Flexitallic®

innovate/customize/educate

THERMICULITE® 866 / 866 LS

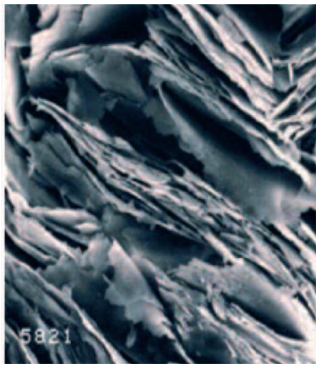
Sealing materials for Solid Oxide Fuel Cells.

www.flexitallicsofc.com

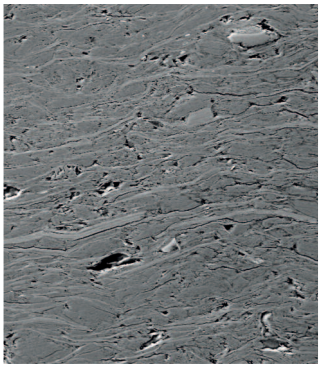
The Flexitallic Group

Flexitallic®

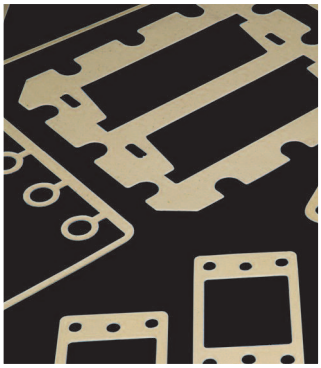
THERMICULITE® 866



Crystal plates: Each crystal plate is nanometres thick



Structure of Thermiculite® 866



Thermiculite® 866 cut gasket samples

Thermiculite® 866 - The proven sealing material for Solid Oxide Fuel Cell applications.

Thermiculite®
innovative. versatile. complete.

THERMICULITE® 866

- Thermiculite® 866 is recognised as the material of choice to achieve high sealing efficiency by leading developers of SOFC technology
- Thermiculite® 866 ensures that a seal is created and then the seal is maintained in service
- No burn off of organic material at elevated temperature
- No reduction in gasket thickness at elevated temperature
- Sealing performance not reduced by thermal cycling

THERMICULITE® 866 LS

- Sealing achieved at very low surface stresses
- Extremely high level of sealing efficiency achieved
- Sealing performance not reduced by thermal cycling
- Sealing coating compensates for irregularities in surfaces to be sealed
- Gasket cutting just as easy for Thermiculite® 866

Thermiculite® 866 is a sealing material specifically designed as a compression seal for Solid Oxide Fuel Cells [SOFC]. It is proving to be very successful in a range of SOFC applications around the world.

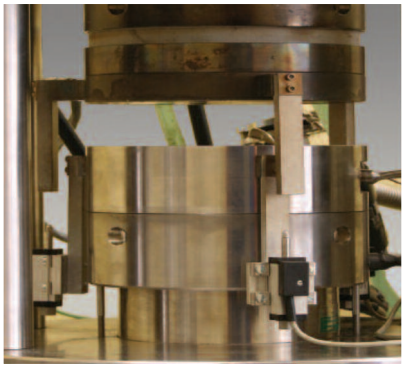
Thermiculite® 866 is a product utilising the Thermiculite® technology, based upon the use of chemically exfoliated vermiculite, that has been developed by Flexitallic to produce a range of high performance, high temperature, patented, sealing materials for industrial sealing.

Vermiculite, a naturally occurring mineral is closely related to mica, a mineral noted for high temperature capability, high chemical resistance and an electrical insulation. Both mica and vermiculite occur naturally as flakes which consist of a stack of very many crystal plates where each crystal plate is nanometres thick. Those flakes of vermiculite, unlike those of mica, are able to be exfoliated so that the crystal plates separate from each other.

This exfoliation can be partly achieved by the application of heat, the result is then the well known form of vermiculite used in many everyday applications such as in gardening compost, as a thermal insulation material, as a packaging material and in fire prevention applications. However, the very thin crystal plates can be separated efficiently from each other by chemical means to produce a form which consists of just these very thin crystal plates. The separated plates are highly flexible and have the most useful property of adhering to each other to produce a thin, flexible, film. If a second material is added to the chemically exfoliated vermiculite then the second material will be bound by the chemically exfoliated vermiculite without the need for the addition of a binder. This binding action of chemically exfoliated vermiculite means that when it is mixed with other, morphology compatible, materials that it is possible to make, by methods developed by Flexitallic, a very flexible sheet material. This sheet material, Thermiculite® 866, is readily cut into gaskets of complex shapes.

