United Kingdom

Ultra-Lightweight Refractory Tackles Energy Concerns

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Used in one form as loose fill insulation in kiln cars, and in another as castable insulation for kiln roofs, doors and walls, specialist technology company Mantec Technical Ceramics reports on the latest developments for one of its proprietary refractory materials. The material's light weight, effective insulative properties across a range of temperatures and applications, and long use life are proving to be a successful combination, leading to welcome performance and energy consumption benefits.

Introduction

Ever-widening end use application possibilities, allied to novel production techniques, have resulted in the development of a unique refractory insulating product. Ultralite™ is manufactured by Mantec Technical Ceramics and is an ultra-lightweight, microporous refractory material – a speciality foamed aluminosilicate aggregate product formulated by experienced ceramic technologists in the UK.

Manufacture & Advantages

The new refractory formulation that is used to produce Ultralite is said to give it the edge over a number of other materials commonly specified for insulation. Numerous in-house trials have shown that Ultralite exhibits improved thermal stability and resistance to dimensional changes across a wide range of temperatures when compared to micaceous and siliceous alternatives in comparable applications.

Mantec conducted range firing trials on four loose fill materials – vermiculite, perlite, expanded clay aggregate, and Ultralite. The trial firings took place at temperatures between 900 °C and 1200 °C and were carried out in standard 30,5 cm × 30,5 cm × 10 cm saggars. The saggars were initially filled to just below the top in each case.

At 900 °C to 1000 °C, the vermiculite, perlite and expanded clay all showed a reduction in volume, significantly so in the case of perlite. In the case of expanded clay, discoloration was also noted. At 1200 °C, these three materials had all fused together, with perlite becoming a solid block and expanded clay also becoming a solid block and actually gluing itself to the sides of the saggar (Figs. 1–3).

Conversely, Ultralite at 900 °C to 1000 °C (and above) showed little or no volume reduction and the colour remaining consistent. At 1200 °C, Ultralite was still consistent in its physical appearance and had no discoloration (Fig. 4).

Ultralite routinely offers a suite of in-use benefits, such as:

- Stability – the material does not change in size, shape, mass or strength at elevated temperatures (continuous use above 900 °C up to a maximum classification temperature of 1250 °C for the highest grade)
- High porosity – >80 % for the loose fill product
- Low thermal mass
- Ultra-lightweight at ~70 kg/m^3
- High internal void space
- Low thermal conductivity
- Free flowing – easy void filling
- No ceramic fibre – so it does not become brittle and lose its insulation efficiency over time; also much safer to work with and use as there are no fibre emissions.
- Negligible free silica – significantly reduced carcinogenic exposure
- High energy saving characteristics
- No volatiles produced, as the material is prefired and inert
- Disposal at end of life is problem-free – typically, no specialised disposal is required, unlike ceramic fibre.

Ultralite has been offering substantial benefits to high-volume operations, where users see its exceptional thermal performance as a super-insulative mass in, for instance, kiln cars. Aside from offering superb thermal insulation, these Ultralite materials reduce the thermal mass inside the cars, retaining useful energy inside the kiln rather than it being wasted on adsorption into the heavy base.

It has already been used successfully in the ceramics industry, both in volume whitewares (sanitaryware) and the heavy clay sector (kilns for bricks and roof tiles).

Loose-Fill Pellet

The principal lines on offer are Ultralite Loose Fill (ULF) and Ultralite Refractory Castable (URC). Ultralite was designed to replace less thermally stable kiln car insulation media such as ceramic fibre, vermiculite and perlite and, in addition to proven insulating performance, ULF does not degrade and so performs consistently over its whole lifetime. There are currently two grades of ULF (Tab. 1):

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Fig. 1 Vermiculite under firing trial at 1200 °C

