Decree on PAC-containing coatings and products Wms 2003 (PAC in extender oils and tyres), Stb 602 (December 2006)
8. Building Materials Decree ('Bouwstoffenbesluit)' (Update 2005)
9. Draft Soil Quality Decree ('Ontwerp Besluit Bodemkwaliteit'), Government Gazette 31 March 2006
10. Initial draft of the Soil Quality Regulations ('Regeling bodemkwaliteit') (September 2006)
11. Directive 2005/84/EC, relating to restrictions on the marketing and use of certain dangerous substances and preparations (phthalates in toys and childcare articles) (December 2005)
12. DIN EN 71 Sicherheit von Spielzeug Europese norm EN 71

Literature

13. INTRON report, Environmental and health risks of shredded rubber from car tyres used in synthetic playing field surfaces (May 2006)
14. Medical Assistance Unit for the region of Gelderland Midden (Hulpverlening Gelderland Midden), Investigation of the health risks associated with the use of SBR-granulate in a synthetic playing field surface at the Rijkerswoerd Sports Centre (August 2006)
15. RIVM report 609300001, Nitrosamines from rubber granulate (November 2006)
16. Danish EPA, Emissions and evaluation of health effects of PAHs and aromatic amines from tyres, (survey of chemical substances in consumer products, no 54, 2005)
17. Norwegian Institute of Public Health and the radium Hospital, Artificial Turf Pitches - an assessment of the health risks for football players (January 2006)
18. EnviroTest laboratories, University of Alberta, Toxicological Evaluation for the Hazard Assessment of Tyre Crumb for Use in Public Playgrounds, Journal of the Air and Waste Management Association 53, 903 (July 2003)
19. MSDS sheets Rosehill Pigments LTD England, 2006

APPENDIX 2 DIFFUSION TRIALS IN ACCORDANCE WITH NEN 7345 (OMEGAM Laboratories Dec 2006)

