

**ARMACELL SOLUTIONS
FOR OIL & GAS**

**ARMAFLEX
CRYOGENIC SYSTEMS**

FLEXIBLE INSULATION SYSTEMS
FOR INDUSTRIAL PROCESS PIPEWORK
AND TANKS



CRYOGENIC INSULATION FOR
RELIABILITY AND PERFORMANCE IN
LOW TEMPERATURE ENVIRONMENTS



Armaflex®

FLEXIBLE CRYOGENIC SYSTEMS

PATENT PENDING

Armaflex Cryogenic Systems are high-performance thermal insulation systems designed to meet the demands of low-temperature environments. These multi-layered systems provide exceptional thermal performance, reduce the risk of corrosion under insulation, and minimize the time needed for installation.

Armaflex Cryogenic Systems are used on pipelines, tanks and equipment in production plants for petrochemicals, industrial gases, and agricultural chemicals. These systems are also designed for use on the import/export pipelines and process areas of LNG facilities. The consistent performance of Armaflex provides significant benefits to facility operators, including improved process control, reduced boil-off and on-going energy savings.

Unique Combination of Features

Armaflex cryogenic foams combine in a single material the key performance qualities that are traditionally only achieved through the labor-intensive combinations of several other materials (e.g. rigid foams combined with vapor retarders and contraction joints). They combine low thermal conductivity, in a lightweight (low density) foam that remains flexible at low temperatures. This flexibility provides a system that inherently absorbs vibrations and impact, to provide a robust and low-maintenance solution to the insulation of cryogenic pipelines, vessels and equipment.

Proven Performance

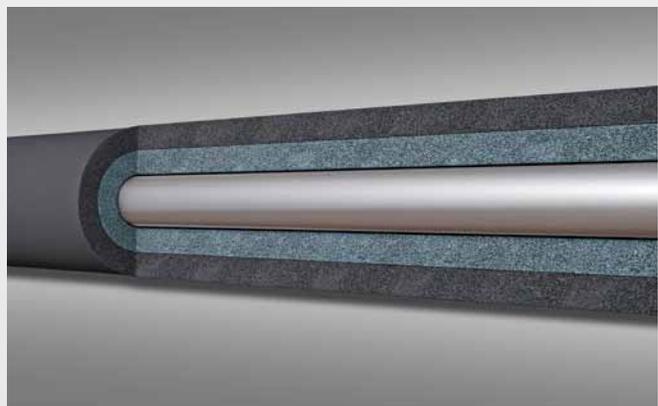
Armaflex elastomeric foams are widely recognised as a highly reliable material for cold applications. Since their invention in the 1950s by Armacell, which was then the insulation division of Armstrong World Industries, the applications of these foams has broadened to a diversity of industrial applications. In more recent decades this has included both thermal and acoustic solutions for heavy industry and petrochemical plants. Through continuous innovation and technical leadership, Armacell has developed a range of cryogenic systems (Patent Pending).



Key benefits of Armaflex Cryogenic Systems:

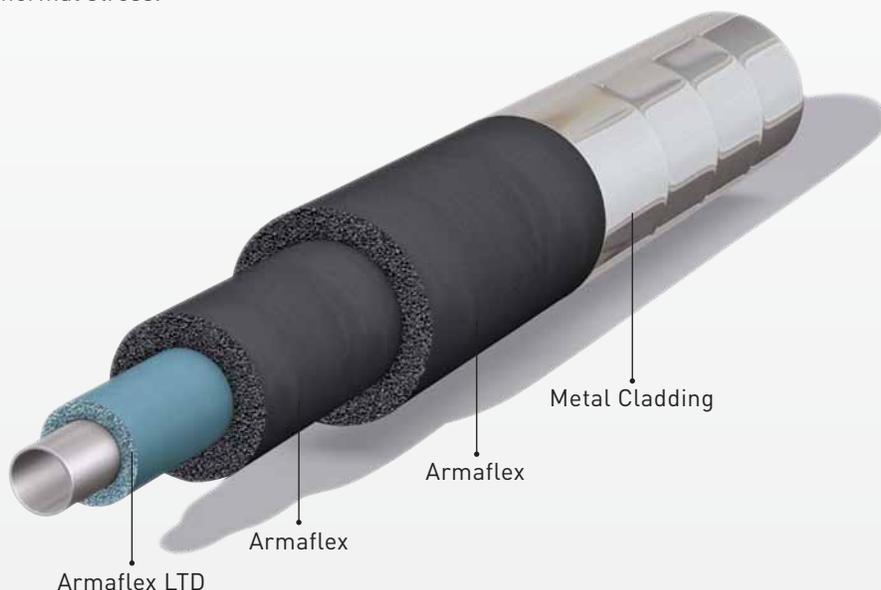
- » Low thermal conductivity
- » Built-in vapor resistance
- » Reduced risk of crack development and propagation
- » Suitable for applications from -200 °C to +110 °C
- » Low temperature flexibility
- » Built-in shock absorbance
- » Built-in contraction and expansion joints
- » Low density and weight
- » Cost effective
- » Low complexity to increase ease of installation
- » Fewer seams to provide a faster and more secure installation
- » Easily applied to awkward and difficult shapes
- » Easily handled and transported
- » Free of fibers and dust