Fig. 2 Perlite under firing trial at 1200 °C

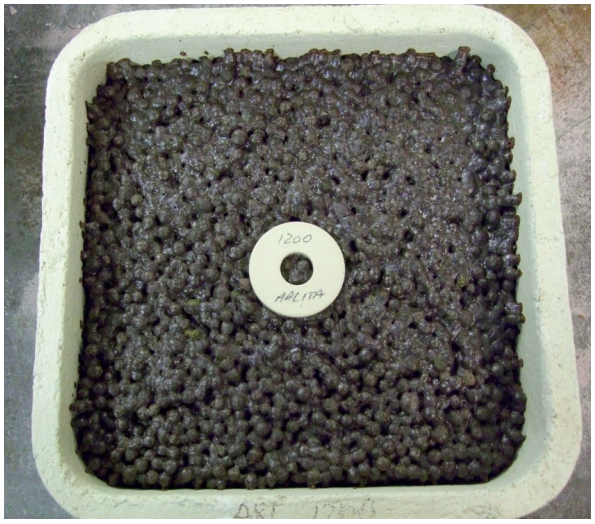

Fig. 3 Expanded clay aggregate under firing trial at 1200 °C

Fig. 4 Ultralite ULF-12 under firing trial at 1200°C

Tab. 1 Grades of ULF

Grade	Classification Temperature [°C]	Density [kg/m³]
ULF-10	1050	75
ULF-12	1250	110

It is supplied in pellet form (sometimes known in the industry as "prill"), formed from a foamed aluminosilicate in a proprietary process – delivering a neat, simple and small aggregate that is easy and safe to handle.

These pellets pour very conveniently into awkward spaces and reduce kiln car construction time as no physical packing is required. The loose fill material is supplied in bulk bags with a tied opening at the bottom. The installation method is to suspend the bag above the kiln car and to allow the material to flow into the cavity under gravity through the opening in the bag.

The fact that it is inert, stable at high temperatures, and does not suffer degradation over time, means that it can be used and reused as an insulating loose fill material time and again, so it can be cleared out and then refilled during kiln car repairs and maintenance regimes.

Should Ultralite be taken to temperatures in excess of its classification temperature, then some shrinkage may be observed. However, it should be noted that there would still be no degradation or melting of the Ultralite prill, unlike other micaceous and siliceous alternatives. Were any shrinkage to occur, additional Ultralite can simply be added to the reduced volume to top it up to the required level. The main properties of ULF are summarised in Tab. 2.

Refractory Castables

The URC range is manufactured by blending ULF material with high-grade refractory aggregates and cements, which results in a range of ultra-lightweight monolithic refractories with exceptional heat insulating properties and very low densities, suitable for use within all types of kilns and furnaces. These versatile products can be used in a

Tab. 2 Main Properties of Ultralite Loose Fill

Main properties		ULF-10		ULF-12	
		[°C]	[°F]	[°C]	[°F]
Recommended maximum service temperature		1050	1922	1250	2282
Determination of refractoriness ASTM C24-09 (13)	Temperature	1659	3018	1659	3018
	PCE value	29		29	
Powder loose bulk density (subject to settling in transit)		[kg/m³]	[lb/ft³]	[kg/m³]	[lb/ft³]
		75	4,68	110	6,87
Thermal conductivity (ASTM C201/182) N.B. All temperatures are MEAN temperatures		[W/m·K]	[BTU in/h·ft²·°F]	[W/m·K]	[BTU in/h·ft²·°F]
	200 °C (392 °F)	0,08	0,55	0,08	0,55
	400 °C (752 °F)	0,10	0,69	0,10	0,69
	800 °C (1472 °F)	0,17	1,18	0,17	1,18
	1000 °C (1832 °F)	0,23	1,59	0,23	1,59
	1200 °C (2192 °F)	0,32	2,22	0,32	2,22
Specific heat capacity at 1000 °C (1832 °F) [kJ/kg·K]		1,15		1,15	
Determination of resistance to carbon monoxide (BS N ISO 12676:2003) after 200 h at 500 °C (932 °F)		Classification 1		Classification 1	
Chemical composition [mass-%]	Al_2O_3	31,34		31,34	
	SiO_2	53,47		53,47	
	Fe_2O_3	0,84		0,84	
	TiO_2	1,21		1,21	
	CaO	0,36		0,36	
	MgO	0,56		0,56	
	Na_2O	0,36		0,36	
	K^2O	2,19		2,19	
	Alkalis	<3,5		<3,5	
Standard packaging		Nominally 1 m³ bulk bags		Nominally 1 m³ bulk bags	

variety of applications, such as hot face and back-up refractory linings (roof, walls, doors etc), in the sub-floor of a kiln or kiln car base, and for the creation of monolithic cast shapes. The three main available grades have maximum service temperatures ranging from 1100 °C up to 1300 °C, and densities from 580 kg/m³ to 645 kg/m³.