GRAN2006-03															
Referentie				GRAN 2006-03-3				GRAN 2006-03-4				GRAN 2006-03-5			
				zwarte veiligheid tegel				rode veiligheidtegel				DHZ tegel koud geperst			
OMEGAMCODE				3463810				3463812				3463813			
Bem.datum				23/08/2006				23/08/2006				23/08/2006			
Materiaal				Bouwstof	B categorie			Bouwstof	B categorie			Bouwstof	B categorie		
diffusiep. NEN 7345 afgel.	DF3G01				Uitgevoerd				Uitgevoerd				Uitgevoerd		
breedte	DF3G09			mm	153			mm	154			mm	162		
lengte	DF3G08			mm	149			mm	150			mm	163		
hoogte	DF3G10			mm	25			mm	25			mm	26		
diameter	DF3G07			mm	n.v.t			mm	n.v.t			mm	n.v.t		
volume	DF3G11			liter	0,567			liter	0.577			liter	0.682		
droge massa	DF3G05			g	470,2			g	442.7			g	480.8		
vorm proefstuk	DF3G06				Rechthoek				Rechthoek				Rechthoek		
uitwendig oppervlak	DF3G12			m2	0,0607			m2	0.0614			m2	0.0697		
volume elutiemiddel	DF3G03			liter	2			liter	2.0			liter	2.0		
proefstuk gezaagd	DF3G04				Ja				Ja				Ja		
mengeluaat 1 t/m 8	DF3G02				af				af				Ja		
				GRAN 2006-03-3				GRAN 2006-03-4				GRAN 2006-03-5			
Anorganische stoffen Metalen		**Grenswaarde**		**Diff proef**		**I100 jr**		**Diff proef**		**I100 jr**		**Diff proef**		**I100 jr**	
antimoon (Sb)	DF2M11	mg/m2	117	mg/m2 <	0,2636	mg/m2 <	**0,875**	mg/m2 <	0,2606	mg/m2 <	**0,865**	mg/m2 <	0,22955	mg/m2 <	**0,762**
arseen (As)	DF2M01	mg/m2	435	mg/m2 <	0,7908	mg/m2 <	**2,626**	mg/m2 <	0,7818	mg/m2 <	**2,596**	mg/m2 <	0,68866	mg/m2 <	**2,287**
barium (Ba)	DF2M02	mg/m2	18900	mg/m2 <	1,318	mg/m2 <	**4,376**	mg/m2 <	6,3	mg/m2 <	**20,918**	mg/m2 <	1,8	mg/m2 <	**5,977**
cadmium (Cd)	DF2M03	mg/m2	12	mg/m2 <	0,02635	mg/m2 <	**0,087**	mg/m2 <	0,02605	mg/m2 <	**0,086**	mg/m2 <	0,22955	mg/m2 <	**0,762**
chroom (Cr)	DF2M05	mg/m2	1500	mg/m2 <	0,2636	mg/m2 <	**0,875**	mg/m2 <	0,2606	mg/m2 <	**0,865**	mg/m2 <	0,22955	mg/m2 <	**0,762**
kobalt (Co)	DF2M04	mg/m2	300	mg/m2 <	0,53	mg/m2 <	**1,760**	mg/m2 <	0,78	mg/m2 <	**2,590**	mg/m2 <	0,46	mg/m2 <	**1,527**
koper (Cu)	DF2M06	mg/m2	540	mg/m2 <	0,26	mg/m2 <	**0,863**	mg/m2 <	0,78	mg/m2 <	**2,590**	mg/m2 <	0,22955	mg/m2 <	**0,762**
Kwik (Hg)		mg/m2	4,5	mg/m2 <		mg/m2	**0,031**	mg/m2 <		mg/m2 <	**0,031**	mg/m2 <		mg/m2 <	**0,031**
lood (Pb)	DF2M10	mg/m2	1275	mg/m2 <	0,2636	mg/m2 <	**0,875**	mg/m2 <	0,2606	mg/m2 <	**0,865**	mg/m2 <	0,22955	mg/m2 <	**0,762**
molybdeen (Mo)	DF2M08	mg/m2	450	mg/m2 <	0,26	mg/m2 <	**0,863**	mg/m2 <	0,2606	mg/m2 <	**0,865**	mg/m2 <	0,22955	mg/m2 <	**0,762**
nikkel (Ni)	DF2M09	mg/m2	525	mg/m2 <	0,2636	mg/m2 <	**0,875**	mg/m2 <	0,2606	mg/m2 <	**0,865**	mg/m2 <	0,22955	mg/m2 <	**0,762**
seleen (Se)	DF2M12	mg/m2	45	mg/m2 <	0,2636	mg/m2 <	**0,875**	mg/m2 <	0,2606	mg/m2 <	**0,865**	mg/m2 <	0,22955	mg/m2 <	**0,762**
tin (Sn)	DF2M13	mg/m2	300	mg/m2 <	0,2636	mg/m2 <	**0,875**	mg/m2 <	0,2606	mg/m2 <	**0,865**	mg/m2 <	0,22955	mg/m2 <	**0,762**
vanadium (V)	DF2M14	mg/m2	7200	mg/m2 <	0,2636	mg/m2 <	**0,875**	mg/m2 <	0,2606	mg/m2 <	**0,865**	mg/m2 <	0,22955	mg/m2 <	**0,762**
zink (Zn)	DF2M15	mg/m2	2100	mg/m2 <	500	mg/m2 <	**1660**	mg/m2 <	750	mg/m2 <	**2490,294**	mg/m2 <	520	mg/m2 <	**1726,604**

