Figure 1 – Open jointed rainscreen on Rockwool/Roxul's Head office in Denmark. Note the open joints in the exterior glass façade allowing for moisture egress and exposure to UV light. Joints in the glass façade are approximately 4" wide. More information including actual current exterior and interior temperatures can be found at; http://www1.rockwool.com/environment/building2k/frame_set.htm

CavityRock- Cavity and Rain Screen Wall Application

Roxul CavityRock has been specifically designed, tested and approved for cavity and rain screen wall applications. Not only has it been tested and approved, CavityRock insulation has been recommended and promoted as a high quality and suitable insulation for cavity and rain screen walls by North America's leading Building Science Experts and Designers. Mineral wool insulation has been successfully used in exterior wall applications in harsh cold and wet environments for over 50 years in Northern Europe and for 20+ years in Canada. Mineral wool insulation is a tried, tested and proven insulating material that is suitable for use in exterior walls where moisture is a concern.

Rainscreen Principle

"Properly detailed and built, the rain screen wall is an effective envelope solution to external moisture penetration" (Canadian Mortgage and Housing Corporation with the Ontario Association of Architects). In general, the purpose of the "rainscreen" is to limit the amount of water entering the building's exterior envelope. The rainscreen principle can be divided into 3 basic concepts, the rainscreen, the air space and the drainage layer. The rainscreen's function is to screen the driving rain and limit the potential for moisture entering the wall system. The air space including weep holes/opened joints will allow for the equal pressurization of the rainscreen. By introducing equal pressurization within the wall system the air pressure differential will theoretically be equal, essentially eliminating the suction of water into the open cavity. The drainage plain's function is to direct the minimal amount of water that enters the cavity to the exterior by the use of flashings. The impact of penetrating moisture on thermal insulation installed in a cavity wall is minimal due to the location of the insulation, presence of an airspace, types of opening and types of cladding.

Thermal Insulation Properties

Moisture is the root cause of the majority of the problems when experts determine why building envelopes fail. This is an accurate statement; however there are additional contributing factors which must be addressed when specifying the exterior thermal insulation and the designing of the exterior wall system. Moisture, Acoustics, Energy Efficiency (R Value), Fire Safety and Durability are the typical qualities, designers refer to when specifying thermal insulation for their exterior wall system. Mineral wool meets and surpasses the "Principal Requirements of a Wall System" as deemed necessary for superior performance by Neil B. Hutcheon from the National Research Council of Canada (CBD 48). Overlooked qualities when choosing a thermal insulation for exterior walls include; building science design, dimensional stability and diminishing R value. Even though these seem like minor issues, they can certainly have a large impact on the design. The remainder of this technical bulletin will address these above noted issues and will assist in the designer's confidence with the use of mineral wool in exterior wall cavities.

Moisture Testing

Roxul Inc. relies only on accredited 3rd party testing to verify its conformance to many of the strict ASTM and CAN/ULC standards applicable to mineral wool insulation. Roxul Inc. has surpassed the required conformance testing criteria set out by ASTM and CAN/ULC, including additional accredited 3rd party moisture testing of CavityRock insulation for use in exterior wall systems. The completed test results shown below prove that Roxul CavityRock is a suitable high quality thermal insulation for cavity/rainscreen wall systems.

ASTM C1104 – Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation (water vapor sorbed by mineral fiber to high humidity atmosphere);

Water Vapor sorption = 0.07%

ASTM C1511 (with additional criteria) – Evaluation of the Water Repellency Characteristics of Board Type Mineral Fiber Thermal Insulation (product was submerged under 5" head of water for 30 min, then measured in scheduled intervals shown below);

Avg. Volume % of H_2O	1 min	3.69%
Remaining after	5 min	2.98%
	15 min	2.51%
	30 min	2.32%
	1 hr.	2.09%
	3 hr.	1.39%
	12 hr.	0%

(Note: This test is intended to represent the maximum water adsorption percentage under the worst case scenario. Full immersion under hydrostatic head is extreme and would not be expected to occur in a cavity wall application).