Only Armacell offers specific elastomeric solutions to provide Thermal Insulation Systems, Acoustic Insulation Systems, and Thermal-Acoustic Insulation Systems. These systems provide substantial benefits over conventional materials used for industrial and chemical processes at cryogenic temperatures.



Armaflex Cryogenic Systems

Armaflex Cryogenic Systems are multi-layered composites that combine the most cost-effective solution with low-temperature reliability. The Armaflex solution provides dedicated systems to maximize mechanical properties and overcome thermal stress.



Armaflex Cryogenic System

- » Armaflex Cryogenic Systems are suitable for temperatures to -200°C .
- » Inner layers of Armaflex LTD provide optimum mechanical properties at cryogenic temperatures, while outer layers of NBR-based Armaflex provide excellent thermal efficiency at the least cost.
- » Armaflex LTD is a purpose-built low-temperature Diene Terpolymer, providing low-temperature flexibility to minimize thermal stress.
- » The distinctive color of Armaflex LTD facilitates installation and inspection.
- » An integral feature of the Armaflex system is the closed cell technology which offers a high water vapor resistance. This can lead to a reduced dependence on additional vapor barriers.
- » Armaflex Cryogenic Systems do not need traditional open-cell, fibrous in-fill pieces for contraction and expansion joints. The material itself can be fitted under compression to fulfill this function.

Armaflex LTD is suitable for applications to -110°C in its standard form. For some applications below -110°C the system is installed with an anti-abrasive foil bonded to the inner surface layer. Armaflex LTD anti-abrasive foil imparts superior surface strength to ensure long-term performance on pipework subject to vibration and regular movement. For operating temperatures below -180°C , Armaflex LTD is installed with an additional gas-tight barrier to prevent liquifaction of oxygen.

LNG Terminals



Ethylene Pipelines



Storage Tanks



Ammonia Pipelines



Key Technical Properties

Property	Test Standard	Armaflex LTD	AP/Armaflex
Material Type	—	Diene Terpolymer	NBR
Thermal Conductivity (W/m.K) (λ)	ASTM C177 EN 12667	0.034 at -50°C 0.028 at -100°C 0.021 at -165°C	0.036 at +20°C 0.033 at 0°C 0.029 at -50°C
Density	ASTM D 1622	60 – 70 kg/m ³	40 – 60 kg/m ³
Recommended Operating Temperatures	NA	-200°C to +125°C	-50°C to +105°C
Closed Cell Content	ASTM D 2856	> 95%	> 95%
Water Vapor Permeability	ASTM E96	<7.25 x 10 ⁻¹¹ g/(m.s.Pa)	<7.25 x 10 ⁻¹¹ g/(m.s.Pa)
Water Vapor Transmission Resistance Factor (μ -value)	EN 12086 EN 13469	$\mu > 2,500$	$\mu > 2,500$
PH	ASTM C871	6.0 – 8.0	6.0 – 8.0
Tensile Strength (MPa)	ASTM D 1623	0.30 at -100°C 0.25 at -165°C	0.15 at 0°C 0.18 at -40°C
Compressive Strength	ASTM D 1621	≤ 0.37 N/mm ² (2mm displacement) at -100°C	≤ 0.16 N/mm ² (2mm displacement) at -40°C

Structural Integrity



Dispersion of Mechanical Impact

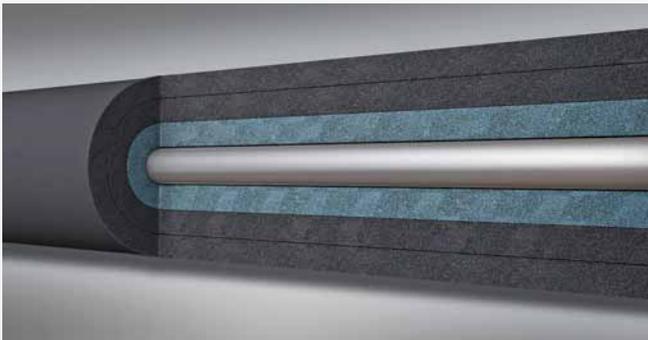
- » Inherently shock-proof system
- » Allows broad dispersion of force from point of impact
- » Avoids stress concentration that leads to induction of fracture
- » Avoids thermal cracking of rigid foams associated with impact

Armaflex Cryogenic Systems are inherently shockproof, with the flexible elastomers absorbing energy from impacts to the structure. The elastomeric foam allows broad dispersion of forces at any point of impact, and avoids the stress concentration that will typically occur on rigid foams.