Overige Anorganische stoffen															
Bromide (Br) (per jaar)		mg/m2	90												
Chloride (per jaar)		mg/m2	30000												
Fluoride		mg/m2	14000												
Sulfaat		mg/m2	45000												
				GRAN 2006-03-3				GRAN 2006-03-4				GRAN 2006-03-5			
PAK's		Grenswaarde		Diffusieproef				Diffusieproef				Diffusieproef			
naftaleen	LC06G2	mg/m2	nvt	µg/l <	0,19			µg/l <	0,14			µg/l <	0,16		
acenaftyleen	LC07G2	mg/m2	nvt	µg/l <	0,23			µg/l <	0,18			µg/l <	0,19		
acenafteen	LC08G2	mg/m2	nvt	µg/l <	0,06			µg/l <	0,05			µg/l <	0,05		
fluoreen	LC09G2	mg/m2	nvt	µg/l <	0,05			µg/l <	0,05			µg/l <	0,05		
fenantreen	LC11G2	mg/m2	nvt	µg/l <	0,07			µg/l <	0,05			µg/l <	0,11		
anthraceen	LC12G2	mg/m2	nvt	µg/l <	0,01			µg/l <	0,01			µg/l <	0,01		
fluorantheen	LC13G2	mg/m2	nvt	µg/l <	0,01			µg/l <	0,01			µg/l <	0,01		
pyreen	LC14G2	mg/m2	nvt	µg/l <	0,02			µg/l <	0,02			µg/l <	0,01		
benz(a)anthraceen	LC15G2	mg/m2	nvt	µg/l <	0,03			µg/l <	0,02			µg/l <	0,02		
chryseen	LC16G2	mg/m2	nvt	µg/l <	0,02			µg/l <	0,01			µg/l <	0,01		
benzo(b)fluorantheen	LC17G2	mg/m2	nvt	µg/l <	0,03			µg/l <	0,03			µg/l <	0,03		
benzo(k)fluorantheen	LC18G2	mg/m2	nvt	µg/l <	0,01			µg/l <	0,01			µg/l <	0,01		
benzo(a)pyreen	LC19G2	mg/m2	nvt	µg/l <	0,01			µg/l <	0,01			µg/l <	0,01		
dibens(a,h)anthraceen	LC21G2	mg/m2	nvt	µg/l <	0,03			µg/l <	0,02			µg/l <	0,03		
benzo(ghi)peryleen	LC22G2	mg/m2	nvt	µg/l <	0,05			µg/l <	0,04			µg/l <	0,04		
indeno(1,2,3cd)pyreen	LC23G2	mg/m2	nvt	µg/l <	0,13			µg/l <	0,1			µg/l <	0,02		
				Omrekening		Extrapolatie		Omrekening		Extrapolatie		Omrekening		Extrapolatie	
		Grenswaarde				I100 jr				I100 jr				I100 jr	
naftaleen	LC06G2	mg/m2	nvt	mg/m2 <	0,050	mg/m2 <	0,166	mg/m2 <	0,037	mg/m2 <	0,123	mg/m2 <	0,042	mg/m2 <	0,140
acenaftyleen	LC07G2	mg/m2	nvt	mg/m2 <	0,061	mg/m2 <	0,201	mg/m2 <	0,047	mg/m2 <	0,158	mg/m2 <	0,050	mg/m2 <	0,166
acenafteen	LC08G2	mg/m2	nvt	mg/m2 <	0,016	mg/m2 <	0,053	mg/m2 <	0,013	mg/m2 <	0,044	mg/m2 <	0,013	mg/m2 <	0,044
fluoreen	LC09G2	mg/m2	nvt	mg/m2 <	0,013	mg/m2 <	0,044	mg/m2 <	0,013	mg/m2 <	0,044	mg/m2 <	0,013	mg/m2 <	0,044
fenantreen	LC11G2	mg/m2	nvt	mg/m2 <	0,018	mg/m2 <	0,061	mg/m2 <	0,013	mg/m2 <	0,044	mg/m2 <	0,029	mg/m2 <	0,096
anthraceen	LC12G2	mg/m2	nvt	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009
fluorantheen	LC13G2	mg/m2	nvt	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009
pyreen	LC14G2	mg/m2	nvt	mg/m2 <	0,005	mg/m2 <	0,018	mg/m2 <	0,005	mg/m2 <	0,018	mg/m2 <	0,003	mg/m2 <	0,009
benz(a)anthraceen	LC15G2	mg/m2	nvt	mg/m2 <	0,008	mg/m2 <	0,026	mg/m2 <	0,005	mg/m2 <	0,018	mg/m2 <	0,005	mg/m2 <	0,018
chryseen	LC16G2	mg/m2	nvt	mg/m2 <	0,005	mg/m2 <	0,018	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009
benzo(b)fluorantheen	LC17G2	mg/m2	nvt	mg/m2 <	0,008	mg/m2 <	0,026	mg/m2 <	0,008	mg/m2 <	0,026	mg/m2 <	0,008	mg/m2 <	0,026
benzo(k)fluorantheen	LC18G2	mg/m2	nvt	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009
benzo(a)pyreen	LC19G2	mg/m2	nvt	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009	mg/m2 <	0,003	mg/m2 <	0,009
dibens(a,h)anthraceen	LC21G2	mg/m2	nvt	mg/m2 <	0,008	mg/m2 <	0,026	mg/m2 <	0,005	mg/m2 <	0,018	mg/m2 <	0,008	mg/m2 <	0,026
benzo(ghi)peryleen	LC22G2	mg/m2	nvt	mg/m2 <	0,013	mg/m2 <	0,044	mg/m2 <	0,011	mg/m2 <	0,035	mg/m2 <	0,011	mg/m2 <	0,035
indeno(1,2,3cd)pyreen	LC23G2	mg/m2	nvt	mg/m2 <	0,034	mg/m2 <	0,114	mg/m2 <	0,026	mg/m2 <	0,088	mg/m2 <	0,005	mg/m2 <	0,018

