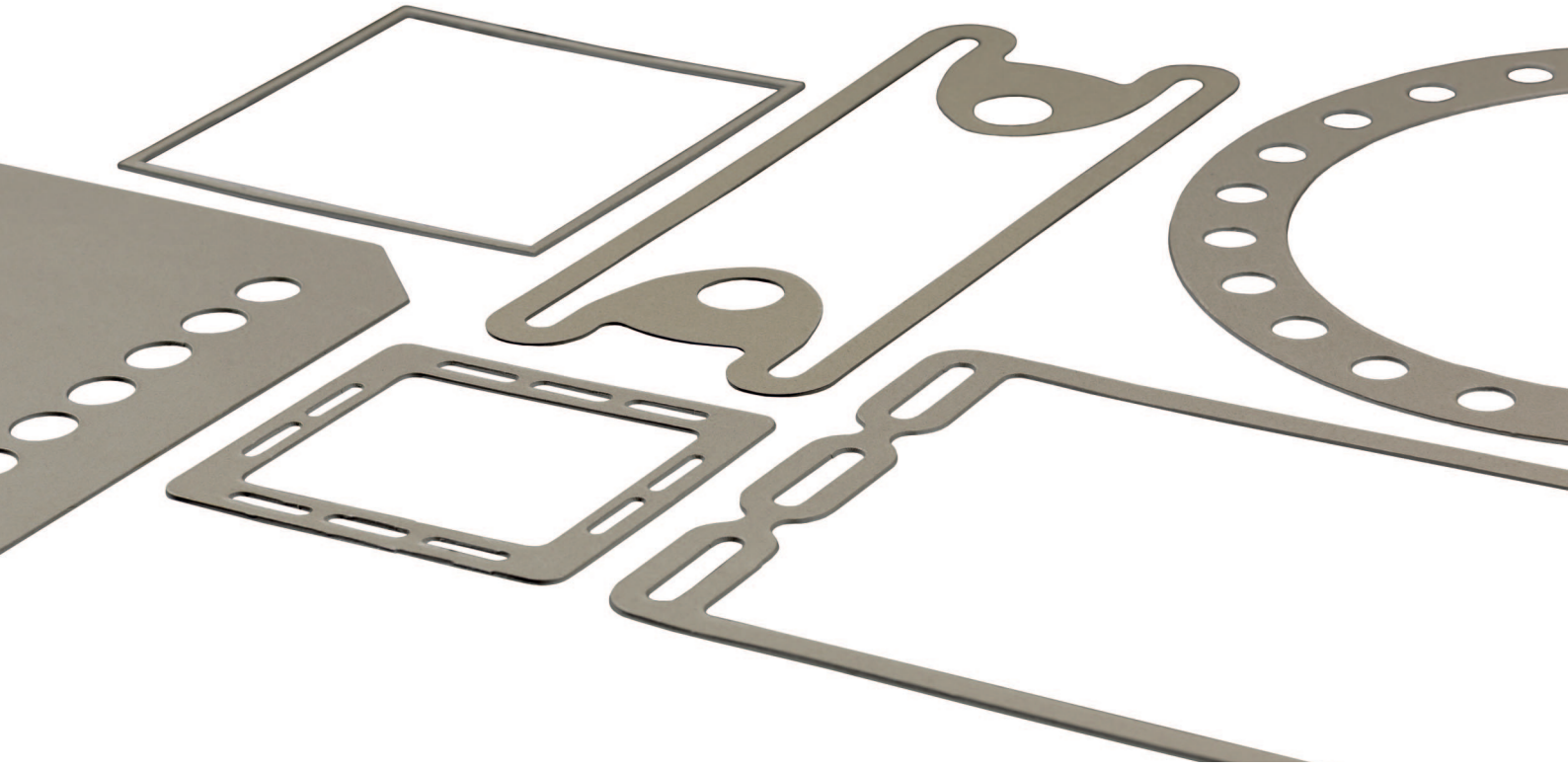
Flexitallic®

POWER TO THE FUTURE

THERMICULITE®

Sealing materials for Solid Oxide Fuel Cells.



www.flexitallic.com

THERMICULITE®

PROVEN SEALING MATERIALS FOR SOLID OXIDE FUEL CELLS.

Thermiculite® 866 and 870 are sealing materials specifically designed for use as compression seals for Solid Oxide Fuel Cells (SOFC) and Solid Oxide Electrolysers (SOE). They have been used very successfully in a range of SOFC applications around the world.

TH866 and TH870 utilise the unique properties of Thermiculite® technology, based upon the use of chemically exfoliated vermiculite, developed by Flexitallic to produce a range of high performance, high temperature resistant, patented sealing materials for industrial applications.

