What is Butyl Rubber?

Technical Article: TA21

Butyl Rubber is a synthetic product with unique physical and chemical properties. Since its invention in 1937 it has been used to make a wide variety of products including car tyres. Its properties of flexibility, impermeability to gas and liquids and its robustness make it an ideal material for the manufacture of the Flexigester.

Introduction

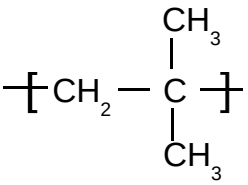
The components of the Flexigester Systems are manufactured by Butyl Products Ltd (www.butylproducts.co.uk) using Butyl Rubber. Butyl Rubber has a number of properties which make it a more suitable material to use in this application than other similar products including PVCs, polyurethane and polypropylene. It is impermeable to gases and liquids so once material is put into the Flexigester it can not leach out and contaminate the ground or release gas and odours into the atmosphere. It is flexible and does not crack enabling the gas storage bags to inflate as biogas is produced and deflate as the biogas is used. It is a strong material so it is not easily ripped or torn and, if it does get damaged, it is easy to patch and repair. It also has good resistance to chemicals and to UV light giving the Flexigester a long life span compared to other plastic digesters.

As with all products the longevity and the robustness depends upon the quality of the material used. Butyl Products Ltd pride themselves on their reputation which comes from manufacturing products to the highest standard using only high-quality British-made Butyl Rubber.

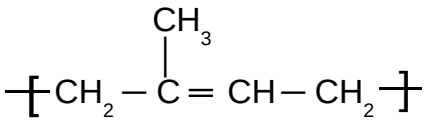
Chemical composition

Butyl Rubber is a synthetic product made from the co-polymerisation of isobutylene ($C[CH_3]_2=CH_2$) with a small amount of isoprene ($CH_2=C[CH_3]-CH=CH_2$) at very low temperatures in the presence of aluminium chloride. The two monomers join together to make a giant multi-unit molecule or co-polymer. The resulting co-polymer is extracted as a slurry of crumb rubber which is dried and formed into bales. These bales can be then subsequently formulated and compounded with other ingredients to confer the desired characteristics of the ultimate finished product. This compounded rubber may then be calendered and vulcanised under heat and pressure to produce the outstanding properties of butyl rubber sheeting.

The polymer repeating units have the following structures:



Isobutylene



Isoprene

It is the chemical structure of the co-polymer that gives Butyl Rubber its unique properties. The regular order of the side groups of the isobutylene contribute to the strength of the Butyl Rubber as well as its excellent impermeability to gases, whilst the limited number of double bonds make it resistant to oxidative ageing, ozone degradation and heat resistance. The glass transition of butyl rubber is very low, which enhances molecular mobility and its unique elastomeric properties at normal operating temperatures.

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The history of using Butyl Rubber

Synthetic Butyl Rubber was first produced in America by two chemists, William Sparks and Robert Thomas, who worked at the Standard Oil Company in New Jersey in 1937. This company then became the Exxon Mobil Corporation. In the UK ExxonMobil trade under the ESSO name.

ESSO believed that Butyl Rubber could be used in the agriculture sector and in 1965 they formed an alliance with Arthur Young who was well known and well connected in the agriculture sector. From that alliance Arthur Young founded Butyl Products Ltd to design, supply, fabricate and install geomembrane liner systems for tanks, reservoirs, lakes and bunds. Since then Butyl Products Ltd have expanded their range of products and also the range of materials used. In fabrication.

The formulation for Butyl Rubber was refined in the early years of using it until the premium blend was developed. This has been used largely unchanged for 40 years and still continues to be manufactured in the original plant within the UK.

Butyl Products Ltd was one of the first genuine installer of geomembranes in the world. They continue to be at the forefront of new developments in terms of technology and alternative materials and were instrumental in raising industry standards with the eventual set up of the British Geomembrane Association.

Manufacture and fabrication

Butyl Rubber sheeting can be produced in various thicknesses, widths and roll lengths. An exceptional feature of the process is to produce sheets from multiple thin layers that are combined under stringently controlled conditions prior to being coalesced and vulcanised under heat and pressure. This gives added security with regard to weatherproofing and barrier properties. The Butyl Rubber can also be produced with additional textile or textile scrim reinforcement.

