STUDY SUMMARY
MOISTURE NO. 101

Exterior Foundation Wall Insulation.

The impact of moisture absorption on the performance of polystyrene foam insulations used for below grade applications is an important design consideration. It has been scientifically proven that water absorption into polystyrene foam insulations will diminish R-values. Any change in R-value due to water absorption should be accounted for in the design of below grade applications.

This Study Summary provides the results of independent testing of below grade insulation consisting of R-Shield® insulation and an extruded polystyrene (XPS) product which were installed adjacent to each other. Samples of expanded polystyrene and XPS were excavated from the exterior foundation of a building in St. Paul, MN. The insulation was placed into service in 1993 and had 15 years of use as vertical wall insulation separating a heated building foundation from soil.

Summary of Test Results

Thermal Resistance		
Sample	**R-value/in. upon removal**	**Conditioned[1] R-value/in.**
R-SHIELD RIGID INSULATION	3.4	3.7
XPS	2.6	2.8

Moisture Content		
Sample	**Moisture Content volume% upon removal**	**Conditioned[1] Moisture Content volume%**
R-SHIELD RIGID INSULATION	4.8	0.7
XPS	18.9	15.7

[1] After four weeks in a laboratory at 72° F, 50% RH.

The results of the independent testing are dramatic. The expanded polystyrene insulation maintained 94% of its stated R-value of 3.6 after the 15 year time period and had a moisture content of 4.8%. However, the XPS retained only 52% of its stated R-value of 5.0.

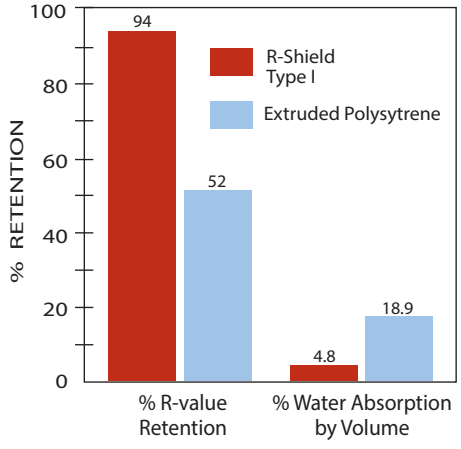
These results suggest very clearly that short term laboratory tests of water absorption for expanded polystyrene and XPS do not necessarily reflect the long term below grade performance of these materials.

R-SHIELD®
RIGID INSULATION

FOAM FACTS:

Below Grade Water Absorption

WATER ABSORPTION AND R-VALUE RETENTION[1]



Retained thermal resistance and water absorption of insulations subjected to 15 years below grade exposure

[1] Testing was conducted by Element, an independent, accredited Third Party Laboratory.

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STUDY SUMMARY
MOISTURE NO. 102

Exterior Foundation Wall Insulation.

The impact of moisture absorption on the performance of polystyrene foam insulations used for below grade applications is an important design consideration. It has been scientifically proven that water absorption into polystyrene foam insulations will diminish R-values.

This Study Summary provides the results of a research project conducted in 1988 by the Energy Division of The Minnesota Department of Public Service. The project report is entitled "A Survey of Minnesota Home Exterior Foundation Wall Insulation: Moisture Content and Thermal Performance".

Two expanded polystyrene and fourteen extruded polystyrene (XPS) insulation samples were removed 6-24 inches below grade from the foundations of Minnesota homes. The objective of the study was to survey the performance of below grade insulation 2-5 years after initial installation.

Summary of 1988 Study Test Results[1]

Material	Age (Years)	Thickness (Inches)	Density (pcf)
Expanded Polystyrene	6.50	1.39	1.27
XPS	2.86	2.00	2.01

Material	Moisture Content (Volume %)	R-value (°F.ft².h/Btu)	
		per inch	% Loss2
Expanded Polystyrene	0.49	3.55	1.4
XPS	0.47	4.91	1.9