Vermiculite is a naturally occurring mineral noted for its high temperature capability, wide chemical resistance and electrical insulation properties. Vermiculite occurs naturally as flakes which consist of a stack of very many crystal plates where each crystal plate is nanometres thick. These flakes are able to be exfoliated so that the crystal plates separate from each other.

Partial exfoliation can be achieved by the application of heat, resulting in a coarse expanded form of vermiculite however the crystal layers can also be separated efficiently from each other by chemical means which produces a form which consists of just these very thin, high aspect ratio crystal plates. The separated plates are highly flexible and have the useful property of adhering to each other to produce a thin, flexible film. The self binding nature of the vermiculite means additional compounds can be added without the need for a supplementary binder.

By exploiting these properties, Flexitallic has developed a process to produce a very compressible, flexible sheet sealing material with very tightly controlled thickness and density. The resulting sheet material can be easily cut into gaskets with complex shapes including those with narrow land widths (≥4mm). The controllable manufacturing approach means sheet material can be produced in a range of thicknesses to suit different designs.

Thermiculite® ensures that a seal can be created and then maintained in service. Thermiculite® 866 is soft, resulting in a compressible and flexible material that is completely free of organic content.

Due to its unique chemical and physical properties, TH866 and TH870 are both highly temperature resistant (1000°C) and, as there is no organic content, there is no burn off of volatile components at SOFC operational temperatures. It also means that the sensitive cell chemistry is not poisoned.

At elevated temperature there is also no reduction in the gasket thickness and no resulting relaxation of the bolts. The seal is therefore stable during cycling between ambient and operational temperatures.

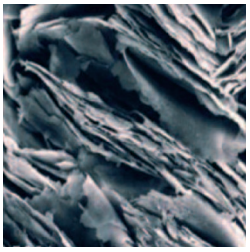
Thermiculite® 866 provides excellent service performance. Figures 3 and 4 show stack results obtained by a customer and reproduced with their full permission.

THERMICULITE® 866

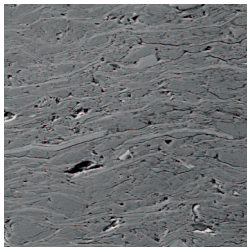
- Thermiculite® 866 is recognised as the material of choice to achieve high sealing efficiency by leading developers of SOFC technology
- Thermiculite® 866 ensures that a seal is created and then maintained in service
- No burn off of organic material at elevated temperature
- No reduction in gasket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

THERMICULITE® 870

- Sealing achieved at very low surface stresses
- Very high compressibility
- Sealing performance not reduced by thermal cycling
- Gasket cutting just as easy for Thermiculite® 866



Crystal plates: Each crystal plate is nanometres thick



Structure of Thermiculite® 866

THERMICULITE® 866 and 870 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

Front cover image: Thermiculite 866 cut gasket samples

Thermiculite®
innovative. versatile. complete.

For some SOFC designs a softer, more compressible sealing material is required. As a result of this requirement, Flexitallic developed Thermiculite® 870, building upon the knowledge and experience gained from TH866. TH870 is significantly more compressible under low loads, e.g. 1MPa. TH870 is around ten times more compressible than TH866.

Figure 1 shows load vs defection for TH870 compared to TH866. At a stress of 1 MPa TH870 compresses 0.22mm whereas TH866 gasket only compresses 0.02mm under the same load.

Thermiculite® 870 also seals at a comparable level to TH866, but at much lower applied loads. This is the case at ambient and elevated temperatures. **Figure 2** shows an 80 hour leakage test at ambient temperature.

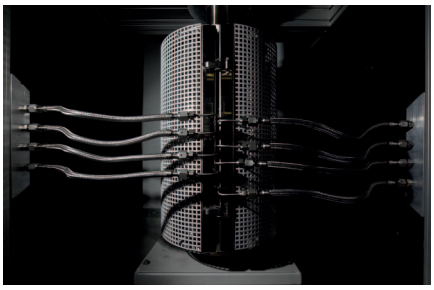
For more information see Introduction of a *Low Sealing Stress Vermiculite Based Compression Gasket for SOFCs;* S Bond & S Shaw, ECS Trans. 2018 83(1): 159-170.

LS COATING

Thermiculite® 866 can be offered with an additional glass based surface coating. This material is known as **TH866LS.** A thin coating of glass powder is bound to each surface of the sheet during the manufacturing process so that at the operational temperature of the SOFC cell the coating melts therefore reducing the interfacial leakage paths.