The Butyl Rubber contains no plasticisers or additives which can evaporate or be washed out over time. This means that the strength, functionality and elasticity of the Butyl Rubber remains practically unchanged for decades, without shrinkage, brittleness, melting or cracking.

Butyl Rubber has a number of properties which make it favourable to use in fabrication compared to other geomembrane materials. These include:

- It can be built into large complex shapes and patterns
- the fabrication process is quick and efficient
- the vulcanised seams are stronger than the material itself
- the material is pliable, easy to handle, and rolls up into small packages making it suitable for shipment

Butyl Products Ltd have the largest vulcanising press in the world. This means they can make a 15 m seam in a single press avoiding the need for joins and reducing the risk of leaks.

Applications

Originally used for tyre inner tubes, today Butyl Rubber has many more applications. In the Aid and Development fields it is used as liners and covers for tanks and reservoirs holding drinking water and waste water as well as the material of choice for the Flexigester System.

It is also used in other industries including in the manufacture of sealants, caulks and adhesives, cling film, fibre optic compounds, bladders for balls used in sport such as football, rugby etc, damp proofing and roof repair, gas masks and chemical agent protection and even in the manufacture of chewing gum.

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Specification of Butyl Rubber

Typical Properties	Test Method	Specification (Typical Values)	Minimum Values
Tensile Strength	BS 903 Part A2	8.0 MPa	7.0 MPa
Modulus at 300%	BS 903 Part A2	5.5 MPa	4.5 MPa
Elongation at Break	BS 903 Part A2	350%	300%
Tear Strength	BS 903 Part A3	30 N/mm	25N/mm
Ozone Resistance (7 days/50pphm/30 Deg C)	BS 903 Part A43 Procedure A		50% extensions No cracks
Heat Aging (Retentions) (7 days @ 100 .Deg. C)	BS 903 Part A19	6.0 MPa 250%	5.6 MPa 200%
Flex Cracking	BS 903 Part A10		200.000 cycles, no crack
Specific Gravity	BS 903 Part A1	1.24 +/- 0.03	*The information herein is based upon data obtained by the manufacturer and is considered accurate. However, no warranty is expressed or implied regarding the accuracy of this data. This information is furnished upon the condition that the person receiving it shall evaluate its suitability for the specific application.*
Nominal Weight	@ 1mm thickness	1240 g/m^2	
Dimensional Stability	1 Hr at 100 .Deg C	+/- 1% Max	
Operating Temperature Range	BS903	-40°C to +130°C	
Grade AA Agreement Board Certificate No 87/1884			
Thickness Available 0.75mm, 1.0mm, 1.5mm, 2.0mm and 3.00mm reinforced materials 1.0mm thick			

Properties of Butyl Rubber

The generic mechanical strength, weathering resistance and outstanding impermeability characteristics combined with ease of fabrication and longevity (see TA20 Durability of Butyl Rubber) gives Butyl Rubber unique properties which make it an ideal material for the fabrication of the Flexigester. These unique properties include:

- good mechanical strength
- good tear, cut and gouge resistance (root puncture)
- good abrasion resistance
- excellent weathering / UV / sunlight resistance
- excellent ozone resistance
- outstanding barrier properties against liquids and gases
- good chemical resistance 'spectrum'
- low toxicity towards aquatic organisms & plants
- excellent resistance to microbiological growth (BS6920 potable water applications)
- exhibits good elasticity (doesn't become brittle unlike plastic liners)
- wide operating temperature window (-40°C to +130°C)
- shrink resistant

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Chemical resistance of Butyl Rubber