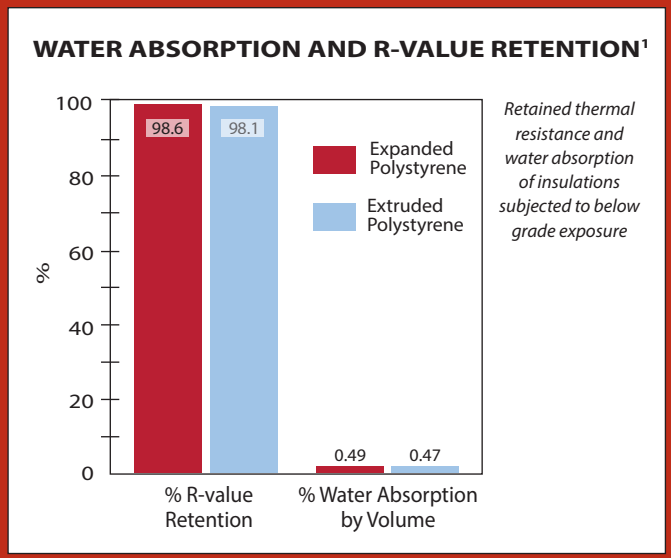
[1] Average of samples.
[2] Based upon R-value of 3.6 for Expanded polystyrene and 5.0 for XPS.

The results indicate that the below grade moisture absorption of the expanded polystyrene and XPS samples are comparable. It is interesting to note that the expanded polystyrene samples exhibited similar water absorption results even though they were installed for more than twice the length of time. These results suggest very clearly that short term laboratory tests of water absorption for expanded polystyrene and XPS do not necessarily reflect the long term below grade performance of these materials.

R-SHIELD®
RIGID INSULATION

FOAM FACTS:

Below Grade Water Absorption



Retained thermal resistance and water absorption of insulations subjected to below grade exposure

[1] Testing was conducted by Energy Division of The Minnesota Department of Public Service.

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STUDY SUMMARY
MOISTURE NO. 103

Exterior Foundation Wall Insulation.

The impact of moisture absorption on the performance of polystyrene foam insulations used for below grade applications is an important design consideration. It has been scientifically proven that water absorption into polystyrene foam insulations will diminish R-values.

This Study Summary provides the results of a research project conducted from 1980 to 1983 by Hoechst Corporation. The objective of the study was to survey the performance of below grade insulation 3 years after initial installation.

Expanded polystyrene and extruded polystyrene (XPS) insulation samples were removed from the foundation of commercial building located in Leominster, MA. The foundation was a poured twelve-inch concrete wall extending six feet below grade. The inside was dirt filled thus eliminating the influence of heat-flux through the wall.

Summary of Study Test Results

Material	ASTM C578 Type	R-value (°F·ft²·h/Btu)		R-value Loss (%)
		Prior to Installa-	After Removal	
Expanded Polystyrene	I	3.74	3.60	3.7
Expanded Polystyrene	VIII	4.15	4.16	0.0
Expanded Polystyrene	II	4.46	4.40	1.3
Expanded Polystyrene	IX	4.31	4.30	0.2
Expanded Polystyrene	XIV	4.49	4.37	2.6
XPS	IV	5.01	4.75	5.2

The expanded polystyrene samples have a slightly higher R-value retention than the XPS, but overall the results demonstrate that R-value retention for expanded polystyrene and XPS samples are comparable.

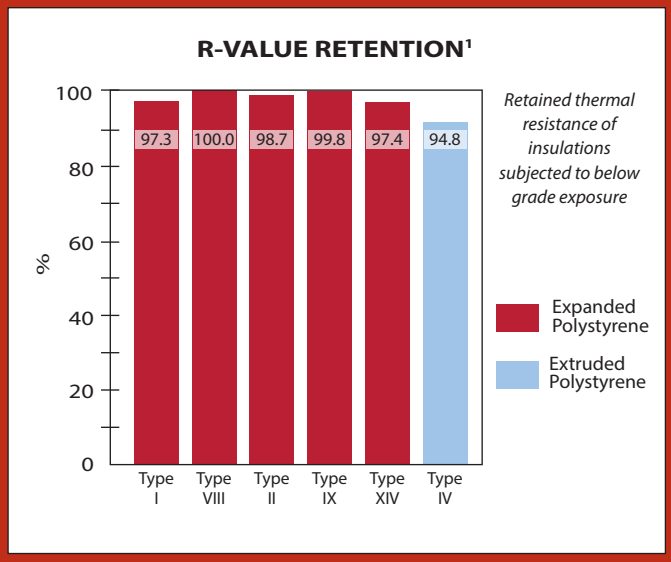
The slight reductions in R-value are anticipated to be primarily from moisture absorption, however it is possible that the greater loss in R-value for the XPS may have been partially due to the loss of blowing agents which diffuse out of the XPS over time.

These results suggest very clearly that short term laboratory tests of water absorption for expanded polystyrene and XPS do not necessarily reflect the long term below grade performance of these materials.

R-SHIELD®
RIGID INSULATION

FOAM FACTS:

Below Grade R-value



¹ Testing was conducted by Hoechst Corporation.

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STUDY SUMMARY
MOISTURE NO. 104

Environmental Cycling and Drying Potential.

The impact of moisture gain and loss on the performance of polystyrene foam insulation in below grade applications is an important consideration. It is well know that water gain and loss in polystyrene foam insulations will effect their R-value. Any change in R-value as a result of water gain and loss should be accounted for in the design of below grade applications.

The EPS Industry Alliance commissioned a study by Intertek, an independent test laboratory to conduct environmental cycling tests using ASTM C1512-07, *Standard Test Method for Characterizing the Effect of Exposure to Environmental Cycling on Thermal Performance of Insulation Products.* This study summary provides the test results related to drying potential.

Three expanded polystyrene and one extruded polystyrene (XPS) insulation samples were tested in accordance with ASTM C1512. ASTM C1512 determines the moisture gain and loss of insulation when exposed to the rigors of environmental cycling. Tests were performed on 1" (25mm) thick specimens.

Summary of ASTM C1512 Test Results

ASTM C1512 Environmental Cycling Moisture Results					
Material	**Before Cycling**	**After Cycling**	**% Moisture Retained**	**% Moisture Lost**	**Drying Observed ?**
Expanded polystyrene Type I	4.7 %	2.7 %	57	43	Yes
Expanded polystyrene Type II	3.2 %	1.7 %	53	47	Yes
Expanded polystyrene Type IX	2.1 %	1.6 %	76	24	Yes
XPS Type X	0.8 %	0.8 %	100	0	No

The results provided important information on the wetting and drying performance of expanded polystyrene and XPS insulation under the severe ASTM C1512 conditions.

- All polystyrene foams retain a very low percentage of moisture by volume after environmental cycling.
- All expanded polystyrene insulation types dried significantly during the cycling stage, demonstrating long-term drying potential.
- The XPS insulation did not exhibit drying potential in the cycling stage.

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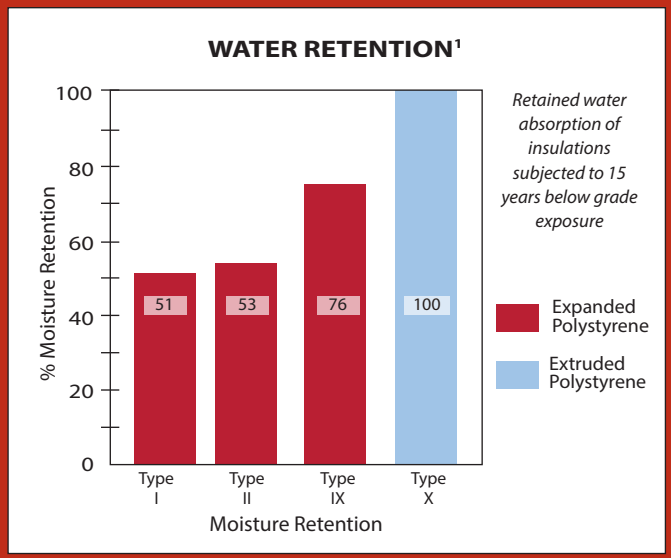
FOAM FACTS:

ASTM C512 Water Retention



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STUDY SUMMARY
MOISTURE NO. 105

R-SHIELD®
RIGID INSULATION

In-Situ Water Absorption of XPS.

The impact of moisture absorption on the performance of polystyrene foam insulations used for construction applications is an important design consideration. It is known that water absorption into extruded polystyrene (XPS) foam insulations will diminish their R-values. Any change in R-value due to water absorption should be accounted for in the design of construction applications.

This Study Summary provides the results of independent testing of XPS which was removed from four different locations and tested immediately for R-value and moisture content.

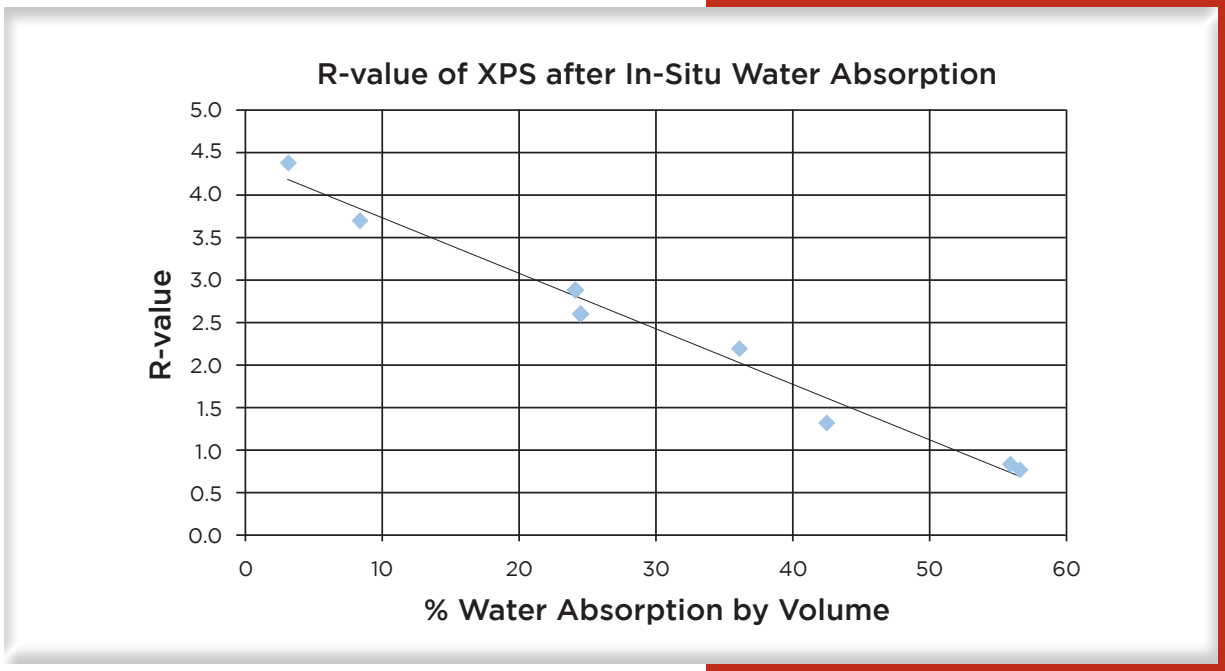
The results of the independent testing are dramatic.

- The water absorption of the XPS was significant, ranging from approximately 5% to 60%.
- The in-situ water absorption of XPS far exceeds the XPS referenced water absorption of 0.3% from laboratory testing.
- The R-value of the XPS is decreased drastically from the claimed R-value of 5.0 down to 0.7 to 4.5, depending on moisture content.
- There is a clear trend in decreasing R-value of XPS with moisture content in XPS even though the samples were removed from four different locations and applications.

See "XPS Insulation Extracted After Field Exposure Confirms High Water Absorption & Diminished R-value" published by expanded polystyrene Industry Alliance in 2014 for additional details.

FOAM FACTS:

XPS R-value and Water Absorption.



[1] Testing was conducted by Element, an independent, accredited Third Party Laboratory.

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STUDY SUMMARY
MOISTURE NO. 106

In-Situ Water Absorption and R-value of XPS

The impact of moisture absorption and age on the performance of polystyrene foam insulations used for construction applications is an important design consideration. It is known that water absorption into extruded polystyrene (XPS) foam insulations will diminish their R-values. It is also known that XPS will lose R-value over time.

This Study Summary provides the in-situ R-value of 6 random XPS samples which were removed below grade from a building in Minnesota during renovation. The XPS is believed to be 33 years old.

The samples were tested following the industry standard for R-value, ASTM C518, at a mean temperature of 75F.

- The lowest R-value was 3.2, an incredible 36% below the claimed R-value of 5.0.
- Even the highest R-value was 4.4, a full 12% below the R-value claim of 5.0.
- The average R-value of the samples was 3.9, a significant 22% below the claimed R-value of 5.0.

Additional testing is in progress to determine moisture absorption, R-value loss due to moisture absorption, and R-value loss due to aging.

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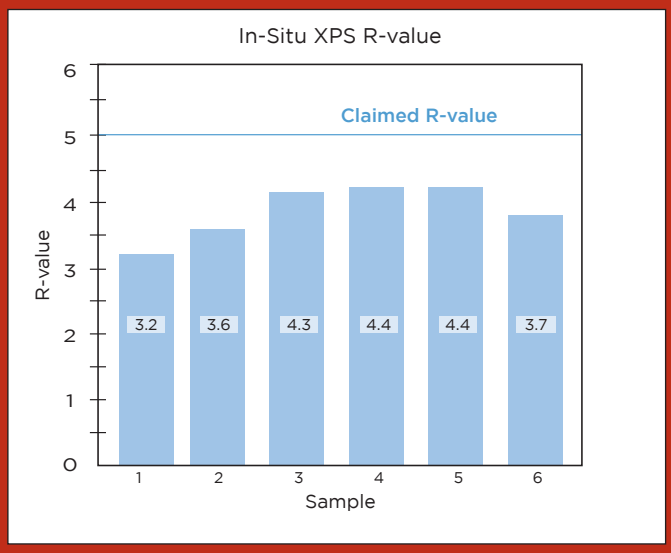
RIGID INSULATION

FOAM FACTS:

XPS R-value.



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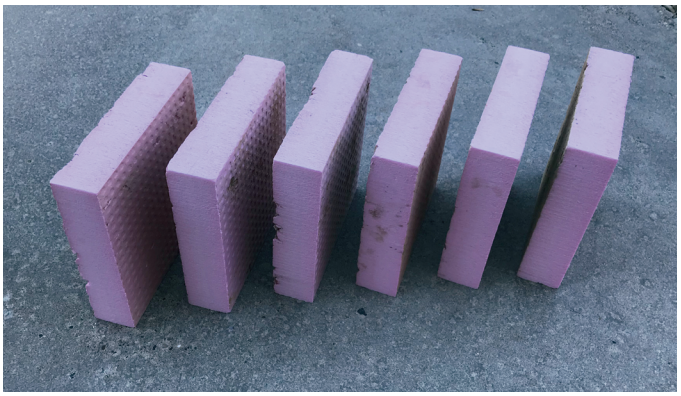
STUDY SUMMARY
MOISTURE NO. 107

In-Situ Water Absorption and R-value of XPS

The impact of moisture absorption and age on the performance of polystyrene foam insulations used for construction applications is an important design consideration. It is known that water absorption into extruded polystyrene (XPS) foam insulations will diminish their R-values. It is also known that XPS will lose R-value over time.

This Study Summary provides the in-situ R-value of 6 random 3-inch thick XPS samples which were removed from above a parking deck in Colorado during renovation. The XPS was protected above and below with concrete slabs. The XPS is believed to be 20 years old.



The samples were tested following the industry standard for R-value, ASTM C518, at a mean temperature of 75°F.

- The lowest R-value was 4.2, over 15% below the claimed R-value of 5.0.
- The average R-value of the samples was 4.4, more than 10% below the claimed R-value of 5.0.

Additional testing is in progress to determine moisture absorption, R-value loss due to moisture absorption, and R-value loss due to aging.

R-SHIELD®
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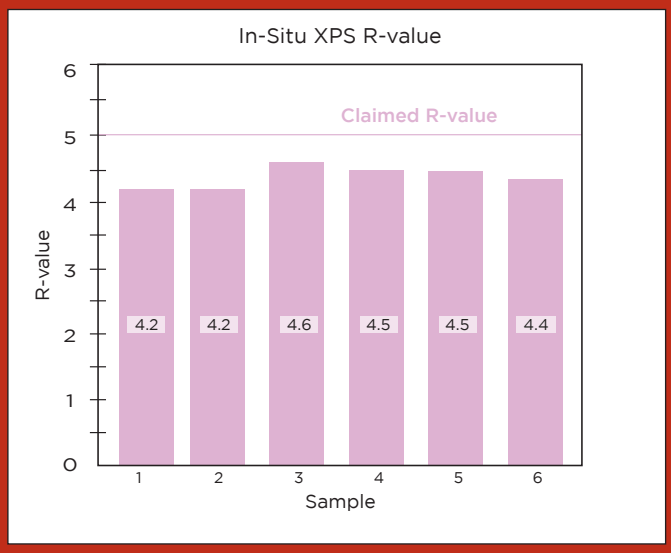
FOAM FACTS:

XPS Long Term R-value.



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