Grenwaarden uitloging

Zware metalen	mg/m2	mg/kg
antimoon (Sb)	117	0,31
arseen (As)	435	1,1
barium (Ba)	18900	50
cadmium (Cd)	12	0,059
chroom (Cr)	1500	4,1
kobalt (Co)	300	1
koper (Cu)	540	1,9
Kwik (Hg)	4,5	0,022
lood (Pb)	1275	4,6
molybdeen (Mo)	450	1,9
nikkel (Ni)	525	2,2
seleen (Se)	45	0,23
tin (Sn)	300	0,85
vanadium (V)	7200	10
zink (Zn)	2100	8,4
Overige Anorganische stoffen		
Bromide (Br) (per jaar)	90	3,6
Chloride (per jaar)	30000	710
Fluoride	14000	125
Sulfaat	45000	3760

Anorganische stoffen Metalen	Grenswaarde mg/m2	Veiligheidtegel Zwart	Veiligheidtegel rood	DHZ tegel zwart
antimoon (Sb)	117	0,875	0,865	0,762
arseen (As)	435	2,626	2,596	2,287
barium (Ba)	18900	4,376	20,918	5,977
cadmium (Cd)	12	0,087	0,086	0,762
chroom (Cr)	1500	0,875	0,865	0,762
kobalt (Co)	300	1,760	2,590	1,527
koper (Cu)	540	0,863	2,590	0,762
Kwik (Hg)	4,5	0,031	0,031	0,031
lood (Pb)	1275	0,875	0,865	0,762
molybdeen (Mo)	450	0,863	0,865	0,762
nikkel (Ni)	525	0,875	0,865	0,762
seleen (Se)	45	0,875	0,865	0,762
tin (Sn)	300	0,875	0,865	0,762
vanadium (V)	7200	0,875	0,865	0,762
zink (Zn)	2100	1660	2490	1727

Omrekening kwik obv uitloogonderzoek INTRON Mei 2006

kwik	0,0015	mg/kg
opp	0,022797	m2
gew	0,4702	kg
soortelijk gew	20,6255209	kg/m2
Kwik /m2 (uitloging)	0,031	mg/m2

Omrekening formule van ug/l naar mg/kg

$$\frac{C \times V \times 8}{\text{opp. uitwendig} \times 1000}$$

C = gemeten concentratie in µg/l
V= Volume water in liter
8= aantal gemeten fracties
opp.uitwendig = uitwendig oppervlakte in m2

volume	DF3G11	liter	0.567
droge mass	DF3G05	g	470.2
vorm proefs	DF3G06		Rechthoek
uitwendig o	DF3G12	m2	0.0607
volume eluti	DF3G03	liter	2.0

Fv voor overige anorganische componenten 64 dagen

$fv = 15 \times \sqrt{fbev} * fiso$

fv	4,74	
f bev	0,1	B toepassing (boven maaiveld)
f iso	1	

Extrapolatieberekening

$lb.V = E64d * ftemp * fv$

lbv	1660	
E 64 d	500	zink
f temp	0,7	
Fv	4,74	