Moisture testing from the Fraunhofer Institute for Building Physics;

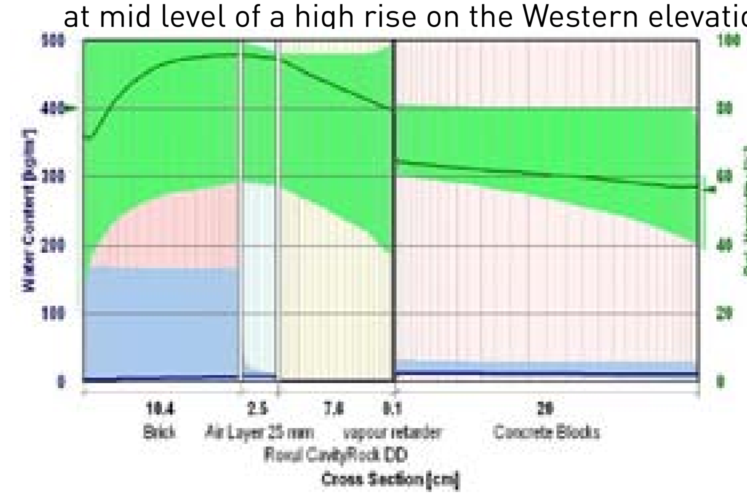
Water Vapor diffusion resistance factor = 1.2%
Water Adsorption coefficient = 0.01%
Water Content at 93% R.H. = 0.07%
Water Content at 97% R.H. = 0.08%

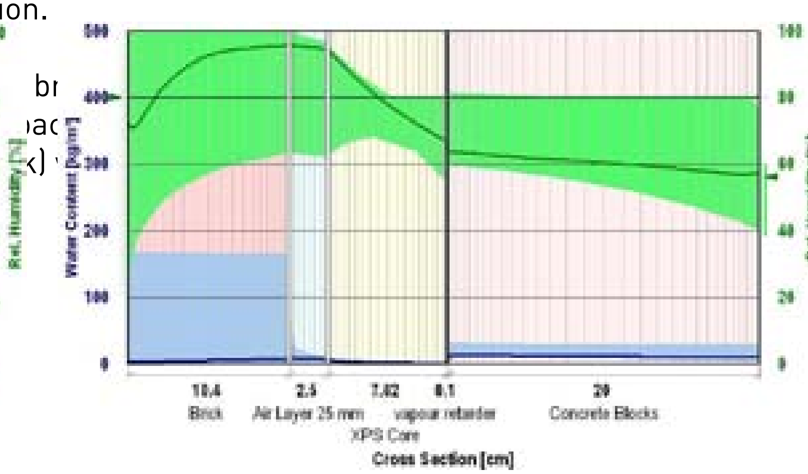
ASTM C612 – Standard Specification for Mineral Fiber Block and Board Thermal Insulation does not require testing using the ASTM C209 Standard Test Methods for Cellulosic Fiber Insulation Board, however Roxul has conducted 3rd party testing on several mineral wool products in the past using the ASTM C209 standard and found that the water absorption was less than 1%. This test was completed for information only and does not represent any typical in use applications for cavity/rainscreen walls.

Mineral wool insulation does not wick water, therefore any bulk water that hits the initial surface of the insulation will drain and not be absorbed into the body of the insulation. As previously stated, if the rainscreen was designed according to the rainscreen principle minimal amounts of water should enter the cavity, therefore having minimal to no effect on the insulation. Roxul Inc. tested CavityRock to ASTM C1511 for information purposes only, there is no instance where this type of situation would ever occur in the building envelope.

WUFI Modeling

To obtain a better understanding of the characteristics of in-situ thermal insulation within cavity walls, Roxul Inc.'s certified WUFI representative conducted 2 applicable scenarios in Seattle, Washington. These scenarios were modeled for a 3 year period and the theoretical wall was located at mid level of a high rise on the Western elevation.