Key: A - Recommended B - Minor effect

Acetaldehyde	A	Acetamide	A	Acetic Acid, 30%	B
Acetic Acid, Glacial	B	Acetic Anhydride	B	Acetone	A
Acetophenone	A	Acetylene	A	Aluminium Acetate	A
Aluminium Chloride	A	Aluminium Fluoride	A	Aluminium Nitrate	A
Aluminium Phosphate	A	Aluminium Sulphate	A	Ammonia Anhydrous	A
Ammonia Gas (Cold)	A	Ammonia Gas (Hot)	B	Ammonium Carbonate	A
Ammonium Chloride	A	Ammonium Hydroxide	A	Ammonium Persulphate	A
Ammonium Nitrate	A	Ammonium Phosphate	A	Ammonium Sulphate	A
Amyl Acetate	A	Amyl Alcohol	A	Aniline	B
Aniline Dyes	B	Aniline Hydrochloride	B	Animal Fats	B
Arsenic Acid	A				
Barium Chloride	A	Barium Hydroxide	A	Barium Sulphate	A
Barium Sulphide	A	Beer	A	Beet Sugar Liquors	A
Benzaldehyde	A	Benzoic Acid	A	Benzyl Alcohol	B
Benzyl Benzoate	B	Bleach Solutions	A	Borax	A
Bordeaux Mixture	A	Boric Acid	A	Brine	A
Butter	B	Butyl Acetate	B	Butyl Acetyl Ricinoleate	A
Butyl Alcohol	B	Butyl Benzoate	A	Butyl Carbitol	A
Butyl Cellosolve	A	Butyl Oleate	B	Butyl Stearate	B
Butyraldehyde	B				
Calcium Acetate	A	Calcium Chloride	A	Calcium Hydroxide	A
Calcium Hypochlorite	A	Calcium Nitrate	A	Calcium Sulphide	A
Cane Sugar Liquors	A	Carbamate	B	Carbitol	B
Carbolic Acid	B	Carbon Dioxide	A	Carbon Monoxide	A
Carbonic Acid	A	Caster Oil	B	Cellosolve	B
Cellosolve Acetate	B	Cellulube	A	Chloroacetic Acid	B
Chloroacetone	B	Chlorobromomethane	B	Citric Acid	A
Cobalt Chloride	A	Coconut Oil	A	Cod Liver Oil	A
Copper Acetate	A	Copper Chloride	A	Copper Cyanide	A
Copper Sulphate	A	Corn Oil	B	Cyclohexanone	B
Denatured Alcohol	A	Detergent Solutions	A	Developing Fluids	B
Diacetone	A	Diacetone Alcohol	A	Dibenzyl Ether	B
Dibenzyl Sebecate	B	Dibutyl Phthalate	B	Dibutyl Sebecate	B
Diethlamine	B	Diethyl Sebecate	B	Diethylene Glycol	A
Diisopropyl Ketone	A	Dimethyl Phthalate	B	Dioctyl Phthalate	B
Dioctyl Sebecate	B	Dioxane	B		
Epichlorohydrin	B	Ethanolamine	B	Ethyl Acetate	B
Ethyl Acetoacetate	B	Ethyl Acrylate	B	Ethyl Alcohol	A
Ethyl Benzoate	B	Ethyl Cellosolve	B	Ethyl Cellulose	B
Ethyl Oxalate	A	Ethylene Diamine	A	Ethyl Chloride	A
Ethyl Formate	B	Ethyl Silicate	A	Ethylene Glycol	A
Ferric Chloride	A	Ferric Nitrate	A	Ferric Sulphate	A
Fluorinated Cyclic Ethers	A	Fluoroboric Acid	A	Fluorocarbon Oils	A
Fluorolube	A	Fluosilicic Acid	A	Formaldehyde	A
Formic Acid	A	Freon 12	B	Freon 13	A
Freon 13B1	A	Freon 22	A	Freon 31	A
Freon 32	A	Freon 114	A	Freon 115	A
Freon 142b	A	Freon 152a	A	Freon 502	A
Freon C316	A	Freon C318	A	Freon TA	A
Freon TC	A	Freon TMC	B	Freon T-P35	A
Freon T-WD602	A	Fufural	B		