THERMICULITE® 866 THE PROVEN SEALING MATERIAL FOR SOFC APPLICATIONS		
Stable to high temperatures up to 1000°C	No thermal degradation of the seal at SOFC operating temperatures	Extended lifetime performance
No organic filler material	Excellent seal integrity maintained	Material does not become porous over time or suffer a gasket thickness reduction
Soft and compressible	Easily cut into complex shapes and profiles	Complex sealing arrangements are easily accommodated
Currently operating in service units	Case studies providing the benefits of Thermiculite® 866	Many reports of very low leakage rates even through many thermal cycles

www.flexitallicsofc.com



THERMICULITE® 866 LS

Advanced test equipment aided Flexitallic's development of Thermiculite® 866

The components of Thermiculite® 866 ensure that a seal is created and then maintained in service. Consisting of highly aligned platelets of chemically exfoliated vermiculite binding other unique key ingredients Thermiculite® 866 is very soft, resulting in a compressible and flexible material that is completely free of organic content.

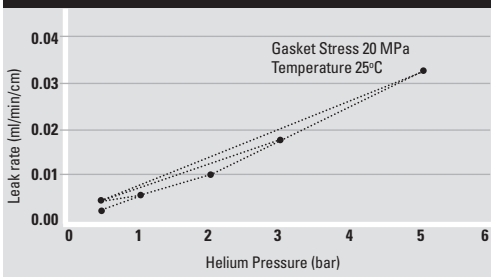
Due to its unique chemical and physical properties, Thermiculite® 866 is highly temperature resistant (1000°C) and, as there is no organic content, there is no burn off of volatile components at SOFC operational temperatures.

This ensures that during the lifetime of the fuel cell there is no increase in porosity and no additional leakage at elevated temperature. Figures 1 and 2 show that there is no difference in sealing performance at elevated temperature.

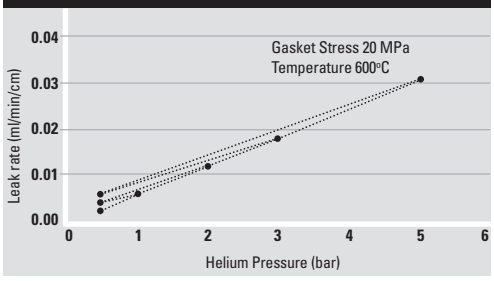
As there is no burn off of organic material at elevated temperature there is also no reduction in the gasket thickness at temperature and no resulting relaxation of the bolts.The seal is therefore stable during cycling between ambient and operational temperatures.

Thermiculite® 866 provides excellent service performance. Figures 3 and 4 show stack results obtained by a customer and reproduced with their full permission.

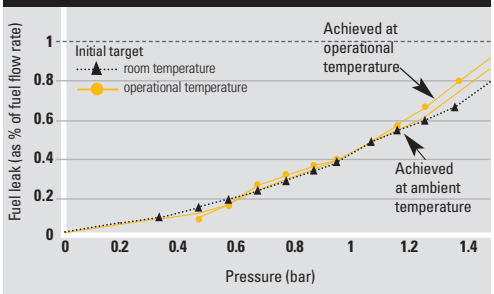
1 SEALING CURVE FOR THERMICULITE® 866 OF 0.92mm 'AS MADE' THICKNESS AT 25°C



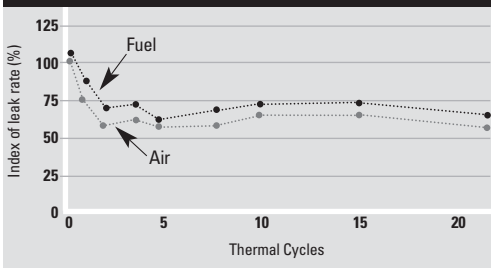
2 SEALING CURVE FOR THERMICULITE® 866 OF 0.92mm 'AS MADE' THICKNESS AT 600°C



3 SOFC STACK SEALING PERFORMANCE ACHIEVED WITH THERMICULITE® 866 COMPARED WITH INITIAL PROJECT TARGET



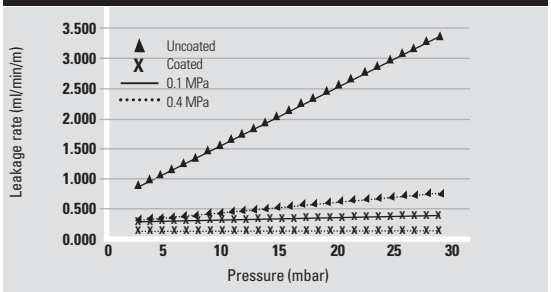
4 SOFC STACK SEALING WITH THERMICULITE® 866 REMAINS STABLE DURING THERMAL CYCLING TO OPERATIONAL TEMPERATURE



Following development work at the VTT Technical Research Centre of Finland, see reference, Flexitallic has introduced Thermiculite® 866 LS using a further developed form of the coating to allow the range use of Thermiculite® 866 to be extended to those stack designs only offering a very low sealing stress. A minor amount of glass powder is bound to each surface during the manufacturing process so that at the operational temperature of the SOFC cell Thermiculite® 866 LS has a very thin coating of molten glass on each surface which seals the interfacial leakage paths.