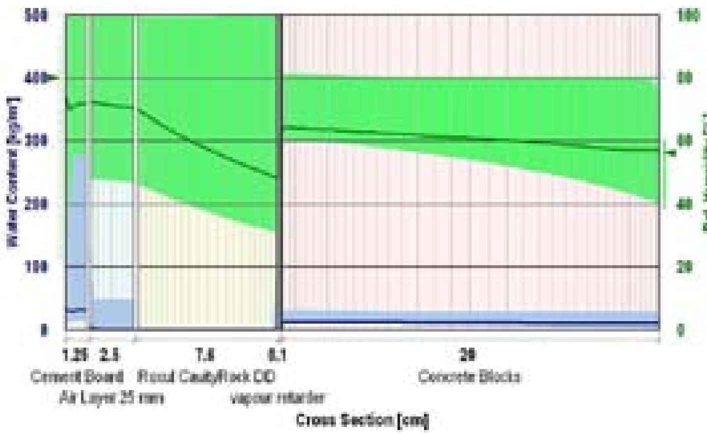
Water Content [kg/m²]

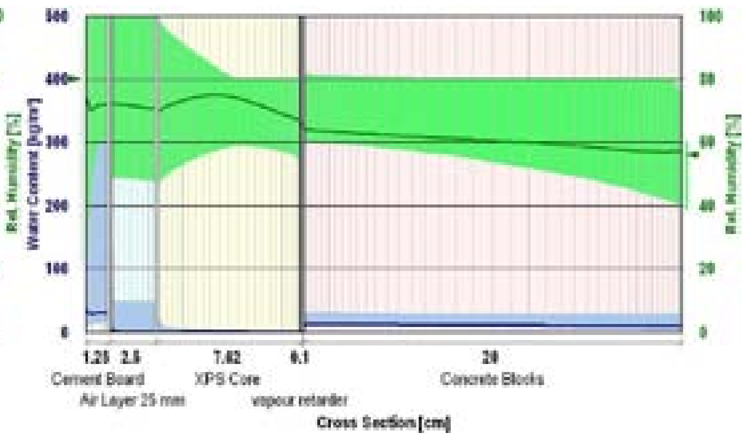
Layer/Material	Start of Calc.	End of Calc.	Min.	Max.
Brick (old)	3,34	4,83	1,53	164,83
Air Layer 25 mm	1,30	3,03	0,67	15,41
Roxul CavityRock DD	0,30	3,03	0,01	0,98
vapour retarder (sd=10m)	0,00	3,03	0,00	0,06
Concrete Blocks, pumice aggregate	28,00	11,83	8,83	28,00
Total Water Content [kg/m²]	6,0	3,01	2,42	21,07

Water Content [kg/m²]

Layer/Material	Start of Calc.	End of Calc.	Min.	Max.
Brick (old)	3,34	6,20	1,65	164,77
Air Layer 25 mm	1,98	2,02	0,62	15,43
XPS Core (heat cond. 0,30 W/mK)	1,78	1,48	0,94	2,22
vapour retarder (sd=10m)	0,00	0,02	0,00	0,03
Concrete Blocks, pumice aggregate	28,28	10,28	8,86	28,30
Total Water Content [kg/m²]	6,13	3,09	2,54	21,28

Results shown above, determined that mineral wool insulation in a typical cavity wall cavity will at a maximum increase in water content from 0.02 kg/m³ to 0.08 kg/m³. XPS on the on the other hand had an increase in water content from 1.79 kg/m³ to 2.32 kg/m³.





Water Content [kg/m³]

Layer/Material	Start of Calc.	End of Calc.	Min.	Max.
Cement Board	43.71	31.12	16.06	280.20
Air Layer 25 mm	1.69	1.19	0.44	47.34
Roxul CavityRock DD	0.02	0.07	0.00	2.32
vapour retarder (sd=10m)	0.00	0.00	0.00	0.00
Concrete Blocks, pumice aggregate	29.30	11.58	9.16	29.30
Total Water Content [kg/m²]	6.19	2.74	2.30	10.10

Water Content [kg/m³]