Reduction of thermal shock is a significant benefit over rigid cellular insulation materials such as cellular glass, PIR and PUR. These traditional materials can show freeze-thaw crack propagation, thermal shock, structural damage from extreme stress, and performance degradation due to their inflexibility at both ambient and cryogenic temperatures.

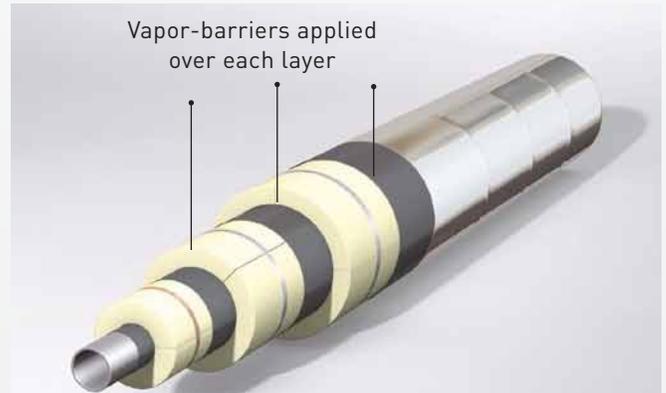
Built-in Vapor Barriers

Armaflex Cryogenic Systems do not require the installation of vapor barriers. Armaflex foams have a high resistance to water-vapor diffusion, which is a key property of their microcellular structure and polymer formulations. The Armaflex foams provide a continuous barrier to vapor diffusion throughout the full thickness of the insulation. This characteristic provides significant benefits by improving the longevity of insulation performance, and by reducing the risk of under insulation corrosion.



Armaflex Cryogenic System
No separate barriers required, with the material itself acting as a full-thickness vapor stop.

Traditional multi-layer insulation systems require a vapor barrier on each layer of rigid foam. These systems must have a continuous vapor retarder, with extensive use of mastics and vapor stops to ensure no possibility of moisture infiltration. The application of separate vapor barriers adds to cost and time, and any gaps or damage in these systems can undermine the performance of an entire layer of insulation.



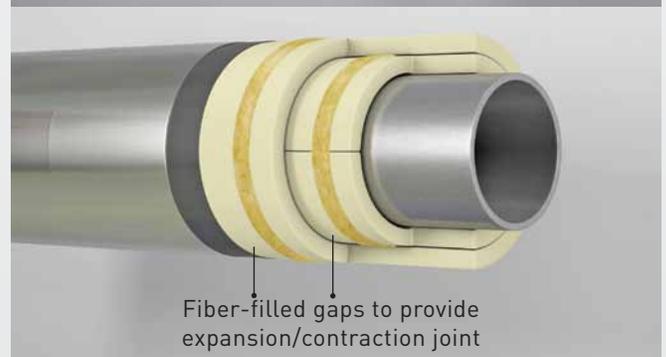
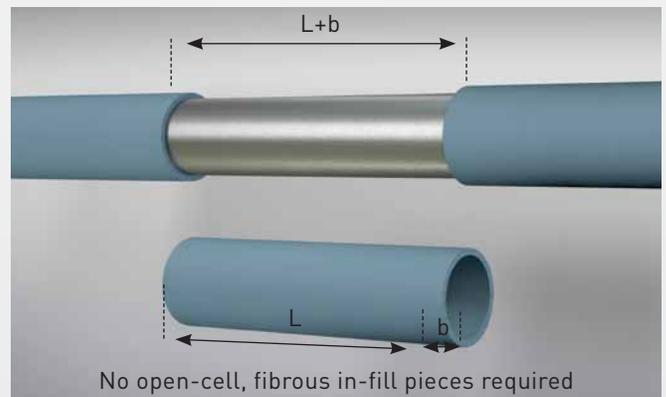
Traditional Rigid Foam with Vapor Barriers