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Gallic Acid	B	Gelatin	A	Glauber's Salt	B
Glycerin	A	Glycols	A	Glucose	A
Glue	A	Green Sulphate Liquor	A		
n-Hexaldehyde	B	Hydrazine	A	Hydrobromic Acid	A
Hydrochloric Acid (cold)	A	Hypochlorous Acid	B	Hydrocyanic Acid	A
Hydrofluoric Acid- Anhydrous	B	Hydrofluoric Acid (Conc.) Cold	B	Hydrofluosilicic Acid	A
Hydrogen Gas	A	Hydrogen Suphide (wet)(Cold)	A	Hydrogen Suphide (wet)(Hot)	A
Iodoform	A	Isobutyl Alcohol	A	Isophorone	A
Isopropyl Acetate	A	Isopropyl Alcohol	A		
Lactic Acid	A	Lead Acetate	A	Lead Nitrate	A
Lead Sulphamate	A	Lime Bleach	A	Lime Sulphur	A
Lindol	A	Linseed Oil	B	Lye	A
Magnesium Chloride	A	Magnesium Hydroxide	A	Mercuric Chloride	A
Mercury	A	Mesityl Oxide	B	Methyl Acetate	B
Methyl Acrylate	B	Methyl Alcohol	A	Methyl Butyl Ketone	A
Methyl Cellosolve	B	Methyl Formate	B	Methyl Oleate	B
Methyl Salicylate	B	Methylacrylic Acid	B	Milk	A
Monoethanolamine	B	Monovinyl Acetylene	A	Mustard Gas	A
Neatsfoot Oil	B	Neville Acid	B	Nickel Acetate	A
Nickel Chloride	A	Nickel Sulphate	A	Niter Cake	A
Nitric Acid-Dilute	B	Nitroethane	B	Nitrogen	A
Nitromethane	B				
Octyl Alcohol	A	Oleic Acid	B	Olive Oil	B
Oxalic Acid	A	Oxygen – Cold	A	Ozone	B
Palmitic Acid	B	Perchloric Acid	B	Phenol	B
Phophorous Trichloride	A	Phorone	B	Phosphoric Acid – 20%	A
Phosphoric Acid – 45%	B	Picric Acid	B	Plating Solution-Chrome	A
Plating Solution-Others	A	Polyvinyl Acetate – Emulsion	A	Potassium Acetate	A
Potassium Chloride	A	Potassium Cupro Cyanide	A	Potassium Cyanide	A
Potassium Dichromate	A	Potassium Hydroxide	A	Potassium Nitrate	A
Potassium Sulphate	A	Propyl Acetate	B	n-Propyl Acetate	A
Propyl Alcohol	A	Propyl Nitrate	B	Propylene Oxide	B
Pydrauls	B	Pyridine	B	Pyroligneous Acid	B
Rapeseed Oil	A				
Sal Ammoniac	A	Salicylic Acid	A	Salt Water	A
Sewage	B	Silicone Greases	A	Silicone Oils	A
Silver Nitrate	A	Skydrol 500	B	Skydrol 7000	A
Soap Solutions	A	Soda Ash	A	Sodium Acetate	A
Sodium Bicarbonate	A	Sodium Bisulphite	A	Sodium Borate	A
Sodium Chloride	A	Sodium Cyanide	A	Sodium Hydroxide	A
Sodium Hypochlorite	B	Sodium Metaphosphate	A	Sodium Nitrate	A
Sodium Perborate	A	Sodium Peroxide	A	Sodium Phosphate	A
Sodium Silicate	A	Sodium Sulphate	A	Sodium Thiosulphate	A
Stannic(ous) Chloride	B	Steam Under 300ºF	A	Sucrose Solution	A
Sulphite Liquors	B	Sulphur	A	Sulphur Dioxide	B
Sulphur Hexafluoride	A	Sulphur Trioxide	B	Sulphuric Acid (Dilute)	B
Sulphuric Acid (Conc)	B	Sulphurous Acid	B		

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Tannic Acid	A	Tartaric Acid	B	Tertiary Butyl Alcohol	B
Tertiary Butyl Catechol	B	Tetrabutyl Titanate	B	Tetrhydrofuran	B
Triacetin	A	Triaryl Phosphate	A	Tributoxy Ethyl Phosphate	A
Tributyl Phosphate	A	Trichloroacetic Acid	B	Tricresyl Phosphate	A
Triethanol Amine	B	Trioctyl Phosphate	A	Toluene Diisocyanate	A
Unsymmetrical Dimethyl Hydrazine (udmh)	A				
Vegetable Oils	A	Versilube	A	Vinegar	A
Wagner 21B Fluid	B	Water	A	Whisky, Wines	A
Zeolites	A	Zinc Acetate	A	Zinc Chloride	A
Zinc Sulphate	A				

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