Layer/Material	Start of Calc.	End of Calc.	Min.	Max.
Cement Board	43.71	31.19	16.39	359.47
Air Layer 25 mm	1.06	1.15	0.46	47.06
XPS Core (heat cond.: 0.03 W/mK)	1.79	1.15	0.00	2.07
vapour retarder (sd=10m)	0.00	0.00	0.00	0.00
Concrete Blocks, pumice aggregate	26.20	11.40	8.13	26.00
Total Water Content [kg/m²]	6.30	2.6	2.46	10.48

The second scenario represents a typical rainscreen wall; 12.5 mm concrete board rainscreen, 25 mm air space, 75 mm thermal insulation, vapour retarder and a concrete block backup wall. As a note, a moisture sink of 15% (amount of moisture passed through 12.5 mm rainscreen) and 25% of the 15% hitting the insulation was included in the calculation. The results of the analysis are listed below.

Reduction in R Value

The R value of all insulation diminishes when moisture or water is present within the thermal insulation body. With the moisture data provided above (ASTM, Fraunhofer Institute and Modeling), the water content within the mineral wool insulation is minimal. Based on testing from the Fraunhofer Institute, the water content based on the second scenario (worst case) would have to be increased by 25 times its maximum level to affect the mineral wool's R value. Even up to elevated relative humidity levels of 100%, the Fraunhofer institute has shown that Roxul CavityRock will only store 0.5kg/m³ of water.

Mineral wool's thermal resistance is stable over time, where as closed cell foam plastics containing blowing agents other than air have a diminishing R value due to the use of blowing agents. There continues to be much debate over predictive methodologies for long term thermal resistance values for these foam products in-situ. A review of foam plastics warranty states that the R value will not vary by more than 10% during the initial years of the building operation. Compensation for the reduction in foam plastics R value should be accounted for when modeling full building energy scenarios. Not accounting for such reduction in R value will potentially create deficiencies in mechanical systems such as ventilation and HVAC. Heat transfer will also increase, resulting in higher building energy costs, as wells as the increase in CO_2 pollution.

Coefficient of Linear Expansion of thermal insulation can have a significant impact on building envelope's heat transfer, therefore special attention must be given to the material's coefficient of linear expansion. Mineral wool is a stable material and will have little to no expansion or contraction due to thermal cycling. Cavity wall insulation's such as foam plastics have a larger coefficient of linear expansion (6.3×10^{-2} mm/mm °C) and can produce voids or gaps in the thermal barrier at lower temperatures. These voids/gaps could potentially be enhanced if the non-dimensionally stable foam plastic insulation was installed at higher temperatures. As a point of reference the contraction of a mineral wool insulating board at thermal differential of 30°C is negligible where as the length direction contraction of a 2.43 m (96") foam plastic board is approximately 5 mm (1/5"). This number can be doubled as the adjacent board would have the same level of contraction. The contraction may seem minimal, however if you combine all of these small gaps in a high rise building, the heat loss through unprotected voids/gaps can potentially be substantial. Contraction of the thermal insulation does not reduce the R value of the insulation, however voids/gaps are created leaving portions of the wall assembly thermally unprotected.

Dimensional Stability is different than the coefficient of linear expansion due to the fact that the coefficient of linear expansion changes due to temperature and dimensional stability is potentially a single change in dimension over time. Mineral wool insulation is dimensional stable and will not decrease in size, bend or warp over time. Many foam plastics on the market claim that their product will not decrease in size over 2%. Is this acceptable, for an industry that is trying to promote energy efficiency and the reduction in CO_2? Imagine your thermal envelope on a high rise building shrinking by 2%, not including the above mentioned coefficient of linear expansion. With these two deficiencies in the thermal envelope, significant increases in thermal transmission and CO_2 can be expected.

Natural convection behind insulation can greatly reduce the thermal insulations effectiveness and in some instances completely negate the thermal value. It is important to ensure that the insulation is flush with the building envelopes back up system. Having a material that is flexible and can conform to curves and wall irregularities, such as mineral wool will be beneficial in reducing convection behind the thermal barrier. Rigid thermal insulations cannot conform to such wall irregularities and architectural curves, therefore enhancing the potential for natural convection behind the thermal barrier. Verification and testing of this phenomenon was completed by a large credible foam plastic manufacture. The foam plastic manufacturer called this phenomenon "thermal short circuiting" and claimed that 40% of the effective R value can be lost by having a minimal 1/8" gap between the thermal insulation board and the back up substrate. To eliminate the potential for natural convection behind thermal insulation the use of flexible and conforming insulations is highly recommended.