Fig. 5 Ultralite – highly effective insulation in kiln cars

Where ULF and URC are used together in kiln car bases, a 25 % weight reduction is not untypical. Depending on the product being fired and kiln and car base configuration, Ultralite can result in energy savings of up to 40 %. The longevity of the ULF material is another positive contributory factor – many installations are still using their original Ultralite insulation after 10 or more years. This compares extremely favourably with any previously used material. The main properties of URC are summarised in Tab. 3.

Major Order

The fact that Ultralite is readily accepted once used was underscored recently when Mantec Technical Ceramics secured what was its second largest order ever for Ultralite – a mix of ULF-10 loose fill, ULF-12 loose fill, and URC-12 castable. This con-

Tab. 3 Main Properties of Ultralite Refractory Castable

Main properties		URC-11		URC-12		URC-13	
Recommended maximum service temperature		[°C]	[°F]	[°C]	[°F]	[°C]	[°F]
		1100	2012	1200	2192	1300	2372
Powder loose bulk density (subject to settling in transit) approx.		[kg/m³]	[lb/ft³]	[kg/m³]	[lb/ft³]	[kg/m³]	[lb/ft³]
		420–460	26,21–28,72	420–460	26,21–28,72	550–600	34,34–37,46
Bulk density (dried & cured at 105 °C) approx.		540–620	33,71–38,71	620–670	38,71–41,83	580–620	36,21–38,71
Bulk density (fired at recommended maximum temperature) approx.		590	36,83	620	38,71	520–550	32,46–34,34
Modulus of rupture (ASTM C133-97 & C865, dried & cured at 105 °C)		[MPa]	[psi]	[MPa]	[psi]	[MPa]	[psi]
		0,73	106	1,36	197	1,32	191
Cold Crushing Strength (ASTM C133-97 & C865, dried & cured at 105 °C)		1,50	218	2,91	422	3,7	537
Permanent linear change (ASTM C133 & C865, heated to to maximum temperature then cooled) [%]		–1,50		–1,45		–1,10	
Thermal conductivity (ASTM C201/182) N.B. All temperatures are MEAN temperatures		[W/m·K]	[BTU in/ h·ft²·°F]	[W/m·K]	[BTU in/ h·ft²·°F]	[W/m·K]	[BTU in/ h·ft²·°F]
	200 °C (392 °F)	0,13	0,90	0,22	1,53	0,21	1,46
	400 °C (752 °F)	0,16	1,11	0,24	1,67	0,22	1,53
	800 °C (1472 °F)	0,22	1,53	0,20	1,39	0,25	1,74
Chemical composition [mass-%]	Al_2O_3	38,75		39,56		54,51	
	SiO_2	27,77		29,33		27,62	
	Fe_2O_3	9,23		8,71		0,76	
	TiO_2	–		–		–	
	CaO	19,54		18,48		14,64	
	MgO	–		–		–	
	Na_2O	0,40		0,28		0,28	
	K_2O	1,05		0,79		0,45	
	Alkalis	<2,0		<1,5		<1,0	
Approx. mixing ratio (vol.-%) Litres Water : Litres URC		40 : 100		34 : 100		30 : 100	
Approx. mixing ratio (mass-%) kg Water : kg URC		90 : 100		77 : 100		52 : 100	
Standard packaging		20 litre sacks		20 litre sacks		20 litre sacks	

tract was a repeat order placed by Cerithern, the renowned French industrial kiln specialist with particularly strong references in the clay brick and tile segments. Multiple consignments were required to fulfil the order from this important European customer, with a delivery in total of around 315 m³ of product. The overall benefit to the ultimate end user has been to reduce thermal mass and save on energy inputs in what has sometimes been a tough operating period for the sector. To give an idea of scale, the product shipped in this order would effectively insulate around 60 kiln cars. Ultralite is also being supplied direct to high-volume manufacturers in the ceramics industry, including world-leading brands in areas such as sanitaryware and heavy clay.

Summary & Outlook

Distinct advantages for ceramics manufacturers are offered by the new formulations used in the production of the Ultralite family of materials, with its combination of light weight, highly effective insulative properties, safe and simple handling, and longevity. With the supply and cost concerns prevalent at the moment (particularly when it comes to natural gas) – as we find across all energy-intensive industries – then Ultralite is a particularly attractive option in the context of pursuing a goal of substantial fuel savings allied to reliable performance.

Mantec sees good prospects for increased uptake of Ultralite, not only because it can demonstrate a suite of sought-for benefits, but the fact that much of its current business for ULF and URC consists of repeat orders, testimony to the proven and appreciated efficacy and cost-efficiency of these products.