Built-in Contraction Joint

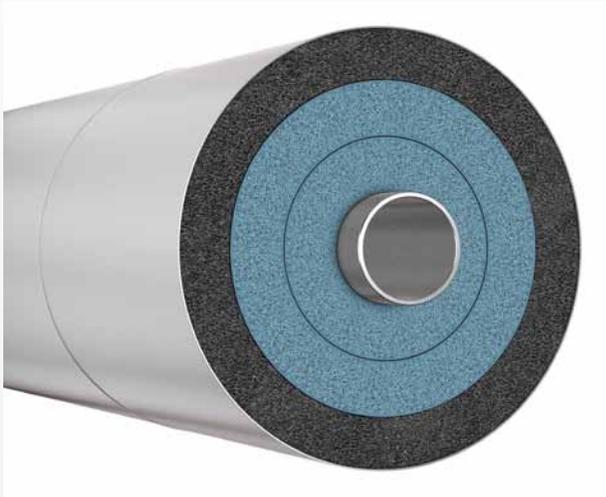
Armaflex Cryogenic Systems do not require the use of fibrous materials for contraction and expansion joints. Each layer of Armaflex is installed under compression at the joints, with additional compression included at those intervals normally requiring a separate "in-fill" sections.

The low-temperature flexibility of Armaflex provides longitudinal expansion and compression, which prevents stress accumulation due to thermal contraction of the pipe.

In-built flexibility is a significant advantage over traditional rigid foams. Traditional systems utilize glass wool or mineral fiber at longitudinal joints as a buffer against contraction and expansion of each insulation layer. These in-fill sections not only increase installation time and complexity, but the use of open-cell fibrous material provides the potential entry of moisture. The complexity of traditional contraction joints is also a consequence of the need to install specific barriers and sealant over the in-fill sections.



Solutions for Temperatures Below -110°C



To meet the unique demands of insulation for low temperature pipelines, the Armaflex Cryogenic Systems incorporate additional features for applications to -200°C. For these applications, the inner-most layer of Armaflex LTD is fabricated with an anti-abrasive layer of reinforced foil. This anti-abrasive layer provides added surface strength and gives enhanced protection from severe vibration and pipe movement.

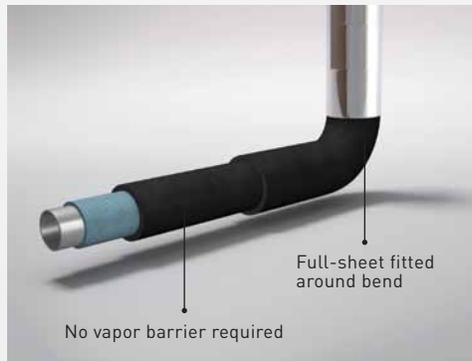
Armaflex LTD is well suited to large thermal shifts expected from both facility operation and the cleaning of process piping. Armaflex LTD is heat resistant to +110°C, providing the necessary tolerance expected during pipe cleaning with pressurized vapor or hot fluids.

Ease of Installation

Ease of installation is a key benefit of Armaflex Cryogenic Systems. One fundamental reason is their simplicity and reduced complexity when compared with traditional, rigid materials. Since the Armaflex systems require no separate vapor barriers or the use of fiber-based contraction joints, there are fewer materials and layers to install.

The flexibility and adaptability of Armaflex cryogenic foams makes fitting far easier when compared with multi-sectional rigid materials. Armaflex can be readily wrapped around curves and bends, and easily adapted to awkward and difficult shapes. Armaflex foam is easily cut on-site, and does not release fibers or particles.

Large sheets of Armaflex are typically a highly convenient form of material for cryogenic pipework. The lightweight of Armaflex makes it easy to maneuver sheets on-site, particularly in areas that may be difficult to access.



Armaflex Cryogenic System

Further, large sheets are easily wrapped around curved substrates without the need for multiple sections and joints. Armaflex foams can provide far greater system security than rigid foams, as the larger pieces of material can significantly reduce the number of seams per pipe section.