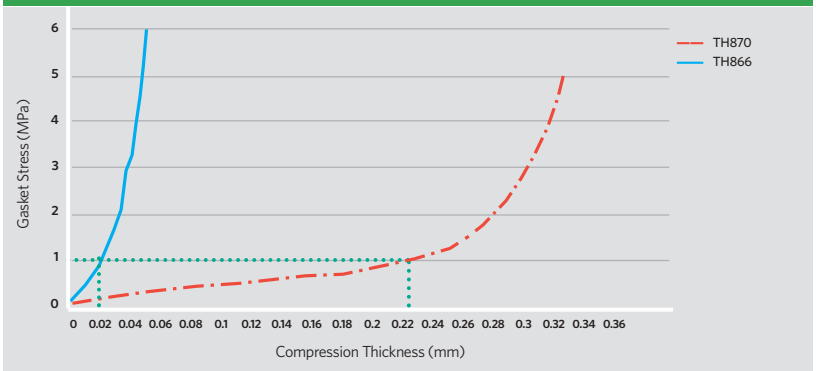
No initial glass sintering cycle to above the operating temperature of the SOFC stack is required with Thermiculite® 866 LS. Provided the service temperature is at least 700°C the glass coating will form the required seal.

Please note 866LS has now been superseded by TH870 material.

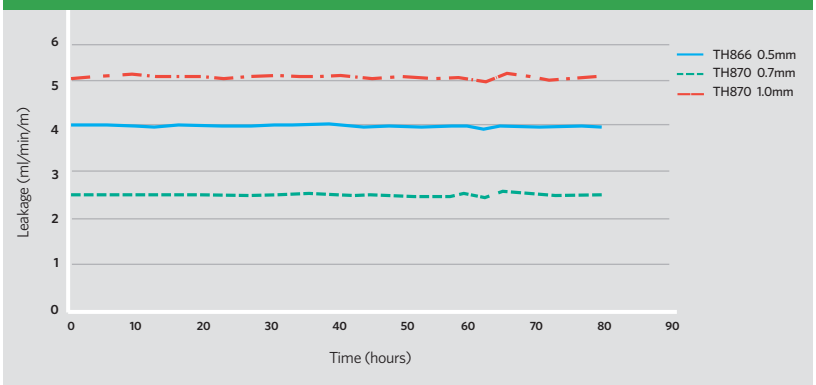


Advanced test equipment aided Flexitallic's development of Thermiculite® 866

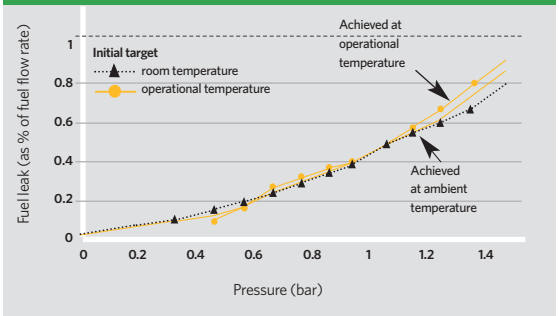
1 COMPRESSION OF TH870 AND TH866 GASKETS



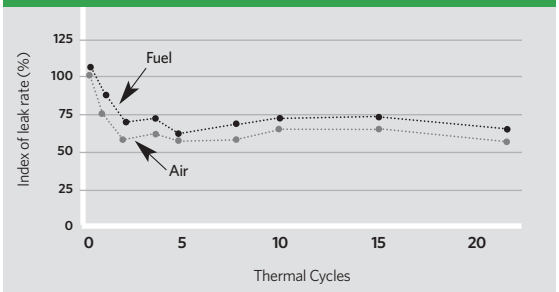
2 AMBIENT SEALING PERFORMANCE. SURFACE STRESS 3MPa, HELIUM PRESSURE 100 mbar



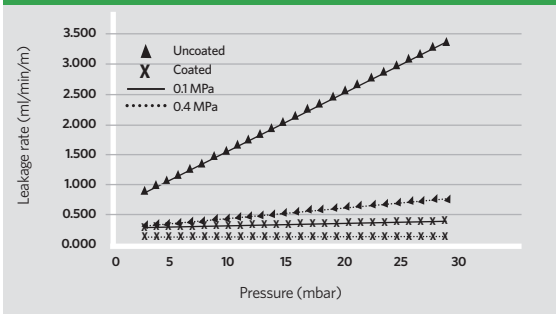
3 SOFC STACK SEALING PERFORMANCE ACHIEVED WITH THERMICULITE® 866 COMPARED WITH INITIAL PROJECT TARGET



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



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



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

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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, Italy, Belgium, the Middle East, India, Thailand, Australia and China plus a network of worldwide licensing partners and distributors.

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