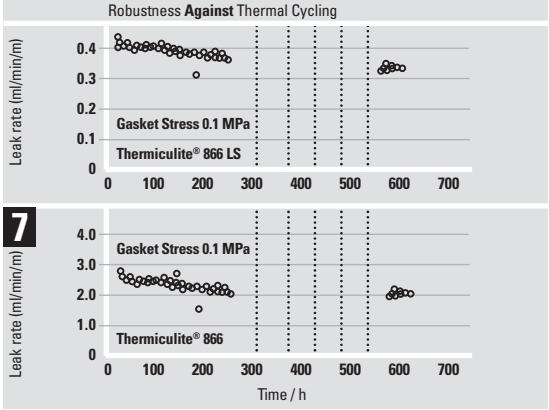
No initial glass sintering cycle to above the operating temperature of the SOFC stack is required with Thermiculite 866 LS. Provided the service temperature is at least 700°C the glass coating will form the required seal.

5 COMPARISON OF SEALING OF THERMICULITE® 866 &THERMICULITE® 866 LS AS A FUNCTION OF GAS PRESSURE AND GASKET STRESS



When glass is used as the sole sealing material it is well known that cracking of the seal with enhanced leakage results during thermal cycling. This is not the case with Thermiculite® 866 LS where the level of sealing is maintained during thermal cycling. Figures 6 and 7 show, under the same conditions, the sealing performance of Thermiculite® 866 LS and Thermiculite® 866 respectively during thermal cycles. Note scale differences of these figures.

6 THE ROBUSTNESS AND SEALING PERFORMANCE OF THERMICULITE® 866 & THERMICULITE® 866 LS



Δp = 25 mBar

Reference: M. Rautanen et al, J. Power Sources 247 (2014) 243-248

Flexitallic®

innovate/customize/educate

UNITED KINGDOM
Flexitallic Ltd
Scandinavia Mill
Hunsworth Lane
Cleckheaton
West Yorkshire
BD19 4LN
UK
Tel. +44 1274 851273
Fax. +44 1274 300303
www.flexitallic.eu

CANADA
AGS Flexitallic
4340 - 78 Avenue
Edmonton,
Alberta, T6B 3J5
CANADA
Tel. +780 466 5050
Fax. +780 465 1177
www.agsflexitallic.com

CHINA
Flexitallic Sealing Technology Co. Ltd
Building 3 South
Wujiang Export
Processing Zone
688 Pangjin Road
Wujiang, Jiangsu 215200
P.R. CHINA
Tel. +86 512 6303 2839
Fax. +86 512 6303 2879
www.china.flexitallic.com

UNITED STATES
Flexitallic L.P.
6915 Highway 225
Deer Park
Texas 77536
USA
Tel. +1 281 604 2400
Fax. +1 281 604 2415
www.flexitallic.com

UNITED ARAB EMIRATES
Flexitallic LLC
P.O. Box 6591
Amenity Centre
Tower Number 2
10th Floor, Office 4
Al Hamra Industrial Area
Ras Al Khaimah
UNITED ARAB EMIRATES
Tel. +971 (0)7 243 4305
Fax. +971 (0)7 243 4306
www.flexitallic.ae

SAUDI ARABIA
Flexitallic Middle East LLC
Al-Aujam Industrial City
6790-Al Badia
Unit No. 1
Al Qatif 32656-2462
KINGDOM OF SAUDI ARABIA
Tel. +966 13 8089635
Fax. +966 13 8089634
www.flexitallic.sa

About The Flexitallic Group

The Flexitallic Group is a global leader in specialised sealing solutions and products serving the oil and gas, power generation, chemical and petrochemical industries in emerging and developed markets. Focused on the upstream, downstream and power generation sectors, it has operations in France, the United States, Canada, Mexico, the United Kingdom, Germany, the United Arab Emirates, Saudi Arabia, Kazakhstan and China plus a network of worldwide licensing partners and distributors.

www.theflexitallicgroup.com

www.flexitallicsofc.com

The Flexitallic Group

FEBRUARY 2014.
Designed by Clear Design (Scotland) Ltd. E. info@clearwebsite.co.uk