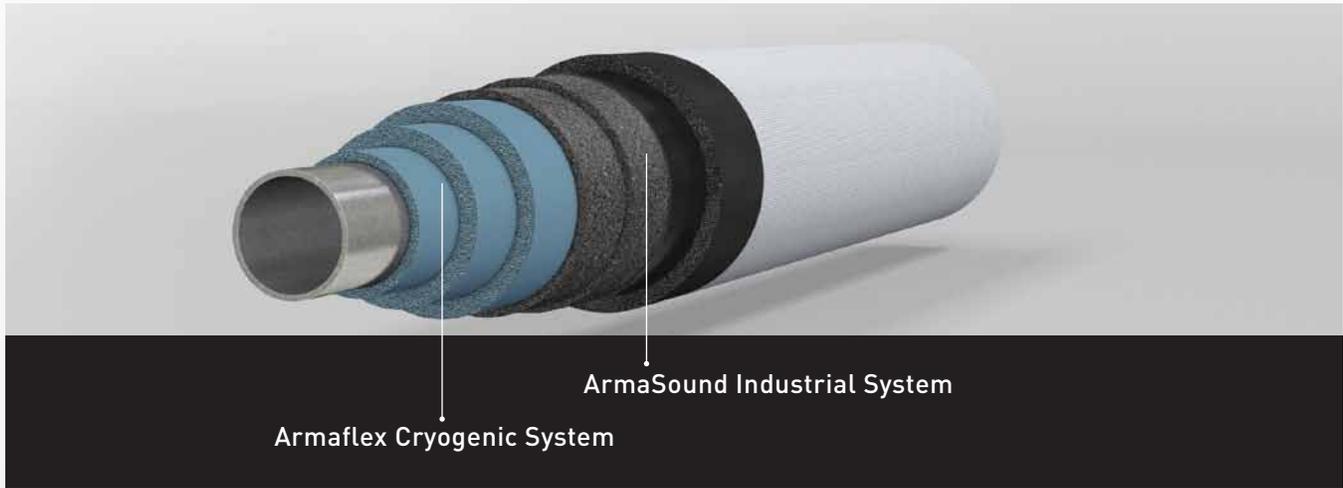
To assist installation, Armaflex foams are available in pre-formed tubes and in pre-fabricated parts. These are highly durable and not easily damaged by rough handling, dropping or movement in transport. During fitting, the Armaflex 520 adhesive provides fast bond-strength to quickly secure all joints and seams in pre-formed parts.



Traditional cellular glass system

Armaflex Cryogenic Systems are designed as multi-layer systems, with the inner-most foam (Armaflex LTD) designed for maximum cold temperature flexibility. The blue color of Armaflex makes it easy to identify, and provides a clear visual aid that assists in the correct layering to maximize performance.

Thermal-Acoustic Systems



Armacell is the first manufacturer to introduce a full thermal-acoustic system that is designed for cryogenics and based on flexible elastomeric foams. Armaflex Thermal-Acoustic Systems combine the benefits of ArmaSound Industrial Systems with Armaflex Cryogenic Systems. The combination of these products can provide significant benefits for cold pipework that must achieve exceptional levels of noise reduction.

ArmaSound Industrial Systems are designed to meet ISO 15665:2003, an international standard for setting classes for acoustic pipework insulation systems. When compared to conventional systems, which are commonly mineral wool with metal cladding, the ArmaSound solutions can offer significant reductions in weight and thickness.

For cryogenic applications, ArmaSound Industrial Systems can be applied over conventional insulation systems, such as cellular glass, PIR or PUR. In these applications, the ArmaSound systems also act as an additional vapor barrier.

The unique properties of Armaflex Cryogenic Systems make them particularly suitable for the combined installation with ArmaSound Systems. The low-temperature flexibility of Armaflex allows this material to perform as an acoustic-isolation layer. This acoustic isolation reduces the transmission of noise and vibration into any surrounding layers and can improve overall acoustic performance.

Installation Support

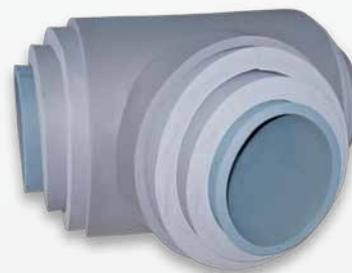
Armaflex Adhesive and Mastic

- » Armaflex 520 Adhesive must be used to secure all joints and seams on cryogenic installations.
- » Arma-Chek Mastic is available to seal all non-elastomeric materials, such as PUR or cellular glass, prior to overlay with Armaflex foams. This is critical where Armaflex is applied against other materials, such as rigid pipe supports.



Prefabricated Parts

- » Armacell can offer training and design advice for methods to pre-fabricate parts.
- » A key benefit of Armaflex Cryogenic Systems is that parts may be pre-fabricated on site, or in an external workshop, and then easily transported to place of installation.
- » Pre-fabricated parts can significantly speed installation in time-critical projects. They can also improve quality control and design consistency, which leads to better system installation.



Armaflex Installation Manuals

- » It should not be assumed that cryogenic elastomers are installed with the same methods as traditional materials, such as PUR, PIR or cellular glass.
- » Armacell provides specialized installation manuals to demonstrate the correct procedures for installation.



Armacell Application Specialists

- » Application and Installation Specialists are available to provide on-site installation training.
- » Armacell specialists are also available to provide advice on pre-fabrication requirements, planning of work procedures and training in quality-assurance inspection.



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