Building Science

Building Science Experts, Design Professionals and Engineers promote the advantages of breathable building envelopes. These professionals understand that when water enters the building envelope through transient vapours or from bulk water, it has a chance for a quick egress. Prolonged moisture in the building envelope can potentially lead to premature failure of wall system components or the complete wall system. CavityRock is a vapour permeable insulation (30-40 perms) and will allow transient vapours to pass through it without restriction. Lower permeable insulations such as plastic foams can also work as vapour retarders and will greatly restrict the drying potential of many typical building assemblies. As an example, installing foam plastics on a freshly poured concrete wall will limit the drying potential to one side Research from the Fraunhofer Institute for Building Physics has shown that drying of that freshly poured concrete wall will take twice as long than if mineral wool was installed. Imagine bulk water entering an assembly that has a vapour retarder and foam plastic thermal insulation. The wall will not be able to breathe, therefore trapping moisture for prolonged periods of time and potentially creating premature failures of building components or the complete wall assembly. Using mineral wool in exterior and interior applications will not restrict the movement of transient vapours and will allow the wall to breathe, as recommended by many design professionals.

Fire and Smoke Properties

Life safety and property damage above anything else should be designed for when specifying materials for building construction. Fire in buildings cannot be eliminated, however methods can be taken to reduce the potential for future loss of life and property damage. Using thermal insulating products that are non combustible, have a low flame spread and smoke development rating will ensure that these products will not start or fuel a fire. Not only would the mineral wool insulation not contribute to the fire, it can add additional minutes of protection for occupants to reach safety. It can also provide fire services personnel valuable time to both clear occupants, control the spread of fire while delaying the collapse of various structural members of the building.

The IBC 2009 states that foam plastic insulation must meet ASTM E84 flame spread of 75 and smoke development of 450 and that it shall be separated from the building interior by a thermal barrier. Even though there is a protection barrier shielding the plastic foam from the interior, there is still "stored" fuel from the foam plastic that could supply energy to a fire better known as the Heat of Combustion. CavityRock is a non combustible thermal insulation as tested to ASTM E136 and has a flame spread rating of 0 and a smoke development rating of 0. As previously stated mineral wool

insulation would not contribute fuel to a fire, in fact mineral wool insulation is used in conjunction with sealants to stop the passage of fire.

Medical journals have shown that smoke inhalation accounts for an estimated 50 to 80 percent of deaths in a fire. Smoke inhalation occurs when an occupant inhales chemicals of combustion during a fire. Combustion of a material is a result of the rapid decomposition of a component by heat. Smoke is generated by a product's combustion and is a mixture of heated gases and particles. To reduce the potential for smoke inhalation in buildings, building with non combustible products is highly recommended.

The easiest way to combat fire in buildings is to not design with products that could fuel or potentially start fires. There have been several recent tragedies where fire caused loss of life and substantial property damage due to combustible building components. There was a recent incident where a high rise building was ravaged by fire and over 70 people injured and over 50 people were killed. The head of the State Administration of Work Safety stated "It also is raising alarm over widespread use of flammable insulation used to retrofit buildings to meet new energy demands". Flammable insulation may not have been the root of this tragedy but it obviously played a role, therefore understanding foam plastics fire properties is critical.

Conclusion

Roxul Inc. has devoted much time, energy and dollars to ensure that all of our products are of high quality and exceed application in-situ performance. Roxul Inc. consulted many building experts, building science professionals and 3rd party testing labs to verify that Roxul CavityRock would have superior performance in cavity and rainscreen wall applications. Information within the body of this document was obtained by 3rd party testing labs or by 3rd party software packages used by trained professionals. Documents published by other manufactures regarding our product and its relation to moisture are either irrelevant to cavity wall or rainscreen system design and